CANAL DE PANAMÁ

Book of Abstracts

34th PIANC WORLD CONGRESS

PANAMA 2018 May 7 to 11

Connecting Maritime Hubs Globally

Panama City, Panama

Riu Plaza Hotel

www.pianc2018.com

Book of Abstracts

Themes:

Inland Navigation
Dredging
Logistics & Infrastructure
Ports
Marinas
Environment

ISBN: 978-2-87223-251-2

www.pianc2018.com

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PIANC World Congress 2018: Panama, Rep. of Panama

Book of Abstracts (electronic resource) / 34th PIANC World Congress, 7 to 11 of May 2018, Panama [electronic source]: Connecting Maritime hubs globally / Organized by PIANC and ACP.

[realisation by PIANC and ACP] – Panama: ACP, PIANC, 2018.

ISBN: 978-2-87223-251-2

World Congress PIANC/ACP

PREFACE

This book of abstracts contains 284 abstracts presented at the 34th PIANC World Congress held in Panama, Republic of Panama, from 7 to 11 May 2018. PIANC World Congress presents and discusses topics relevant to the waterborne transport and infrastructure sector. It rotates among PIANC's member countries every four years and it is open to members and non-members. Participants, have the opportunity to exchange knowledge and experiences.

PIANC's goal is to advance the sustainable development of shallow and deep-draft navigation issues including dredging and dredged material disposal, navigation and pot infrastructure, recreational navigation and related environmental matters.

The Book of Abstract is arranged according to first author´s name.

All these abstracts represent an invaluable source of information, knowledge, experience, and ideas useful for students, engineers, researchers, scientists, authorities and for everyone interested in the fields covered in this World Congress.

Name_____
Title_____
Position_____
Affiliation_____

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1. Design and Construction of a Cellular Cofferdam for the Pacific Approach Channel

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Panama Canal Authority, Panama

As part of the Panama Canal Long Range Master Plan, the Panama Canal Authority (ACP) initiated in 1997 the expansion of the capacity of the waterway. The Expansion Project included the construction of additional locks and navigation channels to allow the transit of Post-Panamax vessels. This project required a new navigation channel to connect the Gaillard Cut with the new Pacific Locks. This channel was designated as the Pacific Approach Channel (PAC). The channel is approximately 7.8 km long, 218 m wide, with a water elevation at 26.82 m PLD (Precise Level Datum for the Panama Canal) and is separated from the Miraflores Lake (elevation 16.45 m PLD) by a new dam. ACP divided the Pacific Approach Channel works into four separate construction packages. One of those package, named PAC-4 included the construction of one of the two embankment dams required to separate the new access channel from the Miraflores Lake, that have a difference elevation of almost ten meters. These dams were designated as Borinquen 1E and 2E; the last one was included in the Locks Contract while the Borinquen 1E dam was built during the PAC-4 contract. The design of the PAC-4 required that the contractor excavate to ground elevations below the Miraflores Lake level. Therefore, it was required the construction of a cellular cofferdam and an embankment cofferdam in order to provide the adequate conditions for the required excavation works. This cofferdam was designed by the ACP design team and the review process was performed by URS Corp., who was the consultant in charge of the design of the embankment 1E. The paper describes the design criteria assumed; the possible additional uses of this structures once the new canal is in operation; and the construction process itself.

2. Erosion Control Program at the Panama Canal

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The Panama Canal is one of the most important engineering works in the world, located in an area with a unique diversity within the Republic of Panama. It stands as a magnificent excavation project, which exposes its greater complexity: a huge variety of geological formations, with different weathering and drainage patterns, areas of heavy rainfall, and large extensions of coastlines, which are subjected to surge waves produced by dozens of vessels transiting the Canal every day.

From the very beginning, when the Canal initiated its operations, many studies and projects have been carried out to reduce the erosion of the banks along the waterway. With the Canal Expansion project, this issue became more relevant, mainly due to the fact that huge retaining structures and new slopes were to be built to safely accommodate the transit of much bigger vessels. Because of this, the control of the bank erosion and sedimentation in the channel are key points of the geotechnical and environmental monitoring of the area. The Erosion Control Program was developed to meet this need and is managed by the Geotechnical Engineering Section of the Panama Canal Authority. The main goal of this program is to reduce the erosion action on the bank slopes produced by the surge waves and also on the cut slopes due to rainwater runoff. Special efforts have been committed to develop designs for erosion control, based on two premises: experience from previous methods used; and new technology which helps to find a balance between investment, performance, and bioengineering.

This paper describes the methods used for the erosion control in some areas along the shoreline of the waterway, which were required not only to protect the slopes but also to protect very important structures located near the banks. The projects hereby presented demonstrate the impact that a proper and effective design can have on such a particular area as the Panama Canal.

3. Exploring the Capacity Limits of Estuarine Access Channels, A Case Study of the Western Scheldt and the Port of Antwerp

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The increase in demand in maritime traffic leads to changes in ship size, charge and draft, leading to more challenging operational conditions of maritime ports, particularly more inland situated ports such as Antwerp. Real time nautical simulations have been developed and used to study the nautical accessibility and to study the conditions for manoeuvring to and in the ports. Such models are limited to the study of the behaviour of one ship and its interaction with other ships and the shallow water conditions in the port basin and the access channel. Useful and necessary information for pilots is deduced from such simulations to improve the safety of the port entry. However, other instruments are required to deduce information on the capacity of the access channel and port basin to accommodate larger vessels in a context of increasing traffic. As in all traffic situations, the increase in traffic density (number of vessels), will at first lead to an increase in traffic flow (cargo), which will at first reach a maximum, and finally decrease to zero (standing still) if traffic density continues to increase. Plans to increase port capacity related to the expected traffic increase, led to a prior demand to investigate traffic flow. IMDC developed a new traffic model capable of investigating the flow and potential saturation point of the access channel and port basin. The existing IMDC Waterways model (Adams et al., 2014) developed for inland navigation, was adopted to take into account the specific requirements for operating a maritime port. The model was developed, tested and calibrated using: detailed navigation data coming from the AIS-based dataset of the Port of Antwerp; the nautical experience from the Knowledge Centre Manoeuvring in Shallow and Confined Water, of University of Ghent and Flanders Hydraulics, deduced from tests on their simulators; hydro meteorological conditions (tide and current) from the detailed 3D hydrodynamic model of the Scheldt constructed by Flanders Hydraulics.

The existing traffic generator was modified to take draft and ship speed into account, as well as destination terminal and the residence time at the port terminal.

A planning tool was developed to check available time slots for generated ships at terminals and for the (6) maritime locks, taking into account tidal windows for tidal bound ships. The tidal window check is performed for newly generated up sailing ships and checked again before leaving the port (after the specified residence time).

The generated ships are then sent on the network. On the network, ship movement is defined by the defined ship speed and simulated current velocity. The speed is altered in case of interaction with other ships (overtaking). The possibility for ship encounters is checked using geometrical rules, taking into account geometrical requirements in bends, drift caused by currents, a safety distance between ships, both in width and length, calibrated on the basis of indications by pilots. In the port basin, ship encounter is complicated by the manoeuvring towards the docks, the terminals and the lock entrances. Specific algorithms have been defined to simulate the turning, and the impact on the possibility of ship encounter and need to adopt the ship's velocity.

The model can be considered as a hybrid traffic model combining theory from both microscopic and macroscopic traffic models, which allow to accelerate the calculations compared to pure microscopic models. The handling of ships is on an individual level (microscopic), checking the interaction ship by ship. It is macroscopic in the sense that links are defined by the most critical section.

After a warming up period an image of the traffic is built. Allowing to evaluate traffic capacity of the access channel and port basin. Calibration is done for ship speed and manoeuvring (number of encounters). Calibration of the different components: the traffic (or ship) generator, the tidal window model, the planning tool, as well as the network model is satisfactory, showing that the model is capable of simulating the development of traffic in estuarine channels and port basins with complex connections to tidal terminals and dock and port basins connected with locks. The model was tested to explore the limits of the capacity of the fairway and port basin. Traffic was finally studied for a future port planning scenario, to check whether this is adopted to the expected future traffic (characterized by a shift from smaller to larger and higher draft vessels).

The model provides a tool for the analysis of ship encounters, and may contribute to the analysis of probability of ship impact.

The presentation will elaborate on the ways criticism of nautical experts was taken into account to improve the modelling approach, and will introduce several concepts for presenting the capacity of access channels and ports.

4. The Dalles Dam Navigation Lock Downstream Miter Gate - Cracking, Instrumentation, Repairs, Replacement and Performance - 2007-2017

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The Dalles Dam navigation lock is located within Portland District, U.S. Army Corps of Engineers on the Columbia River between the states of Washington and Oregon in the U.S. The existing downstream miter gate at the lock began cracking near the pintle in the 1970's after 20 years of service. The gate was repaired in 1980 and performed adequately for another 20 years. Beginning in 2007, a dewatering inspection of the gate identified extensive cracking near the pintle region of both gate leaves. The gate was repeatedly repaired from 2007 to 2009 in an effort to stop crack growth. Each 400 ton gate leaf is 56' wide by 106' tall. Due to a lack of miter/quoin block contact, proper load transfer was lost. Consequently the gate experienced considerable cracking in the pintle region, skin plate, lower girders/ribs, and diagonal supports. The bottom rib cracked through the web in September 2009 dropping the gate over ¼" on the pintle requiring a 12 day emergency outage. Additional cracking was identified during the emergency repairs including fatigue driven gudgeon anchor cracking.

Following the emergency repair, the decision was made to replace the gate during a region wide extended lock outage that was planned for December 10th 2010 to March 14th 2011. Design of the new gate began November 10th 2009. The contract was advertised January 15th 2010 and awarded on February 23, 2010. The new gate was installed during the extended outage in March 2010 and has been in service for over 7 years. The new gate was recently subjected to a hands-on climbing inspection in accordance with no signs of distress identified.

The presentation will focus on the causes of cracking, the repair procedures utilized, the cause of emergency gate repairs in 2009 and the lessons learned from these repairs that were utilized in the design of the new gate. Details of the new gate design including adjustable diagonals, self-lubricated pintle bearings, improved fatigue resistant details, adjustable miter and quoin blocks, use of the new Guide Specification 055913, and SMART gate instrumentation will be discussed. The goal of designing the new miter gate was to design a structure in accordance with the latest engineering guidance and to incorporate lessons learned through the experiences with repairing the existing miter gate.

5. Report on the Findings of Working Group 189: "Fatigue in Hydraulic Structures"

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Hydraulic Structures are subject to varying loads of more or less cyclic character. These loads are primarily generated by differential water heads on, e.g., navigation lock gates, but also by waves, drive system forces and other actions. As a result, the designers must take account of an additional failure mode of these structures – the failure by fatigue.

Prior to the 1970's, fatigue was of minor or no concern for designers, constructors and managers of hydraulic structures. This changed, however, with the following developments:

- Increase of navigation, and higher gate opening and closing frequency;
- Advance of welding and disappearance of riveted steel structures; welded joints are more vulnerable to fatigue;
- Higher demand for infallible, low maintenance hydraulic structures.

A number of serious fatigue damages, particularly to lock gates, emphasized the need for guidelines in this field. Such guidelines already exist for other steel structures, like bridges, cranes or pressure vessels. They do not cover, however, all specific operation conditions and demands that apply to hydraulic structures.

To fill this gap, the PIANC Inland Navigation Commission (INCOM) set up a Working Group that compiled, investigated and assessed the international expertise on the fatigue of hydraulic structures. This report is a result of the Working Group activities. It aims to offer comprehensive guidelines in the field of fatigue to all professionals involved in design, construction and management of hydraulic steel structures.

Investigation method

To meet these objectives, the Working Group comprised a number of international experts in both structural and mechanical aspects of hydraulic steel structures such as lock gates, movable weirs, gates of harbor and shipyard docks. The represented expertise of the Working Group included – among other – the following profiles:

- Structural and mechanical design engineers with long experience in hydraulic structures.
- Field managers, project and program leaders experienced in handling fatigue problems.
- Fatigue experts in similar fields, like cranes, pressure vessels, steel bridges, industrial structures and ships.

- Young professionals willing to specialize in the field of the Working Group.

In the first phase, the group collected and assessed the existing know-how on the fatigue of such structures. This covered all relevant aspects, such as the design, analysis methods, structural detailing, monitoring, material aspects, fatigue damage assessment, maintenance and repair techniques.

Fatigue of hydraulic steel structures has not yet been handled in a PIANC report. There is also little literature in this field published outside PIANC. The issue has, however, been extensively handled in relation to other structures. Interesting in this view are structures like cranes, ships, and to some extend steel bridges. The Working Group collected and studied the reports, standards and other publications on the fatigue behavior of such structures. The Group assessed the relevance of these sources for hydraulic steel structures and issued proper recommendations.

The Working Group favoured a practical approach to the fatigue issues. It followed the line that the report should in the first place address and answer the field-borne needs of the PIANC community concerning the management of fatigue, rather than deliver a scientific discussion on this issue.

Final Product

This report is the final product of the Working Group activities. It contains a detailed analysis of the current engineering practice and offers guidelines for a more uniform, systematic approach to fatigue related issues. The report provides a summary of the appropriate design tools, like analysis methods, technical codes, other guidelines and best practices. It gives examples of both correct and incorrect solutions, provides the discussion of crucial issues and presents the lessons learned from fatigue failures of hydraulic structures. Apart from the design, the report also provides proper recommendations and best practices for the repair of different fatigue damages and for the management (particularly monitoring and assessment) of structures exposed to fatigue.

The Working Group collected a number of case studies from different countries in order to compile the lessons learned on fatigue. The existing guidelines and norms that handle fatigue of structures in other fields have thoroughly be reviewed and recommended if and where appropriate. The matters that have been investigated include:

- Nature of fatigue in hydraulic structures, significance and specific character of fatigue damage.
- Identification of fatigue loads, their sources, characters and correlations. Modeling these loads for analytical purposes.
- Requirements and boundary conditions of fatigue management, e.g. gate service life, permissible damage, accessibility for repair, conditions imposed by maintenance.
- Fatigue analysis methods and their assessment in view of hydraulic structures. This includes a study of literature and a critical discussion of the existing design codes.
- Relevant material aspects of fatigue, like fatigue behavior of various steel alloys, connectors, welding details etc.
- Detailing and construction of hydraulic gate components that are crucial in view of fatigue prevention.
- Monitoring, field inspections, assessment and maintenance of fatigue sensitive details.

- Available repair techniques of fatigue damage and other methods of service life extension, like better control of fatigue loads.
- General conclusions and recommendations.

6. Measurement and Analysis of Ship's Squat on the River Elbe, Germany

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Among the many challenges in reference to the development of today's ports, the accurate prediction of ship's squat for current and future vessel types is of major significance in terms of operability and safety. Due to constantly increasing vessel dimensions, the under keel clearance has become a limiting factor for traffic on the waterway of the Elbe estuary in northern Germany in recent years. Thus, the approach to the port of Hamburg is tide dependent for many modern vessels and regulated according to a tidal transit-schedule managed by the German Federal Waterways and Shipping Administration. To ensure an optimized, economical utilisation of the Elbe waterway, a reliable and estuary-specific assessment of the ship's dynamic response in restricted waters is crucial.

In order of the Waterways and Shipping Board Hamburg and in cooperation with the German Federal Waterways Engineering and Research Institute as well as the Hamburg University of Technology, Consulting Engineers von Lieberman implemented an extensive campaign to measure the ship's dynamic behaviour in various boundary conditions. Between 2013 and 2016, the estuary-specific correlations between the vessels' squat and hydrological, hydrodynamic, nautical and operational parameters (e.g. propeller revolutions) were investigated for container vessels with lengths up to 400 m and for capesize class bulker carriers. Measurements were carried out on board of the design vessel itself as well as on a research vessel, which escorted the design vessel along the pilotage area of the Elbe (approximately 120 km). The survey comprised of 21 measurement runs on seven different vessel classes characterizing the current fleet on the Elbe. For most of these classes two outbound voyages and one inbound voyage were surveyed.

Aboard the design vessel, six high-precision differential GNSS receivers were installed to record the vessels' motions, positions, speed etc. with a frequency of 2 Hz. The devices were installed at the bow, on the wings and at the stern of the design vessel at portside and starboard side. The convoying research vessel was used to measure the local salinity (using a CTD-probe) as well as the local current velocity and direction (using a Doppler Velocity Log DVL). AIS signals were recorded to collect data on encountering and overtaking vessels. Additional information about operational parameters of the design vessel was obtained from the VDR data. Mathematical models were applied for spatial and temporal interpolation of recorded water levels from existing gauges along the Elbe to the exact position of the design vessel. The bathymetry along the vessel's track was generated from official data sets and updated regularly with routine sounding data provided by the Federal Waterways and Shipping Administration and Hamburg Port Authority. Applying this holistic setup, an overall accuracy of the measured squat of ± 0.10 m or even better could be ensured.

The extent of the measurements, the number of considered parameters and the achieved accuracy form a unique squat data set. Based on its high resolution and its completeness it allows an unrivalled comparison between real sinkage and theoretical squat, for example calculated based on the ICORELS formula.

The recorded and processed data were subsequently used to analyse the following parameters in detail:

- Comparison of measured squat to theoretical squat according to ICORELS
- Correlation of speed through water and squat
- Correlation of under keel clearance and squat
- Correlation of river width and squat
- Effect of ship-to-ship interaction on squat
- Correlation of drift and squat.
- Correlation of change of water density and change of trim
- Effect of heel on draught
- Effect of meteorological influences on the vessel's dynamics

Based on the results of the survey the measured squat was compared to computed squat values using the ICORELS formula that is implemented in the tidal transit schedule for the Elbe. The general applicability of this approach, which had been verified for the Elbe for smaller design vessels in an earlier field study, was confirmed to be adequate for the investigated larger vessels as well. Under certain conditions, the ICORELS formula underestimated the measured squat for container vessels with a length over all of 347 m and larger. Here, a dependency on the trim of the vessel could be observed. Additionally, new insights into locally increased squat due to encountering vessels and correlations with the bathymetry could be derived from the analysis.

The paper and the presentation describe the measurement campaign and the methodology of the data analysis including an assessment of the accuracy of the measured and computed parameters. Exemplary squat time series under various boundary conditions and single events such as increased squat due to encountering vessels will be presented. The paper and presentation will focus on the analysis of the correlation of the measured squat to the aforementioned parameters and the applicability of the ICORELS formula.

7. Lessons Learned Dredging Project in Common Maritime Area Puerto de San Antonio, Chile

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In virtue of the development it has had Puerto San Antonio in recent years (managed by Empresa Portuaria San Antonio, EPSA) with a share over 40% market state and national ports, dealers San Antonio Terminal Internacional (STI) and Puerto Central (PCE) have had to execute different investment plans (above MM USD 580) to double the transfer capacity to MM3 TEU/year to the 2028 horizon of the current port, this will allow absorbing the demand projections in the short and medium term that put Puerto San Antonio in the 10 place in the ECLAC ranking (see http://bit.ly/2rjlH2O).

As noted above, considering the role of EPSA as a port facilitator and manager of the common areas, the engineering project and the respective environmental impact study were developed during 2012 to deepen the common maritime area (Poza Grande) of the Port of San Antonio and some adjoining areas until achieving probes between -15 and -16 mNRS to meet New Panamax type ships (lengths and estimated capacities of 367 meters and 13 thousand TEUs respectively). This project finally obtains its technical approval by the National Direction of Port Works of the Ministry of Public Works (DOP) on 14 November 2013 and the Environmental Qualification Resolution (RCA) Favorable by the Environmental Assessment Service of the Ministry Environment on July 31, 2014. Dredging works were contracted through international public bidding to the company of the Netherlands Boskalis International BV, whose dredging operation was 24/7. Due to the characteristics of the material to be extracted from the seabed (higher percentage of index material N-SPT 10 to 30), one type mechanical dredger BACKHOE (BHD) Cornelius I,in conjunction with barge not propelled Kurt Schulte for transport of the material dredged to the dumping area established in the RCA at 5.6 nautical miles from the entrance mouth of the port, a tugboat (RAM Pequén) for support of the dredger and transport barge to dumping area, in addition to ship support personnel carriers and development multibeam bathymetries control probes for determining volumes and feed.

The dredging procedure developed by the contractor basically consisted of:

1. Positioning in dredging area through the use of pylons.
2. Positioning barge by means of RAM.
3. Excavation project level (-16 mNRS) and loading material by the dredger barge (as established RCA volume is limited to 2,000 m3 per trip).
4. Transport of barge by means of RAM to the dumping area.
5. Shedding of Material.
6. Return barge to dredging area.

Due to the use of berthing fronts by both dealers (STI and PCE) and the infrastructure works that were being executed in parallel to the dredging works, one of the challenges on the part of Boskalis International B.V. it was the coordination and spatial programming to dredge in the common maritime area (under normal conditions and in case of port traffic), so it was necessary to subdivide the area project in different areas, some of them as a buffer, other priority areas near the berthing fronts of the STI concessionaire and the rest located within the

common area whose prioritization was established based on historical traffic data within the port (average of 7 daily movements), contrasted with the background that Boskalis International B.V. In order to periodically optimize this coordination and programming, the contractor's participation in the planning meetings was established daily in the bidding process. Another of the challenges presented during the development of the works was, in virtue of the works that PCE developed in parallel with the construction of the first stage of 350 meters against docking, of a total of 700 meters, the establishment of an intermediate stage to guarantee the operation of the first stage at the level -14 mNRS. This provoc or contractor that this area should consider spending a second chance to end dredging level project.

Finally, the project dredging was reflected in the following s figures:

- Start of dredging works: October 10, 2015.
- End of dredging works: October 27, 2016.
- Final volume of extracted material: 745,493 m3.
- Total number of trips barge to dumping area: 415 trips.

From the environmental point of view, the works were developed in strict compliance with the RCA that established a series of measures that were inspected a total of 6 opportunities during the execution of the works (Superintendency of Environment, AA.MM., Regional Secretary Ministry of Health and DOP), which included at least;

1. Monitoring before, during, and after the end of the project (sediment and water quality), in the dredging area as pouring.
2. Monitoring of demersal resources in the discharge area before and during the end of the project.
3. Periodic multibeam bathymetries control.
4. Compliance with Chilean regulations for:
    - Supply of industrial and potable water.
    - Fuel supply.
    - Supply and replacement of oil.
    - Wastewater removal.
    - Storage and removal of solid waste.
5. Controls maximum allowed dumping volumes.
6. Dumping controls only in established area.
7. Control of emissions.
8. Development of talks to staff (environmental risks, archeology, others).
9. Development of dissemination plan, both to the community and to authorities.
10. Others.

In addition to the technical and environmental aspects described, during the execution of the dredging differences between the volume transported by barge on what measured bathymetric surveys were detected, resultingin an additional volume of 89,971 m3 caused mainly by the OBR as surrounding the sector it must be dredged by Boskalis International BV within the scope contract (additional works).

8. Site Conditions for Port Developments on the Atlantic Coast of Central Panama

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The construction of the Panama Canal has motivated the development of multiple ports at both ends of the 80-km long Canal. This tendency is expected to increase with the expansion of the Canal and its new NeoPanamax-size locks.

The aim of this paper is to present a general description of the Atlantic coastal areas' geological and seismic conditions in the vicinity of the Canal. Geologic conditions involve very soft marine sediments, as well as a predominant rock formation that presents quite distinctive characteristics. Seismic conditions have been recently revised, with studies made in support of the Panama Canal Expansion Program, that concluded in 2016. Both sets of conditions pose a number of challenges for port design and construction, that can be substantially mitigated with local experience gained from previous work in the area.

The geology of the area is characterized by sedimentary formations that are usually described as soft rock. In this paper, we focus on the Gatun Formation, the predominant geologic formation in the area. Many projects involving this formation affords abundant experience with its behavior and performance. The regional extension of this geologic formation is shown in the reference: "Geologic Map of the Panama Canal and Vicinity, Republic of Panama", compiled by R.H. Stewart et al, U.S. Geological Survey, Map I-1232 (1980). The upper surface of this formation presents a very irregular geometry. The paper presents typical ranges of the depth, strength and stiffness parameters for the rock strata that corresponds to the Gatun Formation. It also addresses specific recommendations for the compaction characteristics of these materials that have been used in many fills, including the Transisthmian Railway, the City of Colon, the Colon Free Zone, various existing ports, many road projects, and others. The paper also addresses successful practices for efficient pile construction in this type of rock.

Overlying the rock formations, much of the area exhibits soft marine sediments. These are Undivided Holocene sediments, which also include man-made fills and Holocene fringing coral reefs. These materials, which are generally called "Atlantic Muck", are described in the cited reference. Given the erratic nature of the top surface of the rock, the thickness of sediments varies accordingly. Recommendations are given to maintain the stability of underwater slopes and above-water slopes in these materials, under static and seismic conditions. When subjected to surface loads, the soft sediments generally require preloading for consolidation and shear-strength gain, replacement with better geo-materials, or reliance on purely structural solutions, to assure adequate performance.

The paper then describes the range of geologic conditions found throughout the area of interest and lessons learned from working with these materials in the past.

The recently uncovered seismic conditions in the area, require a greater attention to ductility considerations, to maintain adequate levels of safety and reduce life-cycle costs. They also present the risk of liquefaction in the coarser components of the marine sediments. Recent studies, as well as historic descriptions of liquefaction, give some indication on the areas in which this might be a concern.

The integration of these conditions results in specific demand scenarios placed on marine structures, navigation channels, container yards and access roads. The paper describes past experiences that have been effective in defining the types of structures that have worked best. The paper also describes the analytical studies usually required for addressing conditions for which there is no precedent in recent times.

The information provided can help develop a general scope of work for new port facilities, that can form the basis of its feasibility study.

9. Stad Ship Tunnel - The World First Full Scaled Ship Tunnel

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The Stadhavet Sea is the most exposed and dangerous area along the coast of Norway. The aim of this project is to allow ships to navigate more safely past the Stad peninsula at a new fairway in more protected area.

During 2016-17 NCA has made a feasibility study based on the coastal steamer MS Midnatsol, which is the dimension vessel for the tunnel.

Key figures

Length: 1700 metres

Height between seabed and ceiling: 50 metres.

Width between tunnel walls: 36 metres.

The maximum vessel measurement is height of 33 metres, beam of 23 metres and depth of 8 metres. Speed through tunnel is 5 knots. The traffic system is based on one way traffic and the capacity is 110 vessels a day.

NAVIGATION CHALLENGES

The purpose is to navigate and sail into and through the tunnel only with help of the vessels own propulsion. Different studies have been done to predict how to manage those challenges. That is also an important input to the tunnel design.

Computer simulated navigation is used to control the design of the entrance and guiding system as well as simulating incidents with several vessels involved. All relevant weather conditions is tested as well.

Model studies and CFD-simulating are used to study the hydrodynamic conditions in the tunnel. How does model studies and CFD-simulating correspond to each other?

The studies concluded that the Stad shiptunnel would reduce the risk and make the sailing past Stad peninsula more predictable.

10. NAUTICAL RISK ANALYSIS FOR VIDIN-CALAFAT BRIDGE IN THE DANUBE

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At the request of FCC Construccion, S.A. in connection with the Danube Bridge project between Vidin (Bulgaria) and Calafat (Romania), a Nautical Risk Analysis was developed to assess the probability of impact of vessels on the unprotected piles of the bridge located in the secondary channel of the river. The project consists of a combination viaduct - cable-stayed bridge taking advantage of the small island in the middle of the channel. In each of the piles of the main channel a circular fender is arranged. Piles in the secondary channel are not protected. The objective of the study was to evaluate eventual risk of impact on unprotected piles, assessing the probability of occurrence and making a proposal for preventive or corrective measures. Complete traffic statistics were available, as well as information on the river flow, current velocities and wind, from which the actual navigation conditions in this section of the river were modeled.

The study analyzed the consequences of exceptional situations (breakdowns in propulsion or steering of vessels, lack of visibility, errors in position estimation, sudden bad weather, etc.), beyond the normal difficulties in sailing the river.

The analysis identifies, analyzes and evaluates different expected risk situations in the development of manoeuvres in order to establish effective preventive or corrective measures in accordance with the most stringent recommendations. Applying a ship manoeuvrability numerical model, the response of the vessels to each of the measures was analyzed according to the different possible situations.

Consequently, it was possible to evaluate the effectiveness of these countermeasures by determining, where appropriate, the "point of no return", which serves as a basis for the definition of restricted areas and development of contingency plans. During the development of the work a program of emergency simulations was established using model SHIPMA (Delft Hydraulics and MARIN (The Netherlands)). This model reproduces the behavior of a specific vessel during the execution of port access or exit maneuvers, subjected to the action of environmental agents (wind, current, waves, limited depth, shore suction, etc.) and aided by tugs, if any. For this purpose, it has an autopilot and tug control, which develop the necessary actions to maintain a desired track.

The working procedure was developed in the following phases:
• Identification of risk events
• Assessment of response manoeuvres
• Accidental risk assessment
• Definition of preventive and corrective measures

11. INNOVATIVE HIGHLIGHTS - RENEWAL OF SÖDERTÄLJE LOCK

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Introduction

The lock in the Södertälje Canal is situated between Lake Mälaren and the Baltic Sea. It was built in 1924 and with a chamber length of 135 metres and a width of 20 metres; it is the largest lock in Scandinavia. The average differential head is 60 cm. The construction of a new lock is necessary to meet the growing volume and size of marine traffic. Over the years, not only the amount of shipping has increased but also the size of the seagoing vessels. The new lock will have a width of 25.3 metres and a length of about 170 metres. The renewal of the lock is part of the large-scale Mälaren Project.

The renewal project consists of the extension and widening of the lock chambers, the construction of two new lock heads and lock gates plus a new bascule bridge. The client is the Swedish Maritime Administration and the project is performed by Züblin Scandinavia AB partnering with the client. Design and engineering of the lock heads including the sluice gates are performed by joint venture S3P, consisting of the two Dutch engineering firms MH Poly and Iv-Infra.

Special Lock Gate with a Special Construction Method

As requested by the client, a special type of lock gate will be used: a segment gate made of duplex steel (a type of stainless steel). This type of gate is rarely used for locks in The Netherlands. Duplex steel is more expensive than regular carbon steel, but it has the benefit that maintenance during the structure life is minimized. The gates are partly circular, rotate around a horizontal axis and are also used for the levelling of the chamber. In addition, the gates can hold water in both directions and can be rotated up and above water level for inspection and maintenance.

Another unique feature of this project is that the lock heads will be built at the side of the existing canal, after which they will be moved to their final position as complete structures. As a result, the canal can remain available for shipping as long as possible during construction.

Structural and Mechanical Design - Details of the Leaf Gates

The leaf gate has a skin plate formed as a cylinder segment, connected by 2x2 radial arms to two main axles situated in the machine buildings. At the back of the skin plate there are two buoyancy chambers. Here, main and secondary girders and stiffeners are placed. The buoyancy chambers ensure that the gate will tend to close automatically, although it will be locked in position when opened (or closed) for safety reasons. The circular shape of the skin has the benefit that the line of action of hydrostatic pressures stays close to the main axles and that the arms bring transfer of forces to it by normal force. To avoid ships damaging the gate arms, a modular fender structure is mounted on the lock head and between the gate arms and the canal.

The interface between the gate seals and their opposite surfaces in the lock head is complicated, because of the circular shape on the sides and it needs to be both watertight and durable. While opening, due to the innovative arrangement, the side seals will move away from their contact surface, instead of sliding along it, as such limiting friction and wear of the seals. While opening, the gate will temporarily be stopped after 5°, where an indented part of the skin forms a maximum opening to allow the water in the lock chamber to level with the water on the other side of the gate.

Each gate is moved by two hydraulic cylinders at each main axle. A main bearing near the gates arms and a secondary bearing inside the machine building supports each axle. Each axle assembly, the pulley plates, the main and secondary bearing, and the drive cylinder are integrated on one skid, which can be positioned and aligned in the desired position and direction, both at the start of the project and if necessary, adjusted in a later stage. This ensures that any eventual settlements over time will not lead to unnecessary high stresses, friction and wear in the main bearings.

Construction Method

To allow ship traffic to continue during most of the construction phase, the lock heads are constructed in building pits at the side of the canal. Construction of the lock head is thus carried out in dry conditions. The interface area for the gate seals consist of embedded duplex steel and are prepared in a 2nd stage concrete cast so that they can meet the stringent geometrical tolerances required for such areas. Mock-up tests with the drive system and with dummy structures for the seals will be also carried out in these dry conditions.

The original plan was to move the lock head from the construction pit to its final position by skidding, but after an evaluation of schedule, risks and costs, the alternative, based on floating was chosen. When the lock head is in place, it will be temporarily supported by four jacks at the corners. Hereafter, the gap between the canal bottom and the lock head will be filled up with concrete. Moving and sealing the lock heads on their final position is to be done within an outage of maximum one week each.

Interfaces

Building on top of the footprint of an already present lock and dealing with surrounding existing buildings and infrastructure means that the surrounding buildings, temporary structures and new structures which add to the lock function itself, like the bascule bridge, the moveable walkway and the machine buildings, all require specific attention to interfaces. There are many situations where interference can be critical, which requires the various design teams to work together seamlessly.

The presentation will provide more examples and details of the design and elaborate on the process followed to realise this project.

12. Design and Commissioning of the Filling and Emptying System for the Panama Canal Third Set of Locks

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The Panama Canal Third Set of Locks were constructed for the Panama Canal Authority (ACP) under a design-build contract awarded in August 2009 to the consortium Grupo Unidos Por el Canal (GUPC). The design was prepared by CICP Consultores Internacionales, a design JV led by MWH Global (now part of Stantec).

A robust and comprehensive design methodology, comprising numerical and physical hydraulic modeling, was developed and implemented to deliver the required filling and emptying system performance objectives under a design-build model.

This paper will present the process, methodology, and tools employed to develop and validate the filling and emptying system design, from original concept through system commissioning. The approach to translating the owner's hydraulic requirements into functional requirements will also be presented.

It will also present the main results collected during the startup and commissioning of the system. As part of the new facilities commissioning, a prototype measurement plan was developed in order to demonstrate compliance with the stringent Employer's Requirements for system performance. The requirements included maximum allowable filling and emptying times, maximum allowable water surface slopes in the locks, maximum allowable flow velocities in the conduits, and required water saving. Other limiting hydraulic parameters include no cavitation, no air entrapment, no water hammer, and minimal currents in the lock approach channels.

The process was completed successfully and, after the approval of the system, the new locks started commercial operations on 26th June, 2016.

13. Widening and straightening improvements to the navigation channel in Gaillard Cut at the Panama Canal.

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The commercial and industrial development worldwide during the twentieth-century and part of this century caused the world global merchant fleet to grow, making the vessels that transit the Panama Canal become larger in size and draft. The Panama Canal Authority undertook improvements projects along the navigation channel, particularly at the Pacific and Atlantic entrances and in the sector known as Gaillard Cut, a 14-kilometer-long segment that crosses the continental divide in the Isthmus, which is well-known for its landslide occurrences during and after the construction of the Canal.

In the 103 years of service of the Canal, there have been three significant widening programs along the Gaillard Cut. The first widening program of the Cut, started in the mid 1930´s, where the width was increased from the original navigation channel of 300 feet to 500 feet, and the program ended in 1971. The second widening program increased the navigation channel width to 630 feet in the straight segments and up to 730 feet in the curves, and it lasted approximately 10 years, between the years 1992 and 2002.

The third widening program increased the navigation channel width to 715 feet in the straight segments and 730 feet in the curves, in addition, the curves of the Gaillard Cut were straightened, and the program lasted 10 years, between the years 2003 and 2013. This program was divided into several phases to ensure slope stability during the excavation process, this phases included dry excavation, land drilling and blasting, land dredging, underwater drilling and blasting, and conventional dredging. Dry excavation and land dredging was carried out by external contractors, and the rest of the phases were carried out internally by the Dredging Division of the Panama Canal Authority.

The paper describes the design criteria assumed in the improvement of the navigation channel and the excavation process implemented in the widening and straightening of the Gaillard Cut.

14. Using GPS to measure truck operations in a container terminal

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Major container ports may receive thousands of visits per day by trucks dropping off and/or picking up containers. Many of these trucks are now equipped with GPS devices so that their locations can be monitored at a coarse level, such as verifying that the truck went to the correct terminal. We can take advantage of this to measure the performance of truck operations within a container terminal at a finer level of detail than previously. In addition to measuring time in each service, this analysis can also identify the likely container type — dry or refrigerated, import or export or transshipment, etc. — so in many cases we can report processing times for every combination of service and container type. Furthermore this measurement is unobtrusive: It requires no interruption of operations and no extra record-keeping by the terminal. The only data required is access to GPS records and identification on a map of the various yards within the terminal.

We use a Hidden Markov Model and Machine Learning to compensate for inaccuracy of GPS and to match the GPS trail to the most plausible pattern of movement within the terminal. This enables us to infer the types of containers handled and how much time was spent at each step, including time queueing to enter the port and time in traffic. This gives a much more detailed view of port activities than the aggregate, typically reported "truck turn-time" (time from entering the gate to departing). Efforts at improvement can then be directed more precisely.

15. Monitoring dredge placement operations through long-term and fine-scale suspended sediment observations within a shallow coastal embayment.

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The relocation of dredge material within near-shore coastal environments constitutes a major element of commercial dredging operations, with vast resources assigned to environmental monitoring and assessments. However, key parameters such as turbidity and suspended sediment concentration (SSC) are both temporally and spatially variable, requiring complex monitoring approaches. This study developed a comprehensive approach to effectively monitor dredge material relocation and the subsequent deposition in Moreton Bay, Queensland, Australia. We report continuous turbidity and velocity data obtained within a dredge disposal area over an annual cycle to address the long-term evolution of the site. This long-term mooring is equipped with a live stream to update stakeholders on environmental conditions before and after dredge activities. In addition, short-term deployments of a “near bottom monitoring system” is used to characterize the bottom layer during dredge and high-wind events. The monitoring frame consists of a Laser In-situ Scattering and Transmissometry (LISST) instrument, a high-frequency acoustic Doppler profiler and a newly designed high density water sampling system.

Our findings indicate that both sub-seasonal and seasonal fluxes contribute significantly to observed turbidity levels during dredge periods. Long-term current velocity profiling is a notable advancement for dredge monitoring methodologies, with the ability to provide net transport of material through the site. Furthermore, the influence of dredging is most prominent, with near bottom SSCs 300 mg/l higher than those observed during non-dredge periods. The development of the near bottom monitoring system also provides in-situ particle size estimates, with a significant shift in median particle diameter (D_{50}<100 µm) directly correlated with dredge placement operations and material entrainment during elevated wind periods.

The employed methods allow for the assessment of suspended material quantities driven by both dredging and site-specific hydrodynamics. This is a clear advantage to previous monitoring efforts as it reduces the ambiguity surrounding the influence of dredge operations in the area. Furthermore, the live stream turbidity updates enable dredge operators to assess the influence of day to day operations, with the ability to adapt dredge placement operations in accordance with imposed water quality limits. Although this monitoring method is time-intensive, it has the potential to set new standards in dredge activity assessment and to help develop sustainable dredge strategies in sensitive coastal areas.

16. An application-oriented model for lock filling processes

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The safe and efficient operation of locks is most relevant for the transport of goods on the waterways. One of the most important steps during the design process of a navigation lock is the dimensioning of the hydraulic system. There are concurrent requirements in this step, which have to be fulfilled: The construction and operation should be cheap, the filling process has to be as fast as possible and furthermore safety has to be guaranteed at any time by keeping the forces acting on the vessel within a certain range.

Typical approaches in literature can give an idea of the filling time and the forces which can be expected for through-the-head filling systems, but they often do not consider adequately the strongly transient character of the filling process. At the German Federal Waterways Engineering and Research Institute (BAW), traditionally a scaled laboratory model of the prototype is constructed and the forces acting on the vessel and the filling time are investigated. During the last years numerical methods have improved and approaches are available for the substitution of the laboratory model by complex numerical 3D models in some cases.

However, to give a preliminary estimation of the conditions during the lock filling process or to account for differences of the realized and designed geometry, maybe even years after the investigations have been carried out, it is not suitable to construct a new laboratory or a numerical model. Thus, the BAW developed a semi-implicit 1D numerical model which allows the simplified transient simulation of the lock filling process in a very short time with second order accuracy in time and space. Different valve types have been implemented to achieve a correct filling curve. This model allows the simple estimation of the longitudinal forces acting on the vessel.

In our contribution different methods to estimate the forces acting on a vessel during the lock filling process are discussed regarding effort and accuracy. Afterwards, the new numerical model will be described in detail. Validation experiments will be shown and first practical applications will be demonstrated. Finally, the authors will show how the numerical model can be used in hybrid modelling strategies to get better and more accurate results for more complex situations.

17. OptiPort: An Innovative Harbour Decision-Making Tool

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INTRODUCTION

In the last decades, international shipping trade has experienced a considerable growth and ports have been extended to satisfy the increasing demand. Many operations are performed simultaneously in port areas, and they are subjected to a set of random agents, such as maritime climate, sequence of ship arrivals and other factors related to port services and exploitation criteria. Due to this, port management has become a difficult task that cannot be dealt with using traditional tools. In this context, harbours need an aid decision making tool that is capable not only to reproduce maritime operations through simulations but also to assess the uncertainty in the performance of a given harbour management strategy and to compare the effectiveness of different alternatives.

In this work, a port operations simulation software, based on the methodologies proposed in [1], [2], and [3], is presented. For a given port management strategy, the software uses simulation techniques to obtain realizations of the time series that characterize climate and use and exploitation variables. With these variables it reproduces port operations and obtains a series of indicators that measure the performance of the alternative in regard to operationality, waiting times, occupancy and use of harbour services. The performance of the alternatives is characterized from a statistical point of view. The tool also implements the Stochastic Multicriteria Decision Method SMAA-2 [4] that allows to compare different strategies and to rank them according to their performance taking into account multiple criteria.

THE SOFTWARE

The software comprises several modules to (1) define the case study, (2) simulate port operations, (3) analyse the results and (4) compare different scenarios.

1. The case study is defined by the (i) harbour configuration, namely, the elements used by ships, such as entrance, channels, docks, anchorages, etc.; (ii) the information to simulate the climate conditions that affect ship operations (sea level, waves, wind, currents and visibility); (iii) ship traffic characterized in terms of ship arrivals, climate thresholds to operate, dimensions or port services demand (pilot, tug, mooring), navigation, time at docks, etc.; (iv) harbour services offered by the port, namely, pilots and tugs assistance and mooring and (v) management and operational criteria, such as priorities for a certain kind of ships or safety procedures related to dangerous goods ships or climatic conditions (visibility, wind intensity, wave severity).

2. Once the case study is defined, the software reproduces during a certain time interval (one year) the time series that define the climate and exploitation variables (ship arrivals, dimensions, demanded services, etc.). With that information, the software reproduces ship movements at the harbour and checks the viability of the movement considering operational criteria (climate thresholds, priorities) and availability of

resources (harbour services, berths). As a result, the movement will be done or the ship will have to wait. All this information is registered accordingly. The previous step is reproduced a large number of times so that a representative sample of the harbour performance indicators is obtained. This sample is then used to infer the distribution functions that characterize in probabilistic terms the behaviour of the case.

3. The results module shows the variables and functions that characterise the port performance.

4. The software can be applied to different alternatives of a given case and used to select the best alternative. The methodology takes into account multiple criteria, the uncertainty of the preferences of the decision-makers and the stochastic nature of the variables that define the criteria.

VALIDATION CASE

The software has been validated with a real case study of the Port of Algeciras. The Port of Algeciras is located at the south of Spain, in the strait of Gibraltar. Because of the strategic location, the Port of Algeciras is the busiest Spanish port and the fifth port in Europe.

The port performance has been measured through a set of parameters, such as berth or harbour services occupancy rates. These real values were calculated using information related to the use of berths, docks and harbour services, registered and provided by the Port Authority.

Then, a real case study based on the Port of Algeciras has been simulated with the software. The port was modelled within the software using information provided by the Port Authority, such as docks and berths configuration, ships arrivals and their characteristics, port services, etc.

The simulated values obtained from the simulations were compared to the real calculated values. It was observed that the software provides similar values to the real ones, for berth and harbour services occupancy rates, as well as for use of harbour services. Variables like the percentage of time in which N tugs are working simultaneously have been reproduced accurately.

CONCLUSIONS

The presented software has proven to be a useful decision support tool for port management and planning, which reproduces the port performance precisely. Thus, the software is able to help port managers to detect bottlenecks at ports where traffic is high and randomness plays an important role, to optimize infrastructure management criterions and as a decision support tool for berths and anchorages planning, among many other applications.

AKNOWLEDGEMENTS

The software has been developed by Proes Consultores and FCC Industrial, and the Port of Algeciras as pilot-port. The project was co-funded by the European Regional Development Funds.

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18. PHYSICAL MODELLING OF PROPELLER SCOUR ON AN ARMOURED SLOPE

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1INTRODUCTION

CITIC Pacific Mining (CPM) is proposing to increase throughput at their existing Sino Iron Terminal in Cape Preston, Western Australia, using self-propelled Handysize transshipment shuttle vessels (TSV) instead of dumb barges. Initial assessment using various desktop methods (PIANC, 2015) indicated that the armoured rock slope adjacent to the berth face would incur damage due to wash from the vessel side thrusters and the main propeller. Large scale (13.5:1) physical model tests were undertaken in a 6 m x 15 m x 1.4 m deep basin at UNSW to measure wash velocity and armour stability. The physical modelling demonstrated that the rock slope was more stable than expected, but that some armour was mobilized. Additional tests were also completed to investigate the efficacy of Articulated Concrete Block Mattresses (ACMs) to protect the rock slope from propeller wash.

2Jet Velocity

A large-scale physical model was chosen to better represent the turbulent flow characteristics of the propeller jet. Scale models of the ship propellers were calibrated by adjusting their rpm to reproduce the theoretical efflux velocity adjacent to the propeller face. Efflux velocity and its decay with distance on the jet axis were measured at 100 Hz for several rpm settings using an Acoustic Doppler Velocimeter. When compared with the equations presented in PIANC (2015), the velocity decay profiles agreed well for the bow thrusters but not for the main propeller, where the zone of flow establishment was significantly shorter than predicted by the equations and there was evidence of significant three-dimensional flow.

3Armour Stability

Armour stability tests on a 3H:2V slope were conducted by modelling twin bow thrusters and both the main propeller and a single stern thruster. Each model test was run for 8 minutes, equivalent to 30 minutes full scale. Movable bed and fixed bed cases were tested to isolate the processes of seabed undermining and direct rock armour displacement from the test section of the slope. The number of rock movements on the test slope was measured (by comparing before and after laser scans).

The rock armour was found to remain more stable for a given wash velocity than predicted by the empirical equations. However, the model test data showed that the cumulative effect of multiple vessel operations would compromise the long term stability of the armoured slope. Articulated Concrete Mattresses (ACMs) of 3 m x 10 m x 0.4 m size overlain on the slope were subsequently tested to investigate their efficacy. Some movement of the mattresses was observed, especially at higher wash velocities. It was seen that interconnecting adjacent mattress sections along their long edges increased their stability.

4Conclusions

Available empirical equations for predicting the stability of rock subjected to propeller wash were seen to be conservative when compared to physical model results. Decay of the propeller jet velocity with distance is accurately predicted by the equations in the case of the scale bow and stern thrusters but was conservative for the wash from the main propeller. The results from the scenarios tested showed that long term breakwater slope stability and vessel navigability would be compromised at the facility. Articulated Concrete-block Mattresses (ACMs) were demonstrated to remain stable when impacted by thruster and main propeller wash from the operation of the Handysize vessel at the berth.

ACKNOWLEDGEMENT

Generous thanks to Nathan Fuller from CITIC Pacific Mining for enabling this contribution.

19. Port Development to Support Offshore Petroleum Exploration and Production

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Offshore petroleum exploration and production relies upon specialized port facilities worldwide as the industry operates much differently than general maritime trade and has specific needs to operate efficiently. This presentation describes the channel requirements, and the port infrastructure necessary to facilitate offshore petroleum exploration and production. Within the U.S., several Gulf of Mexico ports have developed in tandem with the offshore petroleum industry to facilitate its needs. As offshore petroleum development expands in South America and Africa, there will be a need for nearby ports with the appropriate facilities.

The offshore petroleum industry needs ports that are capable of servicing supply vessels and loading significant quantities of pipe and other supplies and inspecting, repairing and refurbishing rigs and platforms. Servicing offshore rigs and platforms is a volatile, yet profitable, segment of the shipbuilding industry. Ports must have channels at least 11 meters deep to service most semi-submersible rigs and drill ships. Shipyards servicing rigs and platforms require large investments in facilities such as dry docks, cranes and other shipyard equipment, as well as a well-trained workforce. Offshore supply vessels (OSVs) do not need the deep and wide channels necessary for servicing offshore rigs and platforms.

The operators of OSVs prefer to minimize transit times by using facilities that are as close to offshore platforms as possible. The offshore petroleum exploration industry has undergone significant change since the first offshore petroleum exploration platforms were fabricated in the 1950s. Over the past twenty years offshore petroleum exploration has moved further offshore into deeper water, which requires the use of large semi-submersible platforms or drill ships.

Also, the newer OSVs are larger, and have deeper design drafts, than previous generations of offshore supply vessels. Newer vessels are more technologically complex and more expensive, and therefore some owners have implemented under keel clearance requirements of one meter for these vessels. Although technology now allows for offshore exploration and production to proceed with minimal near shore support, there are additional costs to doing so. Also, having a nearby port with facilities to support the offshore petroleum industry improves emergency response to spills and storm events.

Offshore petroleum ports also require a significant landside infrastructure to provide water, fuel, drilling fluids, deck equipment, and bunker supplies to offshore rigs and platforms. Offshore supply vessels are designed to efficiently transport these items offshore. Ports that support offshore supply operations must have conveyances for efficiently obtaining these cargos: channels and docks deep enough for cargo ships, a canal link to allow barge traffic, pipelines, or an efficient highway or rail connection. A significant amount of research on the economics of offshore petroleum rig and platform servicing and the economics offshore supply vessels fleets has been published. This presentation and paper describe the channels and facilities necessary to serve offshore petroleum exploration and production.

20. How to Power Navigation Locks with Electricity

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Navigation locks facilitate navigation uphill by allowing boats to take vertical steps. Navigation locks date back to ancient Egypt, the first “modern” lock was part of China’s Grand Canal that dates back to 600 AD. Essentially a navigation lock is a chamber with gates at both ends where the water level can be adjusted. The measure in which the water level can be adjusted is the measure of the vertical step the navigation lock can lift the boat. The water level in the navigation lock is increased by adding more water.

During the eighteenth and nineteenth century, navigation locks revolutionized transportation in Europe and the United States. The advent of trains and automobiles reduced the importance of navigation locks in inland transportation, primarily because these transportation modes require less infrastructure than inland navigation, if inland navigation is possible at all. The construction of the Panama Canal extended the application of navigation locks to maritime shipping. The Panama Canal allows ocean shipping shorter and safer routes.

An innovation in lock design has been the addition of water savings basins to reduce overall water consumption. Multiple tier water saving basins can save up to 60% of the water required to operate the navigation lock without the water savings basin. The need for introducing water savings basins arises from the ever increasing scarcity of the water available to many navigation systems with locks.

On the Panama Canal, the number of transits has been stagnant since 1967 because of limited water. The ACP has successfully increased the Canal’s capacity by significantly increasing the size of the average ship. Presently, the growing population has placed additional demands on the available water, increasing the urgency to develop new water sources to sustain the current water supply to the Canal.

The purpose here is to modify navigation lock design such that the source of energy used to lift the boats in the navigation lock is electricity instead of the hydraulic energy obtained from adding more water to the navigation lock. The use of electricity taps an endless supply of energy allowing unrestricted use of the navigation lock. Hydraulic energy is the potential energy of the water. The benefit of this innovation is proportional to the scarcity of water where the navigation lock operates.

The nature of the proposed modification to navigation lock design is the inclusion of a device that will transform electrical energy to hydraulic energy. This device would be part of new lock design but it should also be possible to incorporate it as a“retrofit” to existing locks. The addition of such a device to the Panama Canal would allow the number of transits in the Canal to increase without compromising the Canal Authority’s role as custodian of Panama principal source of potable water.

According to the first law of Thermodynamics, described first by Rudolf Clausius and William Rankine in 1850, energy is transformed, not created or destroyed; we propose a device that transforms electrical energy to hydraulic energy for the purpose of operating a navigation lock.

The device proposed to transform electrical energy into hydraulic energy is named the AIR LOCK. The AIR LOCK for the Panama Canal is an accordion, 3.50 m. square, that extends 9.00 m. high. The accordion is made of steel and plastic, it is extended with a hydraulic cylinder positioned at the center. The AIR LOCK has the power to raise the water level in the lock chamber in 15 minutes.

How to raise the water level in the lock chamber without adding water? According to Archimides principle, 250 BC, introducing a solid at the bottom of the lock, will raise the water level in the lock as the solid displaces the water. Conversely, the water level is reduced when the solid is removed.

The AIR LOCK is an accordion like device on the bottom of the chamber floor, connected to the atmosphere, that fills with air at ambient pressure, as it is expanded by a central hydraulic piston to form the solid that displaces the water. The AIR LOCK, in a closed position, is flush with lock chamber floor, in an open position, the accordion is fully extended.

The hydraulic piston is the technology with sufficient power to expand the accordion of the AIR LOCK in a few minutes. According to Pascal's law, 1648, the force applied by a hydraulic piston is directly proportional to the pressure of the fluid. The operating pressure of the fluid in hydraulic pistons can be 100 times greater than ambient pressure. The volume of the fluid used to exert force is reduced proportionally to the pressure difference, namely 100 times. Therefore the power requirement can be met with 100 times less fluid compared to pumping water at ambient pressure. Hydraulic power systems include power accumulators that further reduce the hydraulic pump's power requirements.

The pumps of the hydraulic pistons of the AIR LOCK are powered by electricity. They develop the power to raise the water level in navigation locks, not with water but with hydraulic fluid at high pressure. The high pressure is distributed through the accordion to displace the water.

The Air Lock achieves its design goal, not a single large complex device but as multiple small devices that operate simultaneously to displace the water in the lock. View the AIR LOCK as tiles on the chamber floor of a navigation lock, the fraction of the floor that is covered corresponds fraction of water saved.

This paper presents the design of the installation of the AIR LOCK as a "retrofit" on the original Panama Canal locks to describe its features. In this design, the existing hydraulic system is not compromised. The initial investment for a fully operational pilot system only needs to address a one unit for each lock chamber. The use of a single unit will save 110.25 m3 or 29,120.

21. Design of a lock to reduce salt intrusion in the Vilaine estuary

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The Vilaine estuary is located in South Brittany, along the French West coast. The river has a flow discharge ranging between 2 and 1500 m3/s. Arzal dam is located eight kilometers upstream from the mouth of the Vilaine in the Atlantic Ocean. It is primarily intended to regulate the flow of the Vilaine and provide drinking water during the tourist season. This is one of the rare estuarine dams in the world.

The “Institution d’Aménagement de la Vilaine” (public organization created to carry out the necessary structural adjustments) has initiated design studies for the construction of a second lock at the Arzal dam. This lock must fulfil different and sometimes even contradictory set of functional objectives (protection against floods, drinking water reservoir, river navigation, road crossing, fish crossing, hunting ...). Among these, maintaining and preserving a water resource for the production of drinking water is the major objective of the project. Currently, desalination is carried out by a siphon system which pumps the brackish water in a pit located upstream the dam and evacuates water further downstream. This system is highly water consuming and poses problems especially during the summer. The solution proposed by Artelia and its partners consists essentially of reducing very considerably the quantities of sea salt that enter the reservoir at each lock operation. The tests on the 3D model showed that this abatement can be obtained at the price of a substitution of the brackish waters contained in the lock by fresh water taken from the reservoir before the opening of the upstream doors. The effectiveness of this substitution was tested on a physical model of the new lock, which confirms this and refine the design and operating rules of the lock. A 3D numerical model has also ensured that the impact of the device will be large enough so that salinity problems in the reservoir are fully resolved. The substitution of brackish water by fresh water in the lock is fundamental for the proper functioning of the new lock. A withdrawal of the brackish waters combined with an introduction of fresh water in the upper part makes it possible, by minimizing the mixtures between the two waters thanks to the difference of density, to rapidly lower the salinity present in the lock. The physical model at scale 1/12 allowed assessing the lock water supply system, the duration of the lock chamber emptying, the crest level setting of the outlet ports, the curves of decay of the salinity in the lock as a function of time. The model also assessed the impact of door opening on freshwater and brackish water trapped below the upstream lock’s threshold.

The numerical model of the whole reservoir upstream of the dam allowed evaluating the impact of the new lock on the saline intrusion. The 3D model in place allows to analyze all the processes and to test different configurations of operation of the structures.

22. Bahia Blanca 2040 Master Plan, flexible planning for waterways

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Up-to-date development of the Bahia Blanca Estuary and region was tied to the improvement of the access channel to the main Ports located in the innermost section. Since the late 19th century the Ports constituted one of the main gates to distribute the agricultural produce of a vast region to the world markets. This fact, made the Ports of Bahía Blanca one of the most important in Argentina, which lead to becoming one of the nation's railway and road hubs.

As the traffic and size of bulk carriers grew, it became apparent that the waterway needed to be adapted. Being the State the owner of the ports and responsible for the waterways, this premise was not adequately fulfilled.

It was not until late 1980's that the State decided to make Bahía Blanca the deep-water port of the Nation, thus conducting dredging and expansion of its waterways, allowing ships of up to 45 feet draft to sail using the considerable tide window available. Later on in the early 90's, as a result of a change in policy, Bahia Blanca became the first Self-administered Port in Argentina. This provided the possibility to plan and invest directly on the port system the revenues generated by the Port itself. This circumstance leads to a considerable improvement of the facilities and services, which in time promoted the arrival of new terminals and industries to the region.

Since then, the Consorcio de Gestión del Puerto de Bahía Blanca (CGPBB) has pursued the goal of being the Country's most important deep-water port, keeping up to international standards regarding services and Aids to Navigations.

A great portion of the revenues have been applied to the maintenance of its waterways, since it is located in an area subject to constant siltation. Today dredging represents roughly some 60% of the total budget. It becomes paramount to make a comprehensive planning of the waterways to promote adequate depth and sizes for the current fleet, thus lowering dredging volumes.

In 2017 the CGPBB has taken a big step in Port Planning. For the first time in its history it has undergone, with the help and supervision of Port Consultants of Rotterdam, a thorough process of devising a Plan looking at 2040. This Plan is the result of a comprehensive data collection, interviews and analysis considering not only the CGPBB perspective, but also the points of view of all the parties involved in the Port's activities. It also included the local population of Ingeniero White, a city adjacent to the port area, the Provincial Environmental Agency and local Environment NGOs, Universities and the Local Oceanographic Research Centre.

This work lead to the definition by the terminal operator's needs, according to their perspective, in relation to the deepening of the waterways to cope with future vessels to be received at the port. This means a change of paradigm, were the actual waterways will be defined by the needs of its users, as opposed to what was done up to now where the users were limited to make the best of what the State (and after the CGPBB) offered in terms of size.

This change will lead to a more flexible channel design, where the actual size of the waterways will be the required at the time by its users. As a result, the dredging volumes will be the required to maintain the used depth, thus proving more sustainable both economically and environmentally. Obviously, the CGPBB must keep constant updates on the possible vessels to call on Bahia Blanca to predict with due time (at least a couple of years in advance) the needs for modifying the design.

Working in close cooperation with all the stake holders, keeping constant updates of the needs of the users will allow to fulfil the Vision set for by 2040: “to become one of the most important deep-water ports not only of Argentina but also of the region in terms of cargo handled”. Achieving this also in a more sustainable way.

23. Marinas Working with Nature [WG 148] : The PIANC Philosophy and Experience in Latin America and the Caribbean

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The Working with Nature philosophy is a general approach proposed by PIANC for a broad range of types of projects. This paper discusses an interpretation of the WwN principles specifically applied to recreational navigation infrastructure, which have been presented elsewhere and will be considered for inclusion in the re-launch of PIANC WG 148.

This presentation intends to show how WwN provides a simple framework that - if used adequately - can facilitate the timely consideration of environmental and social issues to achieve sustainable and resilient design of recreational navigation infrastructure.

Selected marina projects in Latin America and the Caribbean illustrate that these principles or design tools have been proposed or implemented in the region in the past. This review unveils practical recommendations for marina design based on the WwN principles, which are based on demonstrating the added value to the project. It further demonstrates that the proposed approach is viable in the region.

Sustainable marina design is seen with scepticism by some and implemented poorly by others. But this framework, along with the systematic use of best practices in marina design and cross-pollination of broad international experience, can lead to sustainable marinas.

24. Working with Nature – Case Study Fehmarn Belt Link

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Introduction

A new 18.5 km long fixed link for rail and road traffic between Denmark and Germany across the Fehmarnbelt is being planned to improve connectivity between Scandinavia and Central Europe. This link will connect Puttgarden on the island of Fehmarn in Germany and Rødbyhavn at the Danish island Lolland. The new link will result in a more energy efficient transport system, as the route is 160 km shorter for railway freight transports compared to the existing route Hamburg – Jutland – Copenhagen.

The Project and the Vision

The immersed tunnel was selected as the preferred solution among others although it requires extensive dredging works for the tunnel trench and associated structures. This chosen solution has a number of benefits and opportunities such as:

- The immersed tunnel has no permanent impacts on birds and harbour porpoise, which use the belt as migration path, transport corridor or as a feeding ground
- The immersed tunnel will have no permanent impacts on the marine environment as there are no permanent changes to the seabed, nor to currents, which could have unintended consequences on water exchange
- Dredging for an immersed tunnel will produce up to 19 million m3 surplus sediment and this provides an opportunity to create re-establish areas with new habitats and landscapes for wildlife and recreational use. Some of these environmental values were lost during the construction of major dikes and reclamation works in the early 20th century
- The tunnel will not present a risk of ship obstruction and collision in the heavily travelled area with app. 80.000 ships pr. year

The re-use of the surplus material from dredging of the tunnel trench will allow for the redevelopment of the coastal landscape primarily on the Danish side, with the following features:

- Artificial beaches. Two artificial beaches are planned on the Danish side. The beaches are designed in their equilibrium orientation by fixed structures. On German side, a minor land reclamation is planed with one beach
- An artificial lagoon with two fixed openings east of the tunnel portal is planned. The lagoon includes wetlands, a major recreational island and a small sea bird island. The vegetation in the nature and wetland areas will be allowed to develop naturally, which will enhance the biodiversity of this environment
- Protected areas. A rubble mound seawall and rubble mound revetments will protect the proposed landing of the tunnel. The structures are designed to minimize the visual impacts of the tunnel portal

- Cliffs. The reclaimed area east of the reclamation area on the Danish side will be filled to produce a “natural” cliff and the eroded sand will be transported eastward by the predominant littoral transport and helps stabilizing the beaches
- Reef - 25 ha hard bottom will be re-established after natural reefs were exploited through stone fishing

Conclusions

The Fehmarnbelt Fixed Link project is an outstanding example for the application of the Working with Nature principles for large infrastructure projects. The re-development of the coastal landscape was identified as win-win opportunity that involved extensive stakeholder involvement, survey campaigns to understand the surrounding nature and environment, and an innovative design basis that fed back into the consultation process to identify the option that met the project objectives and visions.

The Working with Nature findings of this project can be summarised as follows:

- Fitting the fixed link into the physical /rural situation on both sides of the Fehmarnbelt with a minimum of disturbance of the landscape
- Create new nature and leisure areas using 19 million m3 surplus sediment for land reclamation
- Create beaches and lagoon area with associated facilities for the benefit of tourism and locals
- Create new artificial reefs with stones, that can establish new habitats for fish, birds and marine mammals and thereby enhancing biodiversity
- Formerly lost landscape and nature areas re-established

The project represents a win- win situation achieved through a detailed assessment of the environment, innovative design and extensive stakeholder engagement.

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25. Remote Controlled Marine Security of Locks

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Luc Boisclair

St. Lawrence Seaway Management Corporation, Canada

This presentation will be of interest and benefit as it provides insight into a working implementation of remote controlled, state-of-the-art security access control and intrusion detection of locks and bridges in an inland waterway system.

In 2008, when the ISPS code in Canada was implemented, the physical security of the Seaway's Canadian locks and bridges was improved. From 2013 to 2017, all of our locks were equipped with vacuum mooring technology, subsequently allowing for remote control of these same locks.

In 2015, while implementing remote control of the locks machinery, the increased level of marine security threat required even more security safeguards. The goals were to better protect against unauthorized access, have increased control of who was accessing our facilities and vessels, and also improve the continuous monitoring of those facilities. With our on-site staff being reassigned to remote operations control centers and therefore no longer available to personally monitor the locks, these goals could no longer be achieved.

For vehicles, access control points with dual motorized gates were installed, where cameras are used to perform vehicle inspections. Pedestrian identification reporting stations have also been established where persons requiring access (pilots, service to vessels providers, mariners, lock maintenance personnel, etc.) can get their identification and credentials validated using video and intercom technology prior to entering through a controlled access turnstile. Furthermore, non-automated access points are monitored through the use of an electronic key control system. Continuous monitoring is performed using thermal imagery cameras with intrusion detection video analytic software. This has been a challenging application to design and configure as the intrusion detection system has to cope with several moving targets in an outdoor environment such as movement of ships, movement of lock equipment, public vehicles, nearby pedestrians, wildlife, etc. The thermal imagery intrusion detection is also complemented by break beams, motion detectors and conventional building intrusion detection hardware.

This project also involved a significant upgrade to our telecommunication and computing infrastructure. Local and inter-city network connections had to be improved for both bandwidth and latency to support all video, audio and control feeds. Additionally, we integrated the new security technologies within our cyber security; all central controls and networking cabinets are now physically protected and form part of the restricted area. Two form authentications for operator stations have also been implemented. Our security system software, along with our video control software are now running from a fault-tolerant physically distributed virtual computing environment.

In conclusion, access control and security incident response has now been fully integrated into the canal operators' roles. Remote controlled security protocols are being effectively applied without the need for a dedicated security department. Furthermore, this provides vessels with a more secure passage in our inland waterway system while also achieving our staffing optimization goals.

26. Ship Handling Simulation in Approach Channel and Harbour Design.

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For more than three decades now ship handling simulators are involved in the design process when it comes to build new harbours or to extend existing waterways and approach channels. In this time period not only the experience with applying the tool shiphandling simulator has grown, but the technology and capabilities of the simulators themselves have improved and developed tremendously. As a consequence, today the ship handling simulator (SHS) is the preferred tool if a determination of the navigability is required.

The main advantages are in the absence of any scale effect and the realistic interaction between the nautical personal involved and the scenario to be investigated; made possible by real instrumentation and consoles in the simulator's full mission bridge equipment and appealing display of the environment. This strength is at the same time part of the weakness of this approach: the apparent reality is generally not backed by the underlying numerical models, which are not of a similar precision and the reflection one to one to what happens in nature requires careful adjustment of the simulator's behaviour. The art of high fidelity simulation for navigability checking or harbour layout testing is reached by knowing the model's details and use them appropriate to gain the most realistic and reliable result of a simulation with a SHS.

The presentation will provide an overview on the technical development of Shiphandling Simulators and the state of the art available today. This will be followed by a discussion of successful application of SHS to solve nautical problems in approach channels and harbours. The presentation will close with recommendations on future developments on SHS-technology and on the adequate application of SHS for design checking of approach channels and harbour layouts.

The gist of this contribution is to spread generally a deeper understanding of SHS and what can be expected from this valuable tool as well as where careful application is required and where its application may become misleading or may even fail.

27. Reengineering valve opening law to optimise lock levelling: some case studies

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The hydraulic design of a lock levelling has to fulfil several criteria like: (1) short levelling duration; (2) acceptable mooring forces; (3) limited levelling wave amplitude. Usually, reducing the levelling time increases the forces acting on the vessels. In some cases, modifying the design of the levelling culverts enables shorter levelling time, through e.g. longitudinally distributed or even through equal distribution filling systems. This increased culvert complexity may nevertheless impact the building cost of the lock. The hydraulic design usually results in an optimised design of the levelling culverts and a proposed schedule for opening the valves. During lock commissioning, the valve opening laws are implemented, tested and validated.

Then, during the lifetime of the lock, it is often observed that the valve opening schedule evolves. During maintenance or replacement of electro-mechanical parts, performances and settings are not always perfectly replicated. Some technicians may adapt or tune the schedule, without refereeing to the hydraulic design team. In some cases, the reports from the original design are forgotten or even lost. As a result, the lock does not work anymore optimally.

In the last years, the Hydraulic Research Laboratory of the Service Public de Wallonie has been involved in some reengineering studies for such locks on the Walloon waterways network, Belgium. The report from these case studies will illustrate how an abnormal working process can become standard operation, and how reengineering can restore lock performances.

The contribution of field measurement will also be highlighted, in the absence of extensive documentation. A first case study covers the locks of Havré (124m x 12.5m x H 10m) on the Canal du Centre; Pommeroeul (151.75m x 12.5m x H 13.5m) and Hensies (149m x 12.5m x H4.6m) on the Canal Pommeroeul-Condé. The electro-mechanical equipment of these locks will be totally replaced in the next two years. Only partial documentation on the valve opening schedules could be recovered. Field measurements showed that the valve schedules have been significantly modified since the lock commissioning. Notably, the valves on both sides of the locks were no more synchronised. This resulted in a significantly increased levelling time.

Re-computing the filling and emptying of Havré and Pommeroeul locks with modern simulation tools also highlighted some weaknesses of the initial design. Their culverts were designed as equal distribution systems through the lock floor. It appears that the head loss distribution along the culvert components does not ensure this equal distribution of the discharge. Additionally, the valve diameter seems too large.

Therefore, a constant opening rate does not ensure a proper filling: the opening is either too slow, with excessive levelling duration; either too fast, with excessive discharge around mid-opening. A complex opening schedule with different opening rates was eventually necessary to fulfil all acceptance criteria. The second case study covers three old locks (42m x 5.15m x H 1.8 .. 2.7m) on the Canal de l'Espierres. Local staff complained about poor levelling conditions: too long valve opening schedule during filling, and too large water movement in the lock chamber during emptying.

These lock are equipped with grid type valves with a very short stroke (150mm). When manual opening gears were replaced by hydraulic jacks, the opening rates of the latter was probably chosen too fast (25mm/s). An accurate control of the valve opening and of the levelling process is therefore difficult. Nevertheless, re-computing the filling and emptying process enabled to propose more adequate valve schedules.

28. River Information Services (RIS) in Germany

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River Information Services (RIS) in Germany

Since the first initiatives of the European Commission on River Information Services, this framework on information exchange to support traffic and transport management in inland navigation, has found its way throughout the world.

The PIANC RIS Guidelines are the basis for the RIS Guidelines as formally accepted by the Central Commission for Navigation of the Rhine (CCNR) and the European Commission. The CCNR has been supporting the development of the technical standards to this day. Since 2005 the development of the technical aspects of River Information Services has been regulated by the European Commission.

River information Services were formally recognised as a concept for harmonised information services to support traffic and transport management in inland navigation, including interfaces to other transport modes.

The added value of River Information Services has found recognition throughout the world.

The standards of Inland ECDIS, Electronical Ship Reporting, Vessel Tracking and Tracing and Notices to skippers were published and the expert groups have been working on them to improve them and to develop new aspects.

Traffic and transport management in a transport corridor requires an integrated network-approach where the information services to the users are an interactive part of voyage and traffic planning processes. RIS enabled corridor management as support to transport management is becoming more and more an essential and explicit part of RIS.

The last years were very busy. So it is interesting to give a report of the status of RIS in Germany, what happened in the last years, what is on-going and which strategy is followed concerning RIS in the future.

Our presentation will give an overview of the actual RIS projects and our future strategy:

- Implementation of AIS at the main waterways of the German inland waterway network and examples of the use of Inland AIS on board at vessels as well as shore
- Pilot lock management and implementation at the main waterways
- Information exchange in an international network (further development reporting software, data-pool)
- ELWIS (Electronic Waterway Information Service) the internet-based fairway information portal of the German Waterways and Shipping Administration
- Prospects for the near future

Implementation of AIS infrastructure

Following the developments in maritime navigation Europe developed the so called Inland AIS which serves the specific needs for inland navigation while preserving interoperability with maritime AIS. European waterway and shipping agencies in close cooperation with the river commissions are now preparing the mandatory carriage requirement for Inland AIS on European inland waterways or have already introduced the appropriate regulations in their waterways.

Since December 2017 the use of Inland AIS and Inland ECDIS is mandatory for all waterways of class IV and above as well as for selected waterways of class III. This onboard equipment enables the mutual recognition, identification and display of nearby vessels and their course on an electronic navigational chart. The use of these systems will support onboard navigation and will diminish the risk of accidents; thus, it will enhance safety and ease of navigation and will contribute to the efficiency and attractiveness of inland navigation.

In recent years, the Federal Waterways and Shipping Administration has set up additional shore-based AIS infrastructure along selected waterways. Today, a total of 3570 km of federal inland waterways are covered by shore-based AIS infrastructure.

In parallel with physically setting up infrastructure, the legislation procedure to adopt the legal basis for processing AIS data was initiated. The legal basis will enter into force shortly with the adoption of the 3rd amendment to the Inland Shipping (Federal Competences) Act.

Pilot lock management and implementation on the main waterways

To ensure a speedy lock operation, the locking operations should be optimized by minimizing the waiting time for vessels. Therefore it is a necessity to have e.g. an overview about the position of vessels and their sailing directions. Starting from the question of an optimal sequence for a special lock on e.g. the Danube, this question should be expanded to a chain of locks on the Danube. An existing electronic transport diary is intended to be further developed. The aim of this project is to develop a new concept for lock management with an electronic traffic diary using the inland AIS equipment and perform the testing and implementation of the Danube by the middle of 2017. This pilot should be applied to all other locks on federal inland waterways after its validation.

Information exchange in an international network

As part of the modernization of the existing reporting and information system MIB II+ for inland navigation an expandable modular application should be developed to support the calamity abatement which should be used on all inland waterways in Germany. This requires the development of a common data pool for all RIS applications on inland waterways in framework of a so-called “System-Binnen-Verkehrstechnik (SBV)”. The first RIS applications which will use this central data pool are the application to support the calamity abatement and lock management.

ELWIS (Electronic Waterway Information Service)

ELWIS (Electronic Waterway Information Service) has been the internet-based fairway information portal of the German Waterways and Shipping Administration since 1999. Back then, the service was designed to provide traffic-related information to skippers sailing on inland waterways in order to enhance safety and ease of inland navigation and to support voyage planning.

Since 2011, several improvements have been implemented.

Prospects for the near future

Currently, project work is ongoing to develop a successor to today's reporting and information system, known as MIB and MIB II+.

Particular attention will have to be paid to the efficient use of data. A European RIS concept and a RIS Masterplan will be designed and implemented within the RIS COMEX project in accordance with the specific needs of waterway corridor sections.

29. Engineering With Nature for Sustainable Development of Water Resources Infrastructure

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The development and operation of navigation and coastal infrastructure systems are increasingly challenged by the combined influence of weather events, climate, sea level rise, human development, and a range of environmental pressures. This reality has motivated efforts to find ways to more effectively and efficiently integrate natural systems and infrastructure systems to produce desired functions and services. Such efforts support the goal of more sustainable infrastructure that is developed and operated to produce a balanced range of economic, social and environmental benefits.

In 2010, the United States Army Corps of Engineers (USACE) began its Engineering With Nature (EWN) initiative with the purpose of promoting the intentional alignment of natural and engineering processes to efficiently and sustainably deliver economic, environmental and social benefits through collaboration:
(www.engineeringwithnature.org). The EWN initiative includes a combination of communication, research and development, and demonstration activities that are organized to promote four key elements in infrastructure development and operations: 1) using science and engineering to produce operational efficiencies; 2) applying natural systems and processes to maximum benefit; 3) broadening and extending the benefits provided by projects to include economic, social, and environmental benefits; and 4) employing science-based collaboration to engage, organize and focus interests, stakeholders, and partners.

Through its various activities and projects, the EWN initiative has put an emphasis on innovative teaming and field-demonstration projects as a means of developing and illustrating EWN principles and practices. By drawing together project team members from research and development, field practitioners, project owners, multiple government and private organizations, and academia, we are able to combine the creativity and capability needed to successfully align natural and engineering processes in order to engineer with nature. More than a dozen EWN demonstration projects have been initiated across the United States since 2010 (www.engineeringwithnature.org). These projects are being used to illustrate advancing practice, including in the areas of: 1) sustainable sediment management; 2) engineering with natural materials and plants, and 4) the use of natural systems to support resilience. Three USACE Districts (Galveston, Buffalo, and Philadelphia) have taken on roles as EWN Proving Grounds as a way of transitioning advancements in practice into field implementation. These three Districts have committed themselves to applying EWN principles and practices across their portfolio of programs and projects as a means of pursuing sustainable infrastructure development.

This paper will describe the network of projects have been implemented by the EWN Proving Grounds and others across the USACE as a means of demonstrating the opportunity to innovate to achieve more effective and efficient integration of natural and infrastructure systems. These example projects will include: 1) innovative beneficial uses of dredged material that create natural and engineering value, 2) the operation of navigation infrastructure to enhance ecosystem function, 3) the incorporation of habitat value into existing navigation

infrastructure, and 4) the development international guidelines for using natural and nature-based features (NNBF) to enhance coastal and fluvial flood risk reduction and resilience.

NNBF present a particularly important opportunity for the navigation sector because of the influence that navigation infrastructure can have on coastal and fluvial ecosystems, the vulnerability of navigation infrastructure to storms and other natural processes, and the opportunities the navigation sector has to develop projects that produce economic, social and environmental benefits. Nature-based features take a variety of forms, including reefs (e.g., coral and oyster), islands, dunes, beaches, wetlands, and maritime/riparian forests. The relationships and interactions among NNBF and the built infrastructure comprising coastal and fluvial system are important variables determining vulnerability, reliability, risk, and resilience. Nature-based features can support a range of processes, including erosion control and storm risk reduction (e.g., reefs, islands, wetlands), while protecting the economic and social functions provided by navigation channels and ports. A comprehensive approach to navigation infrastructure resilience will seek to integrate nature-based and convention structures to achieve long-term sustainable solutions.

Knowledge about the performance of EWN solutions varies, as do the methods to calculate and measure the performance of infrastructure systems generally. For example, the dynamic behavior and response of NNBF to storms can affect their future performance. Moreover, it is important to design nature-based features in such a way that they will establish and/or re-establish natural processes that will support the adaptive capacity and long-term sustainability of the features. A combination of research and field-scale demonstration projects will help support the innovation needed to engineer with nature for more sustainable infrastructure systems.

30. U.S. Waterways: Toward a More Formal Classification in Support of Navigation

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The United States (U.S.) boasts 12,380 miles of coastline**[1]** including 25,000 miles of commercially navigable channels**[2]** and 239 locks at 193 locations.**[3]** Within the geographic vastness of the U.S., resides eleven domestic and transboundary large basins: Great Lakes Seaway System; Ohio River Basin; Delaware River Basin; Illinois River; Kentucky River; Mississippi River Basin; Missouri River Basin; Columbia River Basin; Gulf Intracoastal Waterway; Atlantic Intracoastal Waterway; and the Tennessee-Tombigbee System.

While the classification of European inland waterways is a set of standards for interoperability of large navigable waterways, the United States classifies waterways in a more piecemeal fashion. There is no broad, overarching classification in the United States for navigation. This paper will present a brief history of U.S. waterways governance and jurisdictions to pose the question about the need for a classification of navigable waters.

A definition of waters of the United States as it relates to the U.S. Army Corps of Engineers (USACE) can be found under Title 33, Part 328 of the Federal Code of Regulations (CFR) to include all waters which are “currently used, were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters subject to ebb and flow of the tide.”**[4]** Title 33, Part 207 of the CFR provides procedural directives to the USACE in a range of operational areas including navigation regulations, flood control, drinking water, removal of wrecks, aquatic plant control, permitting, and the like. Interestingly, Part 329.4 also provides a definition of “navigable waters of the United States” almost identical to that under Part 328, except to also add that “a determination of navigability, once made, applies laterally over the entire surface of the waterbody, and is not extinguished by later actions or events which impede or destroy navigable capacity.” **[5]**

U.S. Coast Guard regulations under Title 33, Section 2.26, defines inland waters to mean the waters shoreward of the territorial sea baseline. Coast Guard regulations also define waters for territorial seas, internal waters, contiguous zone, exclusive economic zone, and high seas. Definitions are often related to boundaries and jurisdictions, particularly with respect to wetland and stream connectivity. For example, the Clean Water Act (CWA) was enacted in 1972 to “restore and maintain the chemical, physical and biological integrity of our nation’s waters. The term “navigable waters of the U.S.” was derived from the Rivers and Harbors Act of 1899 to identify waters that were involved in interstate commerce and designated as federally protected waters. Since then, court cases have further defined navigable waters to include waters that are not traditionally navigable. **[6]** A jurisdiction designation can directly impact permitting requirements and associated challenges, hence its heightened importance.

The National Wild and Scenic Rivers Act of 1968 sought to preserve certain rivers with outstanding natural, cultural, and recreational values in a free-flowing condition for the enjoyment of present and future generations. The goal was to safeguard the special character of a river, while recognizing the potential for appropriate use and development as well as encouraging river management across political boundaries. Rivers are “classified” as wild,

scenic or recreational but do not provide a commercial navigation perspective. Rather, the goal is to balance the location of dams and development against natural, free flowing river aspects.**[7]**

In summary, jurisdiction over navigable waters – generally – belongs to the federal government rather than states or municipalities. The federal government can determine how the waters are used, by whom, and under what conditions and, again generally, has the power to alter the waters, such as by dredging or building dams. While in practice, these actions can impact the navigability of a waterway, it does not provide an overarching operational classification between large basins similar to the interconnected classification of waterways in Europe, except to the extent of describing the minimum depth requirements on the inland system versus coastal, "deep-draft" systems. The question, then, is if a more-broad, yet formal operational classification would be of benefit in U.S. waters. Or, is the United States too far down the regulatory road – particularly since the governance, itself, is different between the 11 large basins?

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31. The safe use of cylindrical fenders on LNG, Oil and Container Terminals

020

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The PIANC 'Guidelines for the design of fender systems' MarCom report of WG 33 – 2002 (short WG33) contains a table (4.4.1) with recommended maximum hull pressures on various vessels. Fender manufactures provide maximum hull pressures of their fenders. The stated maximum hull pressures of cylindrical fenders do not match the recommend values by WG33 for gas carriers, oil tankers or container vessels. However, cylindrical fenders are in use for over 25 years in Northwestern Europe on major container terminals without any complaints by masters, ship owners, pilots or any other stake holder.

In the Hamburg – Le Havre range only the Port of Rotterdam Authority had, mid eighties, these fenders (Delta Terminal) checked against the old fender guidelines. After WG33 release all new projects are designed with panels with cone fenders or similar.

The maintenance department of the Port of Rotterdam has very bad experience with panel fenders as recently applied at the new container terminals and very positive experience with the 'old' cylindrical fenders.

The positive user experience with cylinders and the negative maintenance experience with panels lead to plans with cylindrical fenders on a LNG berth and on 6 oil berths. As these cylindrical fenders do not match WG33 recommendations, the actual ship-fender interaction was investigated by FEM calculations. The out come of these FEM calculations is that cylindrical fenders can safely be used for both LNG and Oil tankers.

This paper explains the recent FEM calculations and the old calculations for the Delta Terminal and proves that cylindrical fenders can be used safely on all major berths in all ports and that table 4.4.1 in WG33 needs to be updated.

32. Bollard Loads on New Port Infrastructure, Port of Rotterdam Authority Policy

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Mooring of vessels is very important for safe and efficient cargo handling of ships in ports, just as safe infrastructure is important. Civil Engineers and Mariners used to have a different approach for the same problem: what should be the safe working load (SWL) of a bollard. Mariners use the Minimum Breaking Load (MBL) of their mooring lines to determine the desired Safe Working Load (SWL) of the bollard, civil engineers are used to use design tables from international standards or guidelines with a relation between displacement of the vessel and bollard loads. There is a big gap between these two approaches, especially concerning the mooring of large container vessels.

Both disciplines meet each other in dynamic mooring analysis (DMA), a computer calculation that calculates the vessel motions and resulting maximum loads in the mooring lines resulting from wind, wave (sea, swell), current and passing vessel forces acting on the moored vessel. As a DMA is a rather complex calculation, a DMA is not carried out for every project and usually not in a preliminary design stage.

This position paper describes a design approach for bollard loads that is understandable and acceptable for all involved disciplines and that is used by the Port of Rotterdam Authority for new builds.

33. Mitigation of Salinity Intrusion Due to Tidal Pumping in a Texas Coastal Salt Marsh

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The Salt Bayou Marsh is a historically fresh to brackish water marsh located in Southeast Texas. It is connected to the Sabine-Neches Waterway (and hence to the Gulf of Mexico) via a dredged canal: the Keith Lake Fish Pass. The Fish Pass serves as an important migratory pathway for larval fish species that require the shelter of the marsh to mature in safety. However, the Fish Pass is also a conduit for salinity intrusion, via tidal pumping, which degrades the wetland substrate and promotes land loss. This presentation details the results of a numerical model study that was conducted to select an effective salinity mitigation structure to be constructed in the Keith Lake Fish Pass. The selected structure was analyzed for impacts to several factors, including salinity, velocities, larval fish recruitment, and flooding. The structure was constructed in 2015, and some initial analyses of the effects of the structure are included in the discussion.

34. Challenges and Considerations in Selection, Anchorage Design, and Installation of Quick-Release Mooring Hooks on Existing Structures

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Quick release mooring hooks have become increasingly popular for use in design of new mooring systems, especially for larger vessels. Hooks offer several operational and safety benefits over the standard bollards or cleats. Such benefits include the abilities to release mooring lines without de-tensioning the lines, release mooring lines remotely from an operator's shack in possible emergency situations, and monitoring of tension in the mooring lines while a vessel is at berth. In addition, mooring hooks are increasingly being required for new installations by local rules or regulations.

Selection, design, and installation of quick release mooring hooks follow a relatively straight forward path when applied in design of new structures. Several institutions and authorities offer codes or guidelines to aid in this process, such as British Standards in the UK, the Marine Oil Terminals Engineering and Maintenance Standards (MOTEMS) in California, or the soon to be released document from PIANC Working Group MarCom 153 "Recommendations for the Design of Marine Oil Terminals".

Quick release mooring hook installations in new design will be in a best practice scenario adhere to a hierarchy of failure modes that attempt to maximize safety and minimize economic impact if the mooring system is overloaded. PIANC Working Group MarCom 153 has identified that the successive modes of failure should be as follows: winch brake tending, mooring line failure, mooring hook failure, mooring structure failure. While the concept is simple for new design, ensuring that the progression of failure adheres to this hierarchy can be difficult when any changes are made to an existing mooring system. These changes can occur at different levels, including change in mooring line strengths or types that are seen at vessels calling at a terminal, upgrades of mooring hardware at a terminal due to regulatory requirements, or upgrade of mooring hardware due to changes of service at a terminal. The question will then arise as to how a possible break in the hierarchy of failure modes can best be handled and at what point in the chain the break should be implemented. In addition, existing marine terminals may have mooring systems and structures that were not designed to these standards, making possible upgrades of the mooring system even more challenging.

This paper will present three case studies that will focus on the challenges and solutions selected for mooring hook installation on existing structures in California. All three cases presented different challenges based on the reason for the upgrades, ranging from voluntary upgrades to installations required by regulatory requirements, the strength of the mooring hook support structures, environmental conditions at the sites, and the size of vessels expected to be calling at the terminals.

The challenges faced started with the selection of appropriate mooring hooks for the installation to satisfy the requirements presented by local regulations. The challenges faced included selection of the number of mooring hooks, the appropriate Safe Working Load (SWL) for the individual hooks and the mooring hook assemblies, as well as the design and selection

of the anchorage system. Further challenges faced included installation of mooring hooks while keeping the terminal open for traffic, both in terms of the order of installation of the hooks as well as methodologies to speed up the installation. Two of the sites were required to install tension monitoring of the mooring hooks. Complications arose when selecting appropriate limits for the mooring line tension monitoring system while simultaneously balancing safe tension limits with ease of operations for the terminal.

In addition, data will be presented from the ongoing monitoring of mooring line tensions after installation of the mooring hooks. The recorded values provide valuable insight into actual mooring line tensions. This paper will show how those values compare to design values as well as tension values obtained from mooring analyses. Cases that exhibit high line tension values will be studied in more detail, including data such as vessel loading condition, wind, and current data.

35. Recommendations for Increased Durability and Service Life Of New Marine Concrete Infrastructure Report of Working Group 162 of the Maritime Navigation Commission

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This proceeding addresses the work done by the PIANC Working Group 162 dedicated to provide recommendations for increased durability and service life of new marine concrete infrastructure.

The durability of concrete structures in the marine environment is not only related to design and materials but also to construction.

As a basis for the durability design and production of new major concrete infrastructure, all minimum requirements in existing concrete codes and standards as well as all established recommendations and guidelines for good construction practice must be strictly followed.

In recent years, many owners of existing concrete infrastructure have experienced a significant and rapidly increasing proportion of their limited construction budgets being spent on repairs and maintenance of the structures many owners are showing an increasing interest to invest somewhat more at the outset of their new projects in order to obtain a better controlled and enhanced durability of the structures.

A better durability design and quality assurance for new concrete infrastructure can be achieved, and documentation of as-built construction quality and compliance with the durability specification can be obtained.

In the report, some additional recommendations and guidelines to existing concrete standards for durability and service life are provided, the objective of which has been to obtain a better controlled and enhanced durability of new marine concrete infrastructure beyond what is possible when based only on existing concrete standards. This guidance is given with emphasis upon durability design and quality assurance as well as condition assessment and preventive maintenance during the operational life of the structures.

36. Transportation Infrastructure and Cargo Logistics Master Plan for the Interoceanic Zone Of The Panama Canal (Pm-Zic)

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The Transportation Infrastructure and Cargo Logistics Master Plan for the Interoceanic Zone of the Panama Canal is the first integrated transportation infrastructure and cargo logistics planning effort in the country commission by the Panama Canal Authority. The need for this master plan was identified in 2015 ´by the Logistics Cabinet´s Infrastructure Committee, which is a part of the Logistics and Competitiveness Secretariat of the Ministry of the Presidency.

This committee is currently headed by the Panama Canal Authority and is composed of public institutions and logistics representatives from the private sector. The document was developed through a consultancy project and in close collaboration with the National Logistics Strategy, led by the Logistics Cabinet.

The objective of this Master Plan is to generate long-term, sustainable conditions for the development of Panama as a global logistics hub, by determining priorities for investment in freight infrastructure in order to provide better integration, optimizing the existing infrastructure and generating opportunities to capture new cargo segments with appropriate value-added logistic services, and ensuring the preservation of environmental resources and public and urban spaces within the Interoceanic Zone of the Panama Canal.

Through interinstitutional consultation, relevant databases were obtained from various national agencies, as well as relevant information from project developers and stakeholders within the zone**[1]** During the formulation, the study was continuously validated through four workshops, a focus group, direct and indirect interviews, and field surveys with stakeholders.

The methodology was divided into four stages. The first stage consisted of an assessment of the current condition of the hub, in order to complete a gap analysis. For this, information was gathered from physical and digital inventories, interviews, secondary information and various databases.

The second stage involved the development of a multimodal transportation and logistics model that comprises Panama´s intermodal cargo flows data from 2006-2015. It also includes an Excel costs and time model for the main logistics chains analyzed. This component captures the key elements that comprise the relevant logistics costs associated with the transport of each product segment through the study area on the main transportation modes. The model also includes a market demand module that summarizes the forecast of demand for the major market segments over the time period of the analysis. This analysis is based primarily on the assessment of a base year demand, which is derived from data obtained from each of the modal options.

Demand is organized by product segment, zone of origin and destination. For future forecast years, demand matrices are estimated based on establishing causal relationships between base demand and key “drivers” of demand. Potential drivers include mainly macroeconomic growth rates by country as a qualitative assessment of potential cargo flow patterns through the region. IHS and CEPAL**[2]** projections for containerized and vehicle imports and exports

for Latin America were some of the sources used for the short term, unrestricted transshipment forecast. For the long-term forecast, GDP was used as a base, utilizing IHS projections for elasticity. A combined analysis was applied in order to evaluate three potential scenarios for cargo flows within the hub. This allowed the identification of future transportation infrastructure needs, as well as the actions required to attract potential market segments that could benefit from VALS (Value Added Logistics Services). Finally, this analysis, along with the benchmarking of seven international logistics hubs, were utilized to establish five strategies, based on international best practices, that support the action plan.

Along with the action plans, an inter-institutional cooperation scheme analysis based on international case studies and local consultation aided in the development of proposals for inter-institutional cooperation schemes at a strategic and operational level. Legal, institutional and financial mechanisms are presented to streamline the execution of mega-infrastructure projects and aid the development of VALS in new logistic segments.

This national integrated initiative provides defined actions for the short, medium and long-term planning of transportation infrastructure and logistics. This initiative is based on quantitative and qualitative analyses, with the purpose of meeting future needs of both logistics projects and cargo demand flows by taking a proactive role. The recommendations contained in this study have been included as one of the pillars of Panama´s National Logistics Strategy, recently launched by the Logistics Cabinet.

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[1] Administrative Unit of Reverted properties of the Panama Canal (UABR) was established in 2007 as a replacement for the former Inter-Oceanic Region Authority (ARI). This Unit oversees managing many of the buildings and areas belonging to former US military bases. Ministry of Commerce and Industry, Ministry of Housing, Ministry of Economy and Finance, Tocumen S.A., Maritime Authority of Panama, Colon Free Zone, among others.

[2] IHS and Cepal are private and public information and analyses provider agencies.

37. Decision-support system based on multi criteria analysis for new port location

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The maritime transport is one of the key elements of the international trade and world economy. In spite of the effects of the global financial crisis in 2009, in the last years the sector's post-crisis evolution has showed to keep a tendency to the growth. Considering the ever-increasing demand for new port infrastructures in the areas of economic and social development, the authors introduce an innovative approach based on multi-criteria analysis as a decision support system for selecting a location for a new port.

The methodology proposed is based on the following fundamental elements:

1. A review of the existing port terminals capacity to check the real needs, for the traffic considered, of a new infrastructure. The study takes into account the current capacity of the terminal and its potential capacity in the case of future planned expansion of the infrastructure. Besides, a comparison between the results of capacity obtained and the future tendencies of maritime traffic in the area is performed.
2. An analysis of the coastal system considering both physical and geographical compatibility factors (depth, orography, connectivity, etc). Based on the infrastructure design and engineering, a preliminary study of the coast is carried out checking the physical and geometric compatibility between the infrastructure and the environment. Once the compatible areas are detected, the aspects that are most important in order to build a new port are analysed: road and rail accessibility, existence and proximity of areas of particular environmental interest, maritime climate conditions, suitable deposits (quarry) in the proximity and closeness to urban centres, etc.
3. The application of a two-phase multi-criteria decision-making analysis.

The first phase evaluates the quality of the suitable places in function of physical, geographic and environmental factors. The best score locations are subjected to a second analysis based on socioeconomic criteria that take into account the economic development potential at the regional level. Between the factors considered in this second phase, a very important role is playing by the production of goods and services in the area and by the position with regard to the main axis of the maritime trade system. In both phases, in order to establish the level of importance of each factor considered, a Delphi approach has been used. The methodological development proposed here has been applied to the case of the Spanish Mediterranean seaboard, using a container terminal design for large ship size, according with the evolution of world-wide fleet.

38. Integrated Maritime Operational Planning System

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The Panama Canal Authority (ACP) is an autonomous legal entity of the Republic of Panama, established under public law, Title XIV of the National Constitution with exclusive charge of the operation, administration, management, preservation, maintenance, and modernization of the Canal, as well as its activities and related services, pursuant to legal and constitutional regulations in force, so that the Canal may operate in a safe, continuous, efficient, and profitable manner. The Panama Canal is approximately 80 kilometers long between the Atlantic and Pacific Oceans. This waterway was cut through one of narrowest saddles of the isthmus that joins North and South America. The Canal uses a system of locks -compartments with entrance and exit gates. The locks function as water lifts: they raise vessels from sea level (the Pacific or the Atlantic) to the level of Gatun Lake (26 meters above sea level); vessels then sail the channel through the Continental Divide.

Vessels from all parts of the world transit daily through the Panama Canal. Some 13 to 14 thousand transits are served by the Canal every year. The Panama Canal serves more than 144 maritime routes connecting 160 countries and reaching some 1,700 ports in the world. Today, the Canal is presented with new challenges and opportunities, defined by a sustained increase in international trade which translates into a greater demand for the Panama transit route. With the inauguration of the third-set of locks, we tended to the demand for larger ships to transit the Canal. The information, electronics and telecommunications systems (IT) play an important role in maintaining the service and efficiency levels offered with this increased demand.

To achieve business agility while reliably supporting its current operation, the ACP is renovating its business processes with a design supported by Enterprise Architecture practices. The new information and technology systems landscape the ACP will be able to obtain the agility and flexibility required for maximizing the return on investment on the recently expanded Canal. This business transformation is geared towards the Canal's core maritime business. The ACP's maritime business is supported by:

1. Systems that enable vessel scheduling, traffic control, resource management among other maritime core capabilities;
2. Customer-facing and Business-to-Business (B2B) applications for maritime service requests, booking, billing and customer service;
3. Back-office systems that include finance, human resources and asset management;
4. Smaller departmental applications;
5. Specialized electronic control systems, positioning systems, network and telecommunications infrastructure.

All the customer-facing, B2B, booking and billing functional components have been renovated to accommodate new business requirements and enable the flexibility and agility to evolve accordingly. The next phase covers the renovation of systems and functional components that support the scheduling of vessels for transit and harbor services, marine traffic control and resource management. After a comprehensive market research, it was determined that there

was at least one Commercial-off-the-Shelf software platform that provides the functionality to satisfy ACP's planning and scheduling requirements with no need for extensive customization or additional coding. The use of a mature software platform with several similar scale implementations in the maritime and other similarly complex industries such as mining and manufacturing significantly reduces the risks associated with the development of brand new or repurposed in-house business applications. ACP acquired the Quintiq's Planning and Optimization Software Platform to serve the operational planning requirements for the core maritime business of the Canal. The full scope of the Integrated Maritime Operational Planning System will cover the scheduling of the Maritime Core Services offered by the Canal:

- Transit
- Harbor Movement
- Anchorage Usage

The Transit Service is the most important among the three and generates most of the business revenue. The services listed above are provided 24 hours a day, every day of the year. To deliver these services the Canal provides four internal services directly to the vessels, and some indirect internal services, that need to be included as part of the Maritime Core Services Delivery Plan:

- Direct Internal Services
  - Lockage
  - Pilotage
  - Tugboat Assistance
  - Deckhands Assistance
- Indirect Internal Services
  - Ground Transportation
  - Water Transportation

To provide this internal services various resources are involved. These resources are distributed along the 80 kilometers of the waterway.

The effectiveness and reliability in the provision of these services is highly dependent on the experience and information available to service planners, maritime resource dispatchers, traffic controllers, port captains, boarding officers (inspectors), pilots, tug masters, locks masters, launch operators, vehicle drivers and other operating personnel.

The Maritime Core Services Operational Delivery Plan focuses on delivering value to the Panama Canal Customers and generating value to the Panama Canal through the achievement of the following business objectives:

Increase Service Delivery:

1. Increase throughput
2. Reduce vessel backlog, waiting times and delays
3. Compliance with maritime services times (transit times, canal water times)
4. Balance customer demands and capacity availability

Increase Resource Utilization and reduce cost

1. Maximizes the usage of locks, channels and reduce bottle necks and idleness

2. Maximizes the usage of tugboats, pilots and deckhands, avoiding idleness, and minimizing overtimes and penalty payments

Improve the visibility and quality of the information for better decision making and risk mitigation

1. Optimize the scheduling capabilities of core maritime services
2. Planning of resources
3. Operational visibility and situational awareness

Finally, a more the detail scope of this project includes:

- Generation of the candidate vessels list sorted by priority for transit, harbor movement and anchorage service.
- Creation of the vessel schedule and itineraries based on:
  - Limited locks and tugboat resources.
  - Unlimited locks and tugboat resources.
- Creation of jobs, for the following internal services:
  - Tugboats
  - Pilots
  - Deckhand crews
  - Locks
- Rostering and assignment for the following internal resources supporting the internal services:
  - Tugboat Crews
  - Pilots
  - Deckhand crews
  - Lock crews
  - Launch Operators
  - Motor vehicle operators
- Calculation of tugboat resources needs for a given plan.
- For a given plan the suggested locks operating mode and its time range.
- Use of locks and tugs availability data.
- Locks and tugs assignment.
- Transportation needs for:
  - Pilots
  - Deckhand crews
- Plan KPIs calculation

39. Globalization -- Slowing, Reversing, Changing? -- Implications for Ports and Waterborne Transport Infrastructure

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There are signs that a dominant trend over the past several decades, globalization, is slowing, and maybe even reversing, or perhaps changing into a new form of globalization driven by data rather than trade in goods. A classic indicator of globalization is trade as a share of GDP. This ratio peaked in 2008 and seems to be stalled, or even declining. Is this a blip, or an inflection point?

Traditional economic thinking views globalization as a pathway to prosperity, and indeed between 1980 and 2015 average global real income rose by 120%. The rationale is that trade increases wealth because it makes nations more efficient by allowing them to specialize in what they do best, sell that, and buy other needed items from countries who can produce them more efficiently. Recently, however, the downsides of globalization have become apparent, as evidenced by the backlash of workers in the U.S. and Europe as manufacturing and other jobs moved to nations with cheaper labor. In response to slowing globalization, banks and corporations are developing strategies for a more localized world. The World Bank reported that global supply chains stopped growing in 2011. During the previous two decades they had expanded about 4% a year. Multinational companies had been building global supply chains in the 90's and 2000's, but now this trend is reversing as companies localize their production and import fewer components for product assembly. Another sign of slowing trade is this statistic from the World Trade Organization: between 2011 and 2015 the value of global merchandise exports went down by 10%. This is the largest drop over a four year period in post WWII history.

Ports are facing slower growth as fundamental structural changes in the container shipping industry and global trade impact throughput volumes. In the 1990s, container volume growth was 3.5 times global GDP growth; from 2000 to 2009 it was 2.7 times global GDP growth, and since 2010 it has been moving towards par. One key factor contributing to this slower growth is the maturing container industry. The container industry is maturing because there are few goods left which can be containerized. So ports may be dealing with overcapacity, and consequent increased competition, in the near future. Even as movement of goods and money has slowed across the globe, a surge is mounting in the flow of cross-border data. The flow of digital information around the world more than doubled between 2013 and 2015 alone. Flow of data now is 20 times greater than it was in 2008. And it is not just Facebook and smartphones. Major companies are using 3D printers to make component parts for jet engines and other products. So in the future, companies may receive equipment by a digital set of orders destined for a 3D printer, rather than by container ship.

40. "Maritime Port Planning and Operations: A review of available guidelines, identification of challenges, and discussion on measuring success factors in the development of a Port Masterplan".

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A Port Masterplan is a document that defines how ports intend to develop in the future. The process of Port Planning and the development of the Port Masterplan is a process that commences well before the port development starts, evolves over time, and expands as an existing facility grows and changes to meet demand. With most of the world's port infrastructure being in highly populated areas, and with the increase in the number and complexity of stakeholders, port master planning in all its forms is going to become a more specialised and valued skill.

Techniques, standards, and guidelines available to generate a Port Masterplan are many and varied. and in some cases conflicting. Whilst there is an attraction to follow industry standards and tailor the Port Masterplan to conform with local regulations and business needs, this does not always guarantee success of the Port Masterplan objectives. Where there is little or conflicting guidance that sufficiently covers all parties involved in Port Masterplanning, the process of developing the ports masterplan exercise quickly becomes a tangled web of stakeholders with widely different interests and objectives. Given the above backdrop, there is a tendency to develop and adopt various guidelines or none, generating a patchwork of confusing documentation with endless revisions and vague outcomes.

There is therefore an opportunity for organizations to realise that a Port Masterplan is not just a rigid blueprint document to guide the future development and be kept in bookshelves. The port masterplan must be seen as a skeleton framework for different stages of the port operation along the years enabling and encouraging flexibility and agility to react to market, environmental and new technologies changing conditions, both as risks and opportunities.

The aim of this paper is to present a review of most common guidelines and standards for Port Masterplan preparation. The objectives involve a critical analysis of key documents in a succinct form where common parameters are compared against each other and differences are summarised. A selection of the world's major Port Masterplans will be discussed in the context of the above review.

This significance of this paper is that the analytical review of available techniques, standards, and guidelines in the ports industry applied to case studies allowed an understand the successfulness of these guidelines and identify areas where Port Masterplan guidelines are required to improve.

41. Ship maneuver patterns to prevent propeller scouring effects

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The propulsion systems of Ro-Ro and Ro-Pax are getting closer to the soil of the docks generating erosion and stability problems to harbor's structures due to the increase in ship and propulsion systems dimensions. Moreover, Ro-Ro and Ro-Pax vessels, which serve regular services, have high docking frequencies. The most significant effect from propeller induced current can be found during maneuvering situation in restricted waters due to the magnification caused by harbor structures. Therefore, larger vessels, more powerful propulsion systems along with higher frequencies can cause severe damages both to docking structures and basin maneuverability. The aim of this contribution is to design new maneuvers of a regular maritime service to minimize their effects on erosion and sedimentation and avoid adverse impacts resulting from ship maneuvering.

This paper describes the results of scouring processes caused by maneuvers of a particular Ro-Pax vessel without the help of a tugboat. The erosion action is studied based on Automatic Identification System (AIS) data. The AIS is an automatic tracking system for identification and location of vessels by exchanging data via VHF communication to other nearby vessels. The AIS information received contains mainly, time, latitude and longitude, ship speed and ship course (IMO, 2003). The use of AIS data permits to understand the effect of changes to the fairway and vessel maneuvering. However, AIS data alone are not enough. AIS data are combined with Acoustic Dopper Current Profiler data obtained during April 2017 at a fixed dock close to the docking area. The parameters extracted from AIS data are used as input to a real-time full mission bridge simulator to mimic the behavior of the real situation (Aarsæther, 2007). From the simulation of specific maneuvers, main parameters of the propellers are obtained (thrust power, speed propeller and pitch/diameter ratio propeller). Considering these parameters and the existing formulae in maritime engineering proposed by PIANC (2015) and R.O.M 2.1-11 (2012), the efflux velocities, the axial velocities along the propeller and the maximum bed velocities are calculated. The potential scouring effects of the particular ship's propellers in the present conditions (weather, harbor and manoeuver) are obtained using the formulae proposed by Hamill (1988) and Hamill et al., (1999). Propeller-generated current velocity measures obtained during the campaign has been useful to consider the duration of the scouring forcing in both arrival and departure maneuvers, but not its magnitude. We can conclude that the used method, based on the study of a particular case starting from the reproduction of the maneuver, becomes adequate to establish the relation between the scouring forcing and its generator, which is the ship's maneuver near the docking. However, field campaign data should be recorded in different positions of the docking area. The present article further analyses maneuver patterns to understand the effects of the sedimentation of the eroded sediment using real-time full mission bridge simulator. The final acceptation of the best maneuvering behavior is chosen according to criteria of acceptable reduction of the effect in harbor basins. Authors propose alternative docking and undocking maneuvers with the

same ship and in the same navigation area in order to reduce the effect of the toe scouring induced by vessel propeller. Docking and undocking maneuvers assessed are: alternative berthing without tugs (controlling the speed of the main engine), berthing with one tug assistance and finally, maneuvers with the assistance received from two tugs (without ship propulsion system). Results obtained show less sediment erosion close to toe of the docks and less stability problems to the docking platforms with the proposed tug-assistance maneuvers.

Acknowledgment

This research has been supported by MINECO (Ministerio de Economía y Competitividad) and FEDER (Unión Europea- FondoEuropeo de Desarrollo Regional "Una Manera de hacer Europa") from Spanish Government through project BIA2012-38676-C03-01 and TRA2015-70473-R.

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42. Safety priorities determination for hydraulic structures relevant for navigable waterways in France : the case of Voies Navigables de France

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Safety issues for hydraulic structures have been implemented with new rules since 2006 in France for all sorts of hydraulic structures (hydroelectricity dams, dams for water supply for agriculture, hydraulic structures for navigation purposes as well). For the navigable waterways they apply to most dams used for water supply in artificial waterways, for dykes and levees with special cases when those dykes are also useful for flood protection. To a lesser extent navigation dams crossing the rivers are also concerned but safety issues are not as high as for the water supply dams.

Recently in May 2016, major floods occurred in the middle reaches of the rivers Seine and Loire and their tributaries, such as the river Loing generating very high damages: the highway A10 was closed to the traffic for several weeks, which hadn't happened since its building in the 1970s and the dykes of the canal de Briare failed.

After those events, Voies Navigables de France, public authority responsible for the main navigable waterways set up a large maintenance program of about 900 M€ concerning the whole navigable network. Considering the fact that with limited financial resources priorization is needed to determine where the main risks are, our High Council was commissioned to help VNF in making the right choices.

Three key issues have to be addressed.

The first relates to the implementation of the safety regulations which tend to consider navigation dams as hydroelectricity dams and canal reaches as whole dams, where the risks may be different. The second examines how to balance the three main safety issues which have to be considered: riverine people, waterways navigation users, waterways operation workers.

The third one is to determine the best way to deal with with aging canals from the 19th century where the freight traffic has disappeared and with very little recreational navigation as well.

The article will describe how the mission from HECSD suggested a new method and introduced recommendations to VNF in order to improve the management of those safety issues.

43. Design and Implementation of the Structural Health & Monitoring System for the Third Bridge over the Panama Canal at the Atlantic side

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A signature bridge is an important part of the nation's infrastructure because of the function it serves, but also because its attests to a country's economic strength and technological advancement. Panama, is building a major cable-stayed bridge with a design life of in excess of one hundreds of years, therefore it would be beneficial to monitor it so that any departure from assumptions made during design are detected early. During its service life, circumstances and conditions may change, resulting in different types and magnitudes of live load, material variations, natural disasters, and human factors. To ensure safety, the operational functionality and durability of the bridge, it is important to have a comprehensive understanding of the reliability of its structural components. Therefore, a Structural Health Monitoring (SHM) system was needed. This paper outlines the design and implementation of the SHM plan for what will be the world's largest cable-stayed bridge with a concrete superstructure – The Third Bridge over the Panama Canal at the Atlantic Side. The proposed bridge, which has a 530 m main span, is located in Colon, Panama, one of the most corrosive environments in the world. The paper summarizes the overall objectives, the design principles, recommended types and locations of sensors. The SHM system proposed and implemented included the following aspects: sensor arrays, a data acquisition and transmission system, data processing and control, a health diagnosis methodology, early warning alarms, and a security assessment process. An important focus of the system was related specifically to durability and the monitoring of corrosion in reinforced concrete. Data collected will support and help optimize decision-making on future maintenance and repair. Tension force monitoring in cable-anchorage system was proposed as well to detect changes that might occur due to corrosion or fatigue.

44. Marina Management in the Natural Resources Program: The US Army Corps of Engineers Case Study

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Recreational boating and other water recreational activities have always been popular in the US. As one of the largest water management agencies in the world, US Army Corps of Engineers (Corps) provides recreational boating opportunities thru its missions in both Natural Resources and Navigation Programs. As the leading federal provider of water based outdoor recreation with more than 400 lake and river projects in 43 states, the Corps' Natural Resources Program hosts more than 500 marinas totalling about 120,000 slips across the nation. These marinas are all on federal lands and waters but owned and operated privately by local businesses and citizens.

It was estimated that in 2016, visitors to these marinas spent about $2 billion on trips and supported about 30,000 jobs to the nation's economy. Marina users, advocate groups and industries are increasingly employing economics (e.g., economic impacts, user values) to gain support of for continued and increased investments in recreation facilities and services.

As the mission of the Corps' natural resources program is to provide quality outdoor public recreation experiences to serve the needs of present and future generations and contribute to the quality of American life, while manage and conserve natural resources consistent with ecosystem management principles, it is important to ensure marinas to be developed and operated to maximize recreation benefits while minimize the environmental impact.

This paper will provide an overview of current techniques for estimating the economic benefits of marinas hosted by the Corps. This will include a review various methods (e.g., surveys) for estimating visitation and spending (e.g., annual craft, trip spending) required for use in economic impact assessment models. It will also discuss the importance of the consideration of social and environmental factors and benefits, and how the agency can benefit from the Working with Nature framework that is currently being developed by PIANC.

45. Multiple purpose water resource in the Panama Canal Watershed: Environmental Education, Sustainable Tourism and Ethnography Research

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The water resource is the driving force for the operation of the Panama Canal, the socio-economic dynamics of the provinces of Panama, Colon and West Panama, and contributes substantially to the country's sustainable economic development by providing water for human consumption, transit of ships, electricity generation and production activities in the different regions of its river watershed and adjacent cities.

In this sense, it is important to emphasize that there is a multipurpose use of water from the waterway that includes the aforementioned and other activities that serve as a showcase in different dimensions of human knowledge and activity, from education, tourism, history, culture and biology, among others not less important.

The ecosystems, biodiversity and socio-historical and cultural scenarios present in the Canal watershed provide the setting for the development of practical actions for the study and strengthening of processes related to water resources, environmental education, science, sustainable tourism and the relationship of indigenous peoples with their environment; all from a holistic, historical, socio-cultural, educational and ethnographic perspective of these different visions and human-nature relations.

For an understanding of these three factors: environmental education, sustainable tourism and ethnographic research, two interesting examples are presented:

1. The first refers to the historical development of environmental education in the Canal watershed, based on the importance of water as a transversal axis that facilitates the path towards a water culture and environmental governance in the region; and
2. The second allows to make an interpretation of the reality of the Emberá people settled in communities within the national parks Chagres and Soberania.

Environmental education

A fundamental historical fact for its development in the watershed, goes hand in hand with the transfer of the inter-oceanic route to Panamanian hands, on December 31, 1999, under the responsibility of the Canal Authority (ACP), which, together with the Ministry of Education (MEDUCA), the National Environment Authority (now the Ministry of Environment) and the United States Agency for International Development (USAID), strengthened the environmental education through a Memorandum of Understanding in 2002, which created the Interinstitutional Program of the Watershed Guardians: an educational model and operating scheme of unique environmental education platform in the country, which became the "flagship program" in this important region. (RCheca, 2005).

The conditions provided by water as the study axis, the relationship with the populations, their conservation and protection, have allowed the achievement of several important milestones from environmental education in the last 15 years, among them:

- Strengthening interinstitutionality (ACP-MEDUCA) and the implementation of a model of environmental education for the construction of responsible environmental leadership and behavior.
- Active and committed participation of the educational community, demonstrated with successful experiences of environmental education.
- Proposals and development of environmental cutting projects and activities that positively impact the educational community.
- Teachers with permanent training in environmental education, participating in regional and national academic activities.
- Development of inter-sectorial and inter-regional integration activities to strengthen the Basin Guardians program.
- Building a sense of belonging and strengthening of the water culture, for the attainment of changes of attitude and pro-environmental behaviors in the territory.
- Joint strategy for the conservation of natural resources, especially water, based on coordinated actions from the educational community in the Working Regions of the river basin.
- Implementation of strategies and actions for the improvement of the quality of life of members of the educational community.
- A permanent and dynamic environmental education program into the Panama Canal Authority; and
- More than 50,000 students and 2,000 teachers from 153 schools participate dynamically and committed each year.

Ethnography research

Prior to the analysis of the indigenous people, it is important to note that in Panama, there are seven ethnic than occupy 20% of the national territory, representing 12% of the country's population. According to the Economic Commission for Latin America and the Caribbean (ECLAC), 6% of this population suffers extreme poverty.

In the case of the Emberá established in the Canal, there are several interesting considerations that allow to interpret several aspects from an ethnographic perspective, including:

- The displacement of the members of the Emberá ethnic group, that originates of the region of Darién (east of the country) to the Chagres River, was part of a "social - military experiment" of the U.S Army and NASA in the so-called Canal Zone, in order to have an indigenous instructor who trained astronauts from NASA different space programs in jungle survival between 1960 and 1975. (RCheca, 2016).
- Subsequently, more individuals migrated and settled in the Chagres River, applying their traditional practices for the use of natural resources within their reach. But, the territory where they were established is declared a "national park" in 1985, and many of their activities were banned by the new legislation of the protected area.
- However, they found in environmental education and sustainable tourism a different way of prosperous in harmony with nature, achieving an alternative of local economic development which provides complementary benefits to the traditional productive activities permitted by law and keep them away from poverty conditions.
- Environmental education is part of their ancestral knowledge, but over time, they have been strengthened by the exchange of information with institutions such as: Panama Canal Authority, National Environmental Ministry, Smithsonian’s Tropical Research Institute and other local and institutional actors.
- Under a combined environmental education and sustainable tourism scheme, they provide a service to national and foreign tourists and contribute to the protection and sustainable use of the natural and cultural resources of this important region, which

provides more than 42% of the water needed for the lakes system of the Panama Canal.

There are many research opportunities related to the multipurpose use of water in this region, which will enable the community at large to have a clearer understanding of the importance of the resource and the need for its conservation and protection in the present and future, for its sustainable use and the need to prepare us for the challenges ahead.

46. Different aspects of dredging and disposal works, experiences and challenge in Panama Canal

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Dredging works implies a lot of aspects that impact this kind of activities; relevant aspects as the diverse geological conditions; nearby structures and those near to the shoreline; environmental and safety issues; interference with other projects or operations; maritime regulations, limited dredging fleet, and a dynamic dredging schedule.

In Panama, the heart of the interoceanic crossing is the Panama Canal Authority (ACP); a government agency, which mission is based on the statement of being efficient and competitive with excellence and quality, guaranteeing an expeditious, reliable, safe and uninterrupted transit through its channels. In order to achieve these goals, ACP invests in increasing its capacity and improving the services using state-of-art technology to strengthen the competitive position of the country and ensure its future viability.

Remarkable excavation and dredging works were executed and completed during the last 17 years; being the most relevant projects, those within the Expansion Program, that complemented the construction of the Third Set of Locks, opened for official operation on June 26, 2016. These projects included deepening and widening of the Navigation Channel required for the transit of the Neo-Panamax vessels.

In addition to this Expansion Program, the ACP continues with a comprehensive maintenance dredging program along the existing and the new reaches of the expanded channel, in the sea entrances and lakes, at the same time develops other projects to improve the efficiency of the Panama Canal operations.

The main dredging challenge in the Panama Canal is to work during traffic operations, since the vessel's transit is the priority. The work plan should consider this limitation, and its impacts, which could represent a reduction of production of the dredgers, increasing6684-1724 logistic and managing the related risks. Others challenges are the interface with other projects, navigation structures, maritime signals, location and capacity of disposal sites and ACP regulation that could be relevant.

The unique experience and lessons learned from those projects feed the ACP´s knowledge and its ability to manage issues in the most efficient way, mitigating impacts and improving the dredging works, optimizing dredging methodology in the Panama Canal.

47. Development of Romanian Inland Waterways and Hydro Connection with Europe

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The paper presents the way of planning in Romania the waterways and the ports. There are a number of actions to make investments more efficient by achieving multiple functions of a waterway and expanding the hinterland. Also, was created a system to prevent saltwater penetration from the Black Sea into the lock.

Transportation is one of the main components of the social and economic life for any human society. It is part of processing products and to take them to their place of consumption. With the development of the global economy, the increase of commercial exchange and especially the transition of the Eastern–Europe countries including Romania to the market economy, the current situation of the ports have to be reviewed in order to efficiently update their technology. This justify consideration of an international transport market. Integration and cooperation often represent a desideratum and one way to fulfill it, is by transportation. Favorable conditions were created to promote the extension of European and intercontinental exchanges, as well as to integrate the regional transport network into the continental network. Strategy for the development of the navigation infrastructure includes the foresights for modernization of waterways, river and ports in an integrated concept.

Romanian major ports and inland waterways have been developed along the 244-kilometers sea shore of the Black Sea, 1,075 kilometers of the Danube which borders and crosses the country and also along some navigable tributaries.

On the Romanian shores of the Black Sea are located three seaports: Constanta, Mangalia, at about 22 miles to the south, and Midia, at about 10 miles to the north.

The Constanta and Midia Ports are connected to the Danube through navigable waterways. This ensures the access of the inland vessels to these ports.

Twenty Five inland ports are located on the Danube River and five on its inland waterways. Given the volumes of materials that are transported, each port serves a specific zone of Romania.

The Danube attracted the attention of many economic, political and military authorities of different countries. Following a series of discussions, the “Convention regarding the rules governing the navigation on the Danube” was signed in Belgrade in 1954 by the countries having direct access to the Danube.

Danube Commission’s (D.C.) purpose is to standardize the regulation for navigation; for example, establishing the manner for performing the maintenance works, signalling, and so on.

D.C. cooperates with CEE and Rhine Commission regarding the protection of the Danube regulations, due to the fact that the navigation takes place both on the Danube and Rhine. Because of its location in the southern part of the country, Danube ports have limited influence

on Romania's inland waterway transportation. Considering this, the strategy for the Territorial Arrangements Plan stipulates the turning into navigable waters of some Danube tributaries (namely Olt, Arges, Prut, and so on).

The same goal has been considered in accomplishing navigable canals, such as: the Danube – Black Sea Canal, connecting Danube to Constanta Port; the Poarta Alba – Midia, Navodari Canal, connecting Danube to Midia Port; the Bega Canal assisting the western part of the country. The Rhine – Main – Danube Canal created a physical connection with the Rhine and the hinterland, potentially extended to Germany and even to the Netherlands. It created a navigation corridor connecting Constanta Port in Romania with the Rotterdam Port in Netherlands.

The Danube – Black Sea Canal has complex functions, such as: navigation and water administration, irrigations, electric energy supply, drinking and industrial water supply, drainage of the adjacent lands, regularization of the water flow and their transit towards the sea. The navigable canal is 64.4 km long and 7.0 m water depth.

At the Channel's extremities there is a locks with specific conditions. Thus, at the Cernavoda side, the variation of the level of water in Danube, requires that at the low levels of water, have to be pumped into the lock. At the Agigea side, where the barges enter in Constanta Port, a system was created to prevent saltwater penetration from the Black Sea in the lock. Also, the entrance of the ships from the Port in lock is provided a compressed air which also prevents saltwater to penetration in the waterlock. A number of actions are to be taken that will lead to an increased efficiency of the facilities and aim to increase volume of handled goods. A unit system transport is necessary in order to reduce the number of transshipment operations and to select the most convenient transport mode and finally of an economic route.

In Romania all the ships using the river ports have access to the maritime ports of Constanta and Midia, as they are connected to the Danube by navigable canals. Furthermore, all major ports are connected without any restrictions to the national rail and road network.

Besides the requirements needed to ensure navigation, the waterways may also be used to meet the requirements on irrigation, water supply, drainage, electricity generation, flow rate regulation even for leisure tourism. The actions for the further development of the waterborne transport on short sea shipping must be also put into force.

Due to its good access to major communication routes and strategic position Romania may become the easterly focus point for East-West trading.

48. Update the Final Report of the International Commission for the Study of Locks Terms of Reference

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Objective of the International Commission

The main objective of the Commission is to update the 1986 Final Report of the International Commission for the Study of Locks.

Background

It has been over 30 years since this benchmark document was produced and much has evolved and an updated report, second version, is needed for the navigation community. The new lock design textbook will be a valuable instrument to promote PIANC and the Inland Navigation industry. This publication will serve the navigation community for years and will solidly place PIANC as the preeminent inland water transport organization.

Final Product

The original document was 445 pages and was an outstanding document in its time however much of it is simply outdated and now is of limited value. Many of the designs presented simply are not used as more efficient, reliable, cost effective, and environmentally friendly solutions are favored. There are multiple areas to update, as a second volume it is envisioned the basic outline of the book will be retained, updated with new chapters or headings for subjects that were not common at the time for such items such as sustainability and in-the-wet construction, etc. Many countries now have mature water transport infrastructure and it is becoming clear the driving force for design are new efficient rehabilitation strategies when expanding or building a lock and maintain existing traffic in an overcrowded waterway. Other strategies such as in-the-wet construction can allow for much smaller footprint since a full scale cofferdam is not needed. There have also been new exciting, innovative projects to highlight, such as, the Third Set of Locks for the Panama Canal, Three Gorges Locks, and the Falkirk Wheel. In addition there are many innovative navigation design improvements to discuss, such as, new lock filling and emptying systems, e-navigation, Computational Fluid Dynamics (CFD) and other advanced modeling has led to much better understanding of vessel behavior in the approach and during lockage, also a better grasp on mooring forces and salt water intrusion movements, asset management, life cycle cost, aids to navigation, gates, gate protection equipment, local coffer-boxes, innovative materials such as composites, hands free mooring, seismic effects, and security improvements (safety and terrorism). Many of these individual techniques and materials have been available for decades, but their broader acceptance has been limited. Their use will be more viable once published with the far-reaching PIANC network.

It is envisioned the finished product could be a hard print text as before or published on the web or both.

Matters to be Investigated

There have been numerous PIANC working groups, treatises, research and development reports and innovations to provide an abundant source of background material for the update. Many working group reports can be used or referenced, however most working group reports deal with specialized concerns while the textbook deals with more basic design concepts. No other organization has the network and organization infrastructure such as PIANC to compile a textbook of this scale and value. While the effort is large, it is building on the first edition and updating the second edition is not expected to be more effort than one of the recent premier working groups such as WG 106 on Innovations in Navigation Lock Design.

Desirable Background or Experience of Working Group Members.

The background and experience may include the following:

1. Navigation design engineers and consultants
2. Academia/educators
3. Operators and managers of existing waterways
4. Representatives of regulatory bodies
5. Promoters of improvement or new navigation schemes
6. Manufacturers and fabricators
7. Suppliers

Relevance for Countries in Transition

The results will help designers and promoters of new or existing navigation projects throughout the world and provide guidance to develop and operate safe, sustainable, and economically viable waterways. This effort can be useful for all countries developing hydraulic structure infrastructure by providing a relevant comprehensive design experience for new or to extend the life of existing hydraulic structures.

Sustainability

This concept was incomplete when the original text was prepared in 1986 and is an opportunity to enhance this value in the navigation design process.

49. Technical management of the cyber-physical waterway: it's all about managing complexity.

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Organizations that manage inland waterway infrastructure (IWI), are rapidly introducing cyber-physical technologies or will do so in the next decade. We argue that you should design your technical management the way you want your overall CPW-system design to be.

The cyber-physical waterway

In cyber-physical systems, physical and software components are deeply intertwined, each operating on different spatial and temporal scales, exhibiting multiple and distinct behavioral modalities, and interacting with each other in a myriad of ways that change with context. (US National Science Foundation).

Some interrelated and overlapping terms that are used around the world are; smart-technologies or Industry 4.0 technology.

The cyber-physical waterway (CPW) is a waterway where for example:

- Infrastructure is connected with different communication networks such as fiber-networks and wireless networks (GPRS, VHF, RF, …)
- level sensor data is used to predict water levels and to automatically adjust weirs in the whole area in the most optimized mode
- bridge, locks and weirs are remotely operated
- traffic flows are optimized based on tracking and tracing of vessels and all other relevant information
- infrastructure is continually monitored to allow for predictive maintenance
- safety is guaranteed by smart safety devices

The technology applied in the CPW differs fundamentally with classic waterway technology on two levels: the component level and the system level.

Characteristics on a component level

Traditionally, IWI comprises of steel or concrete structures and electrical and electromechanical components. The components used to implement a CPW are IT-related such as embedded computers, software and network components. As such, they inherently have IT-related characteristics.

Traditional IWI components	Cyper-Physical Waterway components
Slow technological development	Fast technological development
Long product life cycles (>10 years)	Short product life cycles (<10 years)
Compatibility forms not a big issue	Compatibility issues supplier depended
Knowledge largely supplier independent	Knowledge largely supplier depended
Knowledge relatively easily codifiable	Knowledge difficult to codify
Wide variety of possible contractors	Specialized contractors

Characteristics on a system level

Traditionally, IWI is analyzed by decomposing the infrastructure in a physical bounded component-breakdown structure. The waterway is comprised of several locks and bridges, which in their turn are comprised of several structural elements and a drive system, with an engine and brakes, with brake-pads and so on.

The characteristics and behavior of traditional IWI on a system level is straightforward. Only a few important minimal specifications are needed to describe the waterway: maximum width and length of the vessels, underpass height and depth of the waterway. The design of the lock or bridge itself may vary almost freely. A failure of one component, usually has only a local effect.

To analyze the CPW, a system perspective is more suited. Several components are networked with components that are located outside the physical boundary of the object. Each sub-system has a role to play and provides a service to the other sub-systems and combined they achieve a higher goal then just the services added. You can distinguish a CCTV-system, an access-control-system, a dynamic traffic sign-system, an IP-based radio communication-system etc.

A CPW is a so called “complex” system. The sub-systems have multiple interactions, they vary over time, the effect of a change in one area often has an unpredicted effect on other systems.

Managing complexity

A complex system that isn’t well designed and managed, becomes very vulnerable. A single failure or change can result in failure of the whole system.

There is not one perfect way to manage the CPW but not all ways are equally effective. Managing a CPW, means managing complexity. The preferred way to manage complexity, is to reduce it. Reducing complexity can be done on a technical level and on an organizational level.

Managing complexity on a technical level

Reducing complexity on a technical level can be done by:

- Modular design
- Clearly identifying and defining interfaces between (sub)systems
- Using minimal specifications for the services and interfaces between (sub)systems
- Creating multipurpose, open in between-layers
- Utilizing open widely used technical standards
- Separating functions/services
- If unavoidable, proprietary brand based standardization

To summarize, we need to design the system to allow for continous, fast and easy updates, upgrades, adaptions, modifications, … in contrast with building something that will last unaltered for 100 years.

Managing complexity on an organizational level

The most frequent form of technical management of IWI uses an organizational structure based on two dimensions: by geographical location and by technological phase; construction and maintenance. This is rational for classic IWI. Coordination between geograpical location is easy, because of the very limited minimal waterway specifications. Coordination between

technological phases is relatively easy aswell, because of supplier independency, ease of codification, long life cycles etc.

Given the characteristics of the CPW-system and its components, this strategy becomes problematic. Wether a CPW-component of a sub-system is placed locally or 100km further away, it should always be up to date and compatibel.

Therefore, for cyber-physical systems, organizational structure should be at least partely aligned with a divison into subsystems. Furthermore, procurement strategy for a subsystem should comprise and integrate implementation and maintenance.

Conclusion

Waterways are rapidly evolving towards complex systems. If not well managed, complex systems are vulnerable systems.

For successful technical management of the CPW, it does not suffice to optimize technology, nor does it suffice to optimize organization. Only by combining and syncing technology and organization strategy and adapting for specific technological characteristics, an effective and efficient CPW is possible.

Overall, we apply, expand and interprete Conway’s Law (1968, Conway): "Any organization that designs a system will inevitably produce a design whose structure is a copy of the organization's communication structure."

In conclusion; design your technical management the way you want your overall CPW-system design to be.

50. Remote-control, set the standard by designing a simulator and professionalize!

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Remote operation of inland waterway infrastructure has been around for about 2 to 3 decades. It is now time to evolve towards a reference design so we can professionalize the way remote control is designed and implemented and benefit from the opportunities that lie ahead in the future of remote control.

Why do we not yet have a reference design?

Each bridge or lock is typically designed for its specific boundary conditions and reflects the state of the art of technology at the time of construction. This leads to a wide variety of design and implementations of structures and systems. They were never designed to be connected. This is major technical challenge when implementing remote control.

Currently, history repeats itself. Several locks and bridges are combined into increasingly larger corridors, operating from a control center. When building these centers, several design choices are made based on the involved structures and systems. Then again, this leads to a wide variety of design and implementations of control centers and Human-Machine-Interfaces (HMI). Therefore, these centers are not designed to be interoperable.

We make design choices based on the task at hand, the technology at our disposal and we search for the best fit. We don't take the bigger picture and the future ahead into account, but we should.

Why do we need a reference design?

The introduction of remote operation is historically justified by two main arguments: increasing efficiency by saving manpower and expanding operating hours for waterways with lower volumes of traffic.

However, if we can evolve towards interoperable control centers and interchangeable HMI's, several more advantages can be achieved:

- Increased safety by systematically reviewing and auditing both technical and operational standards
- Speed up implementation of remote control projects by reduced design effort
- Cost-cutting by standardization
- Allow for standardized and professional training of operators instead of on-the-job training
- Allow for back-up and fail-over scenarios for control centers in a mesh-like overall system
- Even more efficiency gains by flexibility in the scheduling of workforce

What are the challenges in establishing a reference design?

- Paper exercises have the risk of not addressing the real-life problems and discussions experienced in the field during construction; we need more than texts and drawings to communicate and discuss.

How do we establish a reference design?

De Vlaamse Waterweg NV has set up the AWATAR project. AWATAR stands for Automation of Waterways: Training and Reference.

The 3 main goals of AWATAR are:

- to establish and maintain the technical and operational reference
- to allow for standardized and professional training
- facilitate, professionalize and mature the way remote control is implemented

We made virtual 3D models of several lock and bridges, together with models of ships, cars, pedestrians, … inside a gaming engine. We connected these virtual models with real PLC and SCADA software and simulated different camera-viewpoints, traffic situations and weather conditions.

This allowes us to discuss and try very different HMI designs, camera-view points, functional behavior, operational procedures, … all without disturbing any real-life operation and in great detail.

We organized multiple participation sessions, workshops and feedback-loops with both engineers and operators. We used Virtual Reality Glasses to design the operator desk.

What is the result?

- A dominant design well documented by technical and operational standards, manuals … supported by both operators and engineers
- A design thoroughly checked on safety issues
- A detailed design and working prototype of the training-simulator
- A camera-simulator, to test camera-viewpoints
- A fully developed training program
- A solid foundation of thrust between engineers and operators
- a modular design, to allow for future changes and technological advancements.

What are the lessons learned?

- It takes time and effort to built trust and understanding and to get the right persons involved, but it is worth it;
- Integration of knowledge and experience from operators in an early stage, results in a more useful design;
- The more tangible and life-like the simulator, the more detailed and interesting the discussions get;
- To keep the engineers involved and the results usable in the field, built it with real automation components and software as much as possible;
- Use a contracter with experience in automation of waterway infrastructure;

What is the future?

This simulator is placed in an operator training center. This center is the meeting point where engineers and operators can thoroughly discuss issues, whereas the conclusions will then

form the reference point for the whole organization. It is a physical location but at the same time, it forms a dynamic body of knowledge.

By having a clear and up-to-date reference, we professionalize our technology management. It allows to evolve to an interoperable and thus robust mesh-like setup of control centers. We will build a network of control centers, rather than separate islands.

51. Value of 3D Physical Modeling in Harbor Design - Gateway Harbor Chicago Case Study

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In this paper the important role that physical modeling can play in supporting the efficient and optimized design of ports, harbors and marinas will be reviewed and discussed. While the power and capability of numerical modeling approaches has increased dramatically in recent decades, some important gaps remain where physical modeling approaches can deliver better, more reliable answers. Physical modeling facilities and technologies have also improved in recent decades, and physical modeling studies, particularly those conducted at large scale, remain the preferred approach to optimize the layout and design of rubble-mound breakwaters to suit local conditions, and validate the performance of proposed designs prior to construction. Physical model studies also remain the best approach to predict the magnitude and character of wave-induced uplift pressures on the underside of pile-supported deck structures, and to develop and evaluate alternative strategies for attenuating the uplift pressures. Physical model studies are also the best approach for predicting overtopping flows due to waves at complex three dimensional structures, and predict the behavior of ships moored within harbors. All of the important physical processes governing wave propagation and wave structure interactions, such as wave refraction, diffraction, reflection, wave breaking, non-linear wave-wave interactions, wave run-up, overtopping, interstitial flows, and armor unit stability, can be reproduced in a realistic manner in a large-scale physical model.

The important role that a 3D physical model study can play in supporting the design of a new harbor will be illustrated through reference to a specific example. Gateway Harbor has been proposed as a new harbor to be constructed beside Navy Pier on the shore of Lake Michigan near the center of the City of Chicago, Illinois, USA. Gateway Harbor will be located just south of Navy Pier, and will offer sheltered moorage mainly for recreational yachts, tour boats and passenger ferries. The project site is located behind an outer breakwater which offers partial sheltering during storms. However, because the outer breakwater is a low-crested structure that experiences a large amount of overtopping during extreme events with high water levels and on-shore winds, the site is exposed to moderate wave action during design events.

A 3D physical model study was commissioned to support the design of the new harbor. Key issues to be addressed included:

1. wave agitation within the new harbor, which is strongly influence by the wave overtopping passing over the low-crested outer breakwater.
2. Wave uplift pressures on the underside of a lengthy pile-supported deck structure
3. Potential optimizations to the harbor layout and the design of the new structures to reduce wave disturbance and wave loads, reduce costs, and improve constructability.

A three-dimensional 1/30 scale physical model of the proposed harbor was constructed in a 36m by 30m directional wave basin the Ocean, Coastal and River Engineering Research Centre (OCRE) of the National Research Council of Canada (NRC). Accurate reproductions of a range of extreme wave conditions were generated in the model by means of a

sophisticated 60-segment directional wave generator. The model was fitted with instrumentation to measure wave agitation within the harbor and uplift pressures on the existing deck-on-pile structure running along the south side of Navy Pier, and with several video cameras to monitor conditions in the model.

An initial series of tests was conducted to verify the incident wave conditions in the model for existing conditions without the new harbor. Following this, a 1:30 scale model of the eastern part of the new harbor was constructed, and tested in a wide range of extreme water levels and wave conditions particular to the site. The new breakwater structures were constructed using rock materials that were selected to reproduce the hydraulic performance and submerged stability of the materials specified in the prototype design. More than twenty alternative harbor layouts were simulated in the model, and the results of these studies have been assessed to help develop an optimized, cost-effective design which minimizes wave uplift forces, wave agitation and construction costs. After modifying the model to simulate the inner (western) part of the proposed harbor, a final series of tests was performed to investigate wave agitation throughout the inner harbor.

The study results showed that the initial harbor layout generated significant uplift pressures on the deck-on-pile structure running along the south side of Navy Pier under certain extreme wave conditions and water levels. Numerous design modifications to mitigate the issue were subsequently developed and verified in the model. The results of the study are being used by the design team to guide the final detailed design for Chicago Gateway Harbor. The role that physical modeling can play in optimizing the design of a new harbor and validating the performance of the new structures in design conditions will be discussed throughout the paper. The methods developed and tested to reduce wave agitation and mitigate wave impact loads at Gateway Harbor will also be discussed in detail.

52. Evaluation of Proposed Jetties for Port of Santos Navigation Channel Depth Maintenance

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Port of Santos, which is located in southeastern Brazilian coast, is one of the most important ports of Latin America. Its hinterland is composed by several Brazilian states including São Paulo, Minas Gerais, Mato Grosso, Mato Grosso do Sul, Goiás and Distrito Federal, concentrating more than 60% of Brazilian gross product (CODESP, 2017).

Currently, Port of Santos navigation channel is 15 m deep, and CODESP (São Paulo State Docks Company) plans to reach 17 m deep. This deepening dredging would allow the traffic of Post Panamax and New Panamax vessels in Port of Santos. However, this depth increment would increase siltation rate along navigation channel, requiring larger maintenance dredging volume (GIRELI et al., 2012).

In order to reduce the dredged volume, alternative depth maintenance solutions may be simulated. Thus, this paper compares the scouring efficiency of several jetties that had been proposed for Santos by other authors. Five jetties were retrieved from INPH report (REIS, 1978), and one from the paper “Impact of climate changes on the Santos Harbor” (ALFREDINI et al., 2013).

The different jetties are simulated using hydrodynamic numerical modelling (software Mike 21 FM – Danish Hydraulic Institute), and the evaluation of each jetty’s efficiency consists of comparing currents velocity and direction maps along Port of Santos navigation channel during ebb and flood with the scenario without jetty. The hydrodynamic model is calibrated and validated using five tide gauge stations data and eight flow station measurements along Santos estuary.

The results analysis will consist of comparing and subtracting the currents velocity and direction maps of each scenario with the scenario without jetty. This approach allows identifying the areas with velocity variation and the impact on currents direction in Santos Bay.

Probably, structures with two jetties will be more efficient to scour Port of Santos navigation channel, because the jetties walls would narrow the flow, and increase currents velocity. Moreover, Santos is a touristic city too; the jetties geometry will influence the pattern of currents direction in Santos Bay, where residual currents are responsible for sediment transport along Santos littoral. Therefore, the most suitable alternative must seek balance between Port of Santos channel depth maintenance with minimum impact on adjacent beaches sediment budget.

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53. Upgrading of seawalls and breakwaters for climate change

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Many rubble mound coastal breakwater structures have primary armour rock and/or Concrete Armour Units CAUs that are undersized, and require regular (and costly) repairs after storm events. This ongoing challenge will be further exacerbated by sea level rise. Rock or CAU protected structures cannot be simply retrofitted with an additional layer of larger armour because different sized primary armour (rock nor CAU) units may not be available or do not necessarily interlock well.

Breakwater design equations predict that the stability of breakwater armour is proportional to the cube of the design wave height and inversely proportional to the submerged density of the armour material. Therefore modest increases in wave heights (due to changes in wave climate and sea level rise with climate change) and material density will lead to either large losses or gains in stability respectively.

A series physical modelling in wave flumes over many years at Water Research Laboratory have been undertaken to provide guidance on Upgrading of Seawalls with Climate Change – Placing larger rock or CAUs over existing rock or CAUs armour can be undertaken but stability is dependent upon achieving sufficiently high placement densities during construction – model testing is essential.

The density of conventional concrete can be increased by replacing gravel aggregate (SG = 2.6) with steel furnace slag (SG = 3.0), but the concrete product is prone to cracking because of chemical reactions between Portland cement and the steel furnace slag. Recent advances in concrete technology have enabled the development of new products where Portland cement can be entirely replaced with geopolymer cement. Geopolymer cement does not react with steel furnace slag, making it suitable for use in high-density concrete.

High density concrete Hanbar CAUs have been found useful in model testing for upgrading existing CAU Hanbar structures, because they provide additional stability while retaining the same dimensions (ensuring good interlocking with existing armour units). This important result provides a potential upgrade pathway for all concrete armour unit structures in response to sea level rise. Prototype installation of 20t CAU Hanbars in a trial repair to a major coastal port in NSW Australia is planned

The paper will summarise the extensive physical modelling undertaken over many years at Water Research Laboratory , synthesizes it with international literature and provides guidance for Upgrading of Seawalls with Climate Change, including financial optimisation for both new and upgraded options.

54. A Planning Framework for Improving Reliability of Inland Navigation on the Madeira River in Brazil

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The Madeira River Waterway is an important transportation link between the agricultural production areas of western Brazil and the deep draft ports on the Amazon River, where commodities are transferred for domestic consumption or international export. However, navigation reliability is limited, especially during low-flows. In addition, current economic studies predict that the demand for the waterway is expected to increase, especially for agricultural commodities. A primary impedance to navigation on the Madeira River is sand shoals in thalweg crossings, especially near split flows at islands. These bottlenecks in the system require navigators to light-load their barge convoys to tonnages less than 25% of loads transported during high water levels. A secondary impedance is associated with rock outcrops near the navigation channel, which combined with a lack of aids to navigation, increase risks of accidents for the convoys. To address navigation reliability and safety, a planning study framework has been developed on the Madeira River. This framework aims to design alternatives that will provide economically justifiable engineering solutions for improved waterway reliability and reduced navigation risk (safety) during low flow conditions. The planning study implements the USACE 6-step planning process, which includes identifying navigation opportunities; forecasting future navigation conditions; and formulating, evaluating, comparing, and ultimately selecting a recommended plan. The planning study evaluates alternatives consisting of maintenance dredging, rock excavation, river training structures, and bank stabilization using engineering tools that were developed to assess design effectiveness. Alternatives were analyzed by combining five primary studies; namely, a statistical analysis of navigation reliability; a fluvial geomorphology study, a hydraulic model to determine low water datum conditions; development of a design barge configuration and associated channel dimensions; and a sediment transport model to evaluate channel response due to the proposed measures and alternatives. The statistical analysis developed a framework for the determination of the navigational low water reference level. This information was used to calculate the low water reference plane in a hydraulic model between observed gage locations. The model was calibrated to known sand shoal depths under low-flow conditions as well as moderate and flood flows. The design barge configuration task was combined with a fluvial geomorphology study to demonstrate the navigability of a 3x3 barge convoy (60m long x 11m wide per barge) configurations during low-flows and a maximum of 5x4 barges during high flows. The channel alignment associated with these design barge configurations was determined to fit within the current sinuosity of the Madeira River, which does not require channel straightening in the system. Finally the sediment transport model was developed and applied to predict the future conditions associated with the proposed alternatives and to evaluate the effectiveness of dredging, river training structures, and other measures for improved navigation. The planning study analyzes alternatives that will provide the maximum cost-benefit ratio over the 50-year economic life-cycle of the Madeira River Waterway Project.

55. Small Hydro Power in Inland Navigations - Environmental Aspects

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All inland navigations involve the movement and control of water, sometimes in large quantities. Good design ensures that most of this water moves downhill by gravity but some inevitably must be pumped up hill to satisfy navigation needs.

The current desire to maximise the supply of green renewable energy and minimise operational expenditure has focused waterway managements to look at the potential use of the flowing water to generate electricity to increase revenues, reduce operational expenditure and lower the impact of inland navigation on climate change

Investing in hydro power does not come cheap but some waterway managers have been innovative in the way that they have implement schemes. This has required the skilful combination of technology for

existing types and models of hydro turbines and generators

control schemes integrated within existing navigation water control systems

integration within existing structures on the navigation including the use of redundant structures

dual use of the hydro scheme to both produce energy and pump water as required

Perhaps the biggest design consideration and biggest challenge in developing a hydro power scheme on an inland navigation is environmental. The protection from harm of fish is vitally important; they must either be excluded from entering the turbine or be able to pass through the turbine without harm.

This leads to the development of fish friendly turbines and fish friendly intake screens, screen cleaners and other devices to prevent fish entering the turbine.

Where a navigation passes through a watershed and links two originally separate river system together, any dual use hydro scheme that pumps as well as generates must not cause and detrimental transportation of plants or animals across the watershed to the satisfaction of the applicable environmental regulations.

The paper present examples of fish friendly technology both for fish passing through a turbine and for the means to exclude fish from entering a turbine.

56. Small Hydro Power in Inland Navigations - Best Practice and Examples of what can be achieved

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Nicholas Crosby

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dual use of the hydro scheme to both produce energy and pump water as required

Three other papers from the same working group presented aspects of hydro power related to inland navigations. This paper shows how these have been combined in projects that have been completed in different countries. The schemes will show waterway managers what can be achieved with investment and commitment.

57. The development of Aberdeen Harbour Expansion Project

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Introduction

The Aberdeen Harbour Expansion Project is one of Europe's largest greenfield port capital investments projects over the next few decades . With a project investment of over £300 million, the project involves the construction of two new breakwaters each 600 m long, quay lengths of over 1.5 km, 2 million m3 of dredging including 0.25 million m3 of rock dredging, and about 1 million m3 of reclamation. The site is situated on the east coast of Scotland in a severe wave climate with design waves exceeding Hs~8m with single layer concrete armour units of up to 16 m3 required for the Southern Breakwater.

This paper sets out the development of the port masterplan and the key engineering design and environmental constraints, together utilising many of the principles set out in the forthcoming PIANC WG185 guide to the site selection and masterplanning of greenfield ports. The paper includes details of the background and context, the masterplanning process, numerical and physical wave modelling studies, and navigation simulation as well as the engineering and procurement process. Construction was fully under way in September 2017 and completion is scheduled for 2020.[PH1]

Background and context

Aberdeen Harbour has undergone substantial development over the last 40 years, primarily as a result of the growth in the oil and gas industry in the north-east of the UK. The growing trend for new, larger, multi-purpose vessels combined with the potential for new business streams including large cruise ships, the renewable energy sector, and decommissioning of oil and gas installations indicated that there is a case for growth beyond the capacity of the existing harbour infrastructure. Aberdeen Harbour Board therefore proceeded to develop a masterplan examining the case and direction for growth.

Masterplanning process

The masterplanning process is described in the paper using the same structure as the PIANC masterplanning guidelines, namely:

1. Establishing the 'Needs and Vision' and the 'Performance and Functional' requirements. This set out the initial vision and objectives of the new port at Aberdeen.
2. Establishing the 'Spatial Needs'. Understanding the water and land areas and hinterland links.
3. Identifying and subsequently characterising three potential sites addressing issues such as:
    1. Marine: Bathymetry, geology, geotechnical, currents, sediments
    2. Terrestrial: Road and rail connections, material sources, utilities
    3. Environmental constraints: Legislative framework, Local planning issues, constraints and consultation. The chosen site included a Site of Special Scientific Interest (SSSI) and was adjacent to other designated sites.

4. Developing and screening the options based on multi-criteria analysis. This involved examining over 20 options in the three different sites.
5. Project Implementation:
    1. Undertaking
        - Numerical and physical wave modelling,
        - Navigation simulations and
        - Site surveys and ground investigations.
    2. Developing the:
        - Preliminary engineering and
        - Reference and Illustrative designs and associated specifications for tender purposes.
    3. Developing cost estimates, schedules and the procurement process.

The project implementation is described in more detail in the subsequent sections.

a) Modelling and simulation studies

The paper will describe the modelling and visualisation studies in detail:

1. Wave modelling for use in design and modelling of conditions from 50:1 to 1:200 year using MetOffice and ReMap data sets.
2. Flow modelling for use as input to the navigation simulation, sediment transport and environmental assessments.
3. Sediment transport assessments
4. Real time navigation simulation of the approach and berthing
5. 2D Physical modelling of the northern breakwater
6. 3D physical modelling of breakwater stability, wave disturbance in the harbour and vessel motions and line and fender loads
7. Visualisation: fly-through visualisation of the proposed works to enable the client and stakeholders to understand the nature and scope of the works being proposed.

b) Engineering design

The paper will describe the key engineering design features of:

1. The layout design including wave attenuation.
2. The breakwater design including examination of a number of options. The adopted Reference Design included 8m3, 10m3, 12m3 and 16m3 concrete armour units with crests at +12.6mCD and toes down to -11mCD. It included an unusual rear drainage trench to enable lowering of the crest structures.
3. Site surveys, review of historical information and extensive ground investigation.
4. The quay wall design, landside works: including paving, services and tie in to the existing local infrastructure.
5. The dredging design and associated revetments.

c) Environmental impact

The paper will describe the environmental impacts and mitigation measures.

d) Procurement strategy

Key to achieving best value for the marine construction was configuring the design to suit the operational constraints of the contractors' plant and equipment, environmental constraints as well as material sourcing. It was seen that significant optimisation could be achieved if

contractors were empowered to refine the design to suit their preferred methods of construction and hence the procurement strategy was configured to enable this goal. A Design & Build form of contract was adopted using the NEC3 form of Contract with a Reference Design forming the basis of the tender.

Key parts of the design package were:

- Detailed Reference design reports
- Design and performance requirements
- Construction and material requirements
- Drawing packages
- Environmental impact assessment
- Site information and ground investigation.

58. Hydrology and Hydraulic Analysis for the diversion of the Cocoli River

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Panama Canal Authority, Panama

Excavation and construction of the new locks on the Pacific side for the Canal expansion requires a series of ancillary works in order not to affect the development of the works when they start to run.

One of the immediate problems that has been detected and that may negatively impact the development of the work is the current course of the Cocolí River which discharges its waters into Lake Miraflores and will be intercepted in its course by the projected alignment of the new locks of the Pacific side.

The solution to this problem is to change the trajectory of the waters of the Cocolí River through the design and construction of a diversion channel, which is part of the Canal Expansion Project (PAC-2). This will prevent future excavation work from conflicting with the schedule of activities to be developed in the area.

The design of the channel of diversion of the Cocolí River contemplated two stages: the development of the hydrological study and the integral hydraulic analysis of the projected channel and its impact along its trajectory.

In the hydrological study, the design flow rates of the Cocolí River were estimated up to the diversion site and three tributaries that run naturally through the area and that will be affected in their natural course by the projected alignment of the diversion channel. In order to estimate the design flows, preliminary studies were used, but due to the magnitude of the project, they were expanded using hydrological modeling techniques, which were complemented with field inspections.

The hydraulic analysis of the diversion channel contemplated, the integral study of all the existing components and structures and those that are designed to design, the alignment of the new channel and the problems that can be introduced in the area due to the new channel, flood plains and determination of the long water profiles of the diversion channel. In order to model the whole system to determine all problems and recommend their solutions in the most economical way.

Within the hydraulic design of the canals, it was contemplated to take advantage of part of the existing channels in order to reduce excavation work. In addition, it is contemplated the construction of a vehicular bridge to give access to the west side of the channel and to the contractors who are going to be developing the works of excavation and construction of the new locks.

59. Amador´s Cruise Terminal Project

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Fred Cui

Consorcio Cruceros del Pacifico, Panama

Panamanian Maritime Authority (AMP) has defined the contract to studies, design and construction of the new Amador´s Cruise Terminal, as part of the celebration of 100th Year Flagging Ships.

Consorcio Cruceros del Pacifico, composed by the companies China Harbour Engineering Company (CHEC) and Jan de Nul, will be responsible to execute this Project that is considering the key to transform Panamanian´s cruise operations.

The robust growth of the cruise industry, the excellent location and the elevated level of connectivity of Panama, potentiate the development of the project for the preparation of studies, designs, development, approval of plans and construction of the Amador Cruise Terminal.

Aware of the global and regional growth of the cruise market and the new mega vessels that are sailing some, and in other manufacturing, it leads the National Government, through the Panama Maritime Authority, to make the decision to promote the construction of the new Cruise Terminal to operate at the entrance of the Panama Canal, specifically in Perico Island, Calzada of Amador, Panama City.

The Project must be carried out within 18 months, and will be operated under public administration, a measure that seek to ensure that this terminal provides a quality service to all operators interested in using it and not limiting the use to any shipping company.

For these operational purposes and to provide an efficient and excellent service, AMP has signed a cooperation agreement with Hamburg Port Authority, and has already start conversations with the port of Valparaiso in Chile, to technical agreements.

In accordance with the general terms of the Tender Document, the design of the new Terminal should accomplish with the minimum requirements set out in the PIANC Cruise Terminal Design Guide (Report 152-2016).

The Project includes the preparation of studies, designs, development, approval of plans and construction of the Amador Cruise Terminal, to be in Isla Perico, Panama, and is an integral part of the Amador Development Plan, which seeks to boost the economy of the sector, taking advantage of the strategic geographical location and the unbeatable natural conditions of the site.

The new Amador´s Cruise Terminal, has been conceptualized to operate under the philosophy of a "Home Port".

The Project includes the construction Terrestrial and Maritime Facilities:

- Terrestrial Facilities - Passengers´ Terminal Building
- Parking Area
- Treatment Plant and other infrastructure items

- Heliport
- Maritime Facilities – Pier to be used by 2 vessels, which one with a 5,000 passengers' capacity

Considering the characteristics of this Project and the opportunity that ACP will host the 34th PIANC World Congress 2018, in Panama City, we understand that will be a great opportunity to show this relevant initiative from AMP, and also to discuss about the experience to be working on a new Cruise Terminal Project.

60. Integrating Planning, Operational, and Risk Management Technologies to Drive Port Optimisation.

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Brendan Curtis

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Keywords: innovation, port expansion, channel depth optimisation, UKC, risk management, technology

Ports and shipping channels are critical components of many nations' transport infrastructure, and make a significant contribution to the economy. With increasing global trade comes further pressures on ports through greater volumes, larger vessels, and more demanding shipping schedules. This is occurring against a backdrop of increasing regulatory, environmental, and social requirements for port authorities and operators that makes development more challenging. Furthermore, port authorities often hold the dual responsibility of facilitating trade and ensuring port safety.

Advancements in technology from a range of fields in the maritime sector are enabling new solutions to these challenges. Developments include improvements in hydrodynamic modelling capabilities, high density bathymetric surveys, improvements in weather forecasting, cost effective access to real time met-ocean data, advancements in environmental data assimilation techniques, broad adoption of AIS and Electronic Navigational Charts (ENCs), and high precision measurement of vessel motions in full scale and real time using DGPS and IMU technologies. Each of these developments individually has provided benefits to the industry. However, the greatest benefits, from the dual perspectives of risk management and efficiency, are realised when they are integrated and implemented across both the planning and operations of a port.

Static rules are the mechanism by which shippers and regulatory authorities have traditionally managed the under keel clearance (UKC) of a vessel. Static rules typically comprise a fixed UKC requirement to determine times of sailings and/or maximum sailing drafts. This fixed UKC requirement must account for a range of conditions, and does not consider individually the factors that influence UKC.

In reality these factors change dynamically depending on vessel, channel and environmental conditions. The implication is that the static UKC rules typically must account for some level of uncertainty to accommodate the expected range of scenarios and conditions. Adopting a one size fits all approach generally results in an inefficient operation. Furthermore, the assumptions on which the static UKC rules were originally based also change over time. Often, the static UKC rules themselves are not reviewed in line with the changes to the underlying assumptions. Examples of changes to port operations that may influence the applicability of a static UKC regime include vessel size, transit speed, channel depth profile, transit time, and changes to port layout resulting from new berths or dredging.

To highlight the changing nature of the port operating environment, this paper presents a number of examples where assumptions about the operations have been incorrect, and consequently, the design or procedures have required amendment.

The paper culminates with three case studies for the Ports of Port Hedland, Whyalla and Geelong, to examine how a suite of integrated software solutions deliver increased safety and improved operational performance. This is achieved through a consistent approach to port planning, capital and maintenance dredging, vessel fleet planning and chartering, vessel transit planning, and real time in-transit monitoring.

The ports of Geelong, Whyalla, and Port Hedland differ significantly in terms of operations, volumes, trade, environmental conditions, channel profiles, and port layouts. Despite these differences, and the unique challenges they present, the same risk management technology has been for tailored for use at each to improve the shipping efficiencies, thereby achieving significant increases in throughput and reductions in freight costs.

With ever increasing scrutiny on the financial and environmental credentials of ports, and higher expectations from ports' customers, stakeholders and local community, particularly with respect to dredging, it is imperative that ports continue to apply best practice with respect to risk management, and be in a position to demonstrate the value delivered from capital investments and operational decisions. The suite of tools presented herein provide port authorities and operators with a comprehensive solution to manage risk, and analyse and evaluate decisions, both planning and operational. This helps ports meet their commercial demands whilst ensuring vessel safety and channel integrity.

61. A simplified approach to operationalise UKC calculations

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Introduction

The widening of the Panama Canal together with the larger new-generation vessels in operation means that port authorities and pilots are being challenged to handle larger vessels than they are accustomed to. This means that they are having to make critical safety judgements on situations for which they have not had years of experience to build up an empirical understanding across a range of weather conditions.

One aspect ports are concerned about is the under-keel clearance implications of these unfamiliar vessels. These uncertainties, along with the growing acceptance of the limitations associated with the traditional static under-keel clearance (UKC) rules and the use of subjective personal judgment, have encouraged ports to seek better ways to manager UKC risks. Traditional static UKC rules can be unsafe, the challenge is to know when.

While there are advanced systems such as DUKC® which manage all aspects of UKC advice for a port, such highly advanced and bespoke systems may not meet the needs of ports with simpler requirements. Recent developments in technology now mean that there is a simpler option for ports seeking to reduce the uncertainty around sailing decisions.

Easy accessibility to UKC calculators

The first step to improve UKC management is to facilitate access to UKC calculators. PIANC publications like “Harbour Approach Channels Design Guidelines” have numerous examples of formulae developed by specialist researchers. While these publications are generally focussed on design and are targeted at the port design engineer, they obviously have broader applicability and can be used to assess operational UKC requirements. However, simple and efficient access to these formulae has been limited, with the descriptions hidden in manuals and applicability cases hard to decide on the fly.

Lack of easy access has resulted in some pilots coding simplistic formulae into computer spreadsheets. This approach has several flaws

-Risk of calculation error (In formula)

-Risk of applying outside range of applicability

-Lack of information about the considerable range of formulae / uncertainty levels

To address these issues online calculators are now available that allow pilots to simply apply the formulae to their port and proposed transit and the result is calculated. To date formulae for Squat, Wave Response, Wind heel, Turning heel and Stability have been made available.

An additional advantage of the having multiple formulae available can indicate the uncertainty associated with the formulae. For example, many empirical squat formulae are derived by fitting theoretical formulae to data measured in the field or in towing tank experiments. Like all such approaches there is an uncertainty associated with the results of these formulae – and

these uncertainties are often described in the original literature. However, once these formulae are adopted in publications like PIANC, the details of the uncertainty are lost. A practitioner thus relying on a single formula without information about its uncertainty will psychologically start to give more credence to the result that may be due. However, when presented with a simple calculator that presents a series of seemingly equivalent formulae with different results, the same practitioner may more clearly appreciate the underling uncertainties.

Ready access to environmental observations and forecasts

Environmental information is as important as the underlying equations driving the UKC calculations. Real-time weather data such a tide gauges, wind sensors or wave buoys, are required to obtain a complete picture of the conditions in the port's region. The lack of such equipment is often a limitation in UKC risk management for many harbours around the world. Previously, access to this type of data was limited by cost, but in the past year a series of light weight wave measurement devices have entered the market with the potential to make access to real-time wave data much more accessible to ports with cost constraints.

In addition to instantaneous environment monitoring, the path to improved safety during vessel transits requires an appropriate understanding of the future weather conditions. Safety and operability planning are now made possible by modern technology developments, enabling port-specific high-resolution weather forecasting to be delivered anywhere in the world. Ports worldwide can now benefit from 7-day high resolution forecasts accessible through an online subscription system.

Bridging the gap from the past, and a port's traditional static UKC management rules, the present through real-time monitoring systems, and the future accessed through state-of-the-art forecasting solutions and UKC predictions, PortWeather provides a unique decision-support platform empowering all port users.

User experience

Ultimately the successes of a simplified approach to operationalise UKC calculations depends on how the users respond. To date feedback has been positive with many ports and pilots responding well to the ability to be more involved with the UKC decision making. We are working with a number of ports interested in the technology to streamline the use of the online UKC calculators and make them more efficient for daily professional use. Indeed, some pilots in New Zealand have begun to adopt these techniques into their operations, using the calculators and forecasted environmental conditions to assess the UKC prior to undertaking a transit.

Summary

The lack of easy access to UKC calculators and limited access to environmental information has meant that ports have relied on personal judgement and simplistic static UKC rules. Based on such limited information these rules tend to be either unnecessarily conservative or occasionally risky. However, with freely available web-deployed UKC calculators and subscription services offering high resolution environmental forecasts for ports around the world, port users can now make much better-informed operational decisions.

62. Long-term Sediment Management Planning at North America's Largest Port Complex: Balancing the Need to Accommodate the Largest Ships while Complying with Complex Environmental Requirements

044

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Port growth is an important economic investment and ports are performing infrastructure improvements that include larger cranes, higher capacity backlands for quicker through port transfer, greater inland infrastructure, and deeper drafts. The dimensions of the world-wide fleet of container vessels have increased significantly in the last ten years, and it is anticipated that this trend will continue into the future as shipping companies continue to consolidate. As a result, ports throughout the United States have been actively positioning themselves to accommodate larger vessels to maintain or grow trade opportunities. While market pressures are driving the Ports of Long Beach and Los Angeles to deepen/redevelop their berths, tightening regulations that limit cost effective sediment management options like ocean disposal have created new challenges for Port staff.

Planning for large dredging/redevelopment projects frequently entails unique engineering and environmental challenges. The financial and environmental feasibility of these projects is often dependent on the management of contaminated sediments or large quantities of clean sediment that must be undertaken within region-specific regulatory requirements. In California, several regulatory authorities oversee the movement and disposal of sediment. They make up the Los Angeles Regional Contaminated Sediments Task Force and include: U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, National Marine Fisheries Service, U. S. Fish and Wildlife Service, California Coastal Commission, Los Angeles Regional Water Quality Control Board, and California Department of Fish and Wildlife. Dredging and disposal activities are also watched closely by local non-governmental organizations to ensure that regional initiatives like the promotion of beneficial reuse opportunities are being met. In the Los Angeles region, the preferred management strategy for clean sediments is beach nourishment and port fills. Management strategies for contaminated sediments,

in order of preference, include beneficial reuse of sediments in construction fill (e.g., nearshore confined disposal facility), temporary storage in an approved upland area (until a fill project becomes available), treatment and reuse as a marketable product (e.g., cement-stabilized fill), or for other beneficial upland placement areas. The ports do not necessarily have planned fill opportunities to align with maintenance and capital dredging projects; therefore, the ports have been helping the regulators recognize the need for regional opportunities to manage both clean and contaminated sediments effectively and efficiently. Both ports have developed sediment management guidance documents and contaminated sediment management plans to provide clarity in the ports' decision processes, and to prioritize management strategies that are feasible for implementation within a working port.

Through frequent communication with the regulators, the ports have been able to generate renewed interest in confined aquatic disposal facilities and shallow water habitat enhancement

opportunities because of the need to identify economical and logistically feasible management alternatives for clean and contaminated sediments beyond use as port fill material. Creation of biologically valuable habitat with dredged material has the added value of providing mitigation credit for port development projects.

This talk focuses on the Ports' sediment management challenges and discusses the research conducted over the last few years to identify suitable sediment management alternatives at the nation's largest ports, Port of Los Angeles and Port of Long Beach.

63. New Guidance on Carbon Management for Port and Navigation Infrastructure

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There is international scientific consensus that anthropogenic emissions of greenhouse gases (GHGs)**[1]** have and will continue to contribute to changes in the global climate. Although there is uncertainty concerning the magnitude, rate, and ultimate effects of this change, it is generally accepted that climate change will result in a number of substantial adverse environmental impacts. In 2013, the Intergovernmental Panel on Climate Change (IPCC) began releasing components of its Fifth Assessment Report,**[2]** providing a comprehensive assessment of climate change science. The Fifth Assessment Report states that there is a scientific consensus that the global increases in GHGs since 1750 are mainly due to human activities such as fossil fuel use, land use change (e.g., deforestation), and agriculture. In addition, the report states that it is likely that these changes in GHG concentrations have contributed to global warming.

The Paris Agreement**[3]**, developed at COP21 in December 2015, is an international agreement among parties in the United Nations Framework Convention on Climate Change (UNFCCC). The central aim of the Paris Agreement is to maintain the global temperature rise in the 21st century below 2 degrees Celsius above pre-industrial levels. Furthermore, the Paris Agreement provides for increased transparency, requires all Parties to maintain and communicate "nationally determined contributions" that they intend to achieve, and aims to erect financial and technology frameworks for reaching the climate goals it puts forth. The agreement addresses a range of areas necessary to combat climate change, including a long-term temperature goal, global peaking of GHG emissions, mitigation, and a "global stocktake" every five years.

Given this context, there is growing regulatory interest globally in managing the GHG emissions, or "carbon footprint", of industrial activities to respond to climate change. Effective carbon management involves steps to reduce and offset GHG emissions and sequester carbon. While the International Maritime Organization (IMO) under the UNFCCC has recently spent efforts to reach agreement on a global approach to reduce international shipping GHG emissions, there has been much less focus on the infrastructure that supports waterborne transport. PIANC and its partners in the Think Climate coalition are working to fill this gap.**[4]** Taking proactive steps to effectively manage carbon will help the navigation sector: 1) comply with emerging regulatory requirements, 2) respond to general stakeholder and public pressure to reduce environmental burdens, 3) take a leadership role in carbon management practices, and 4) drive innovation and investment while influencing future practice and regulation.[5] In addition, there are unique opportunities to reduce and offset emissions from waterways navigation infrastructure development, including dredging and the beneficial use of dredged sediments, which need to be addressed in any carbon management framework.

PIANC's Work Group (WG) 188 on Carbon Management for Port and Navigation Infrastructure is tasked by PIANC**[5]** to review and report on the technical literature related to the carbon

footprint of navigation infrastructure and supporting activities, provide guidance on applying life cycle analysis and related assessment tools and techniques, and investigate opportunities for reducing atmospheric GHGs through operational practices, Working with Nature, land use management, blue carbon projects, and related environmental management. In this talk, WG188 progress on the development of new guidance on carbon management framework considerations for navigation infrastructure and example case studies will be discussed.

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[1] For the purposes of this presentation, the terms “GHGs” and “carbon” emissions refer to those gases regulated under the Kyoto Protocol of the UNFCCC: carbon dioxide, methane, nitrous oxide, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride.

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[3] Text of the Paris Agreement, accessed December 29, 2016. **http://unfccc.int/paris_agreement/items/9485.php**

[4] Navigating a Changing Climate. 2016. Action Plan of the PIANC Think Climate Coalition. November. Accessed December 29, 2016. **http://navclimate.pianc.org/about/action-plan/download/20_343c041d3eaefbfe8021913973f54ee7**

[5] PIANC. 2015. Terms of Reference for Work Group 188. July. Accessed December 29, 2016. **http://www.pianc.org/downloads/envicom/tor%20188%20final.pdf**

64. Towards an ecosystem-based port design process: Lessons learnt from Tema port, Ghana

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Traditionally, ports are designed for their primary economic function - to accommodate trade. Often the ecological and social aspects are not an integral part of the port design process, but are dealt with to a limited extent or at a later stage through mitigation and compensation measures. As a consequence opportunities to create added value may be missed. A growing consensus recognizes the need for sustainable port development, aimed at finding a balance between economic, ecological and social aspects. However, in practice, an integrated inter-disciplinary approach, which embraces all of these aspects, is missing. An international, collaborative research project was initiated to address this need, by developing an integrated framework for sustainable port design combining the engineering, economic, ecological and social aspects. In the Sustainable Ports project, a stakeholder-inclusive approach is followed to identify which ecosystem values and services are important to stakeholders. This paper focuses on the integrated, ecosystem-based approach to port design, which takes into account the identified ecosystem values and services. The expansion of port of Tema in Ghana, which is currently in the construction phase, serves as the case study.

An ecosystem-based port design aims to include ecosystems and the services they offer to human beings (e.g. ecosystem services) as an integral part of the design process from the early stages. In this way it aims to generate added value in terms of user functions such as food production, coastal protection, recreation and cultural heritage. Furthermore, ecosystem-based design can help to avoid failing to pass environmental impact assessment requirements - the “green handbrake” and, hence, create opportunities for a wider range of (port) developments. Based on literature research, project experience and interviews Slinger and Nava Guerrera (2016) distilled 11 criteria for ecosystem-based design, namely (1) continuity, (2) limited direct human disturbances, (3) endogeneity, (4) species population viability, (5) opportunity for threatened species, (6) trophic web integrity, (7) opportunities for ecological succession, (8) zone integrity, (9) characteristic (in)organic cycles, (10) characteristic physical-chemical water quality and (11) resilience. These criteria serve to provide ecological design principles that are then combined with the more common geophysical and engineering design principles (Slinger, 2016) for port design, such as accessibility, structural integrity, reliability and implementability. The ecological and engineering principles are sometimes conflicting and inherently require trade-offs in the design choices that are made with regard to port location, lay-out, structures and materials. However, our integrated ecosystem-based method shows that they can also be complementary and offer new opportunities for port developments.

In this paper we describe the results and lessons learnt on the case study of Tema port in Ghana. We demonstrate the identified trade-offs and the opportunities of ecosystem-based design following the above principles. Furthermore, we provide examples of the alternative design choices that could/can be made in moving from ecological compensation and mitigation to a more creative, ecosystem-based design approach. Next steps focus on how to evaluate

and quantify the economic and social costs and benefits and how to account for future developments such as climate change and changing markets in ecosystem-based port design.

Why this presentation will be interesting/ useful for the conference attendees?

After this presentation the attendees will understand the importance and potential added value of an ecosystem-based approach, and consider taking this into account earlier in the design process. More potential win-win situations in port design can potentially result.

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65. The diversifying business of Port authorities: from commercial ports to commercial waterfronts

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In the past decade, it is observed that port authorities have become active in developing port lands, either obsolete old port areas or actively acquired lands, into urban waterfronts.

Why do port authorities do so? Part of the answer is because of the global financial crisis. With the ports facing declines of their cargo volumes, they have actively sought other means of business, diversifying their portfolio. Another reason is that port authorities believe in urban waterfronts as revenue generators. Employment is a third reason why port authorities seek opportunities in urban waterfront development.

At first glance, it does make sense: ports are workig waterfronts, port authorities have the experience of using the water's edge to generate profit from leasing it or giving it in concession to parties that use both the land and water for their business.

However, developing and operating a commercial waterfront and marina, is something different after all. Port authorities experience difficulties in setting up the corrent business case for such urban waterfronts, as they do not have the experience in combining real estate knowledge with water related leisure knowledge and they often lack an appropriate management organisation to plan, realise and operate such a facility.

Two very different examples will be provided to showcase the challenges of a port authority when embarking on a waterfront development mission.

1. Walvis Bay

The port authority in Walvis Bay owns most of the coastal zone directly adjacent to the urban areas of the city of Walvis Bay. The port is very successful and is undergoing a program of major expansion of the commercial port facilities. The port authority acknowledges that due to its activities, there is little land left for the citizens to enjoy the views of the coastal lagoon.

The port authority therefore has earmarked a large plot of obsolete port area for development into a waterfront and marina development project to cater for the Walvis Bay citizens as well as for tourists. Plans have been drafted to develop a new mixed use area, with various residential and commercial functions. A small marina facility complements the new urban and public waterfront. The port authority requested support on the development concept for the project. How to create a business case, what elements should it consist of, what role should the port authority take on and how could the new marina and waterfront best be connected to the commercial sea port, where a large cruise terminal was going to be realised adjacent to the project. These questions have been transferred into a development strategy for the project. The port authority has taken these suggestions on board and is currently developing the plans together with project developers to the next stage.

1. Kuwait

In Kuwait, the port authority not only manages the commercial sea ports, but is also responsible for smaller facilities used by(recreational) fishermen. The cultural heritage of the country is connected to the sea, where trading, pearl diving and fishing have been the main sources of economic development until oil was discovered. These small ports are dotted along the long coast line of Kuwait. Some of these facilities are very rudimental, and the port authority, as part of the Kuwait government, has embarked on a plan to develop some of these locations to modern marinas and waterfronts. In this case, the port has been assigned the use right of the land and water in the specific spots and wants to create a vision and design to realise not only a new recreational fishing facility, but to create a world class waterfront that will attract local citizens as well as international tourists. The reason to create this project is to provide Kuwait with:

- More yachting facilities, as Kuwait lacks sufficient berthing for certain types of yachts
- New public waterfront space, as most of the waterfront is private, either by hotels or clubs, or with beachfront residences.
- New urban hotspots, such as commercial real estate (mall, entertainment, hotel, etc.)

The port authority embarks on this project as it sees a new way of business and revenue generation. The current development plans will provide designs and the capex side of the business case.

Concluding, it is observed that ports seek new business diversification, by means of developing their waterfront land (and water) into urban marinas and waterfronts. Generating profits from real estate and marina operation is a new means of business for port authorities, where earlier this was mainly the domain of municipal bodies and real estate developers. Having the land and water as their assets, port authorities can have a very strategic position to develop these projects. However, running urban marinas and waterfronts requires different knowledge and skills than operating a sea port. Successful examples exist, where broad minded port authorities have taken on board the knowledge of marina and waterfront development and operation, and have set up dedicated teams in their organisation to oversee this specific business.

66. Towards improved prediction of dredging plumes: numerical and physical modelling

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INTRODUCTION

Construction and maintenance of ports and waterways involves dredging activities in many cases. Dredging projects require assessment and mitigation of a number of environmental impacts. Some of the potential impacts are related to turbidity plumes resulting from hydraulic and mechanical processes bringing sediment into suspension. To limit the impact on sensitive habitats (eg. corals & seagrasss habitats) or nearby human activities, monitoring and predictive numerical modelling of the fate of these plumes is required. The extent of the impacts will depend on the quantity, frequency and duration of dredging, adopted methodology, site-specific conditions (wind, wave and current fields, grain-size distribution and water depth), proximity to sensitive sites and tolerance of living organisms to altered turbidity conditions.

Increased awareness has instigated stricter environmental legislation related to these activities. Project environmental permits often stipulate project-specific regulations, which can entail strict turbidity thresholds for these activities. Operational turbidity management in these projects is warranted, as exceeding turbidity thresholds can trigger corrective measures, increased monitoring efforts, relocation of dredge activity, a decrease in or –worst case - a cease of dredging and dredge spoil placement activities. The modelling tools presented in this paper add to the development of a system with which accurate real-time forecasting of the plume behaviour can be achieved. The operational planning of dredge operations a few days to a week ahead can be implemented in this forecasting environment. In case a violation of turbidity thresholds is predicted by the models, the operational planning is revised until no violations are predicted.

Trailer Suction Hopper Dredgers (TSHD's) often deploy an overflow system through which excess sea water is skimmed from the hopper. The overflown mixture contains a mass load of fine sediment material, partially descending gravitationally to the seabed, partially diluted to form passive turbidity plumes, often visible at the surface. A low excess density avoids the gravitational descent of passive plumes. Depending on the settling velocity of the sediments and on the degree of turbulent mixing, these plumes can travel over long distances. The plumes can therefore affect environmentally sensitive areas throughout coastal, river or offshore systems away from the dredging site.

An important open question in the research field of dredge plume forecasting has long been the determination of the fraction of released fine sediments entering the passive plume (and the remaining part sinking gravitationally to the seabed).

In the presented work, the highly complex, three-dimensional, multiphase flows of water-sediment-air mixtures near the overflow release have been studied using a physical model as well as Computational Fluid Dynamics (CFD). The insights gained from these modelling exercises lead to the development of a fast parameterised prediction model. At present, engineers at IMDC have coupled this parameter model to the existing far-field plume dispersion model codes, with improved plume dispersion accuracy as a result. In this paper, an overview

is given of the different near-field plume modelling tools developed during the project, and their current application to the improvement of turbidity assessment in planning phase and in operational phase. The presented research was initiated and executed at IMDC with support of Ghent University, KULeuven and Flanders' Agency for Innovation by Science and Technology (IWT). The authors have also recieved the PIANC De Paepe-Willems Award 2017 for the presented work.

Near-field CFD Model

A 3D numerical simulation model has been developed in the Ansys Fluent environment. The aim of the CFD model is to represent accurately the flow patterns of the water-sediment-air mixture in the direct vicinity of a hopper dredger while trailing. The CFD model solves for the 3D velocity vectors and diffusion of three phases: water, sediments and air bubbles. The actual geometry of an existing TSHD is embedded in the model grid. The model includes the mixing induced by the propeller jets and solves explicitly a large part of turbulent motions.

The CFD model was validated against both the physical model and against in situ measurements, taken behind a TSHD at work. After validation of this highly detailed simulation tool, the model has been used for two main applications:

1. Gaining insight in the behaviour of the near-field plumes under a variety of circumstances: different current velocity, dredging speed, sediment load, air bubble entrainment, the efficiency of a green valve, the shape of the overflow shaft, water depth, distance of the overflow from the stern and propeller mixing.
2. Derivation of a grey-box parameter model solving the vertical profile of the plume's sediment flux near the vessel. The model is based both on analytical plume solutions and empirical parameters, fitted to match the CFD results of a large number of cases.

Near-field Parameter model

A parameterised model is a trade-off between speed and accuracy. It will be less accurate compared to a CFD model, but will be fast enough to be applicable in cases where the CFD model simulation times are prohibitive, e.g. plume scenario simulations and real-time forecasting simulations. The parameter model is validated for a large range of boundary conditions and can be used to determine near-field plume behaviour in a large-scale model, as a function of time-varying water depth, currents and dredging vessel operation.

Discussion and conclusion

The sediment flux profiles generated by the grey-box parameter model can be imposed as source terms in a large-scale plume dispersion model, where the parameter model inputs are coupled with the large-scale flow properties. In this way, the fraction of released sediments moving to the large passive plume is determined every time step. This is a significant improvement over the rather arbitrarily chosen constant value used in the past.

Currently, the grey-box model is applied by consulting engineers at IMDC during environmental impact assessment of port development and maintenance, both in scenario analysis and in a real-time plume forecasting system.

Additionally, the model is to be applied as a tool to optimise the design of future dredging vessels to minimise the expected turbidity generation.

67. Physical and Numerical Modelling of Ships Moored in Ports

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CONTEXT AND OBJECTIVES

Study of moored vessel in presence of waves is a very important issue for all harbour design project as vessel dynamic behavior has a direct impact on safety of (un)loading operation as well as on berth equipments (mooring lines & fenders) integrity. In addition, waves conditions are one of the main factors which could affect the berth operational downtime. As this downtime shall be very low to ensure cost-effectiveness of port, it shall be demonstrated that waves induced motion are acceptable to enable (un)loading operations in presence of the most frequent waves conditions.

Different numerical tools are available to perform dynamic mooring analysis of ships exposed to waves. However, despite the fact that these tools are very efficient to simulate rapidly a large amount of different environnemental and mooring conditions, some parameters used in these numerical models need to be calibrated from physical model tests measurements. Physical model tests are hence required to calibrate numerical simulations but are also necessary to model some specific hydrodynamic complex configurations for which numerical approach is not sufficient (as moored vessel close to rubble-mound breakwater for instance).

In order to improve the reliability and relevancy of numerical mooring analysis as well as to improve our understanding of some specific hydrodynamic complex configurations, a research project has been launched in ARTELIA hydraulic laboratory which consists in carrying out series of physical modelling tests to provide relevant experience feedbacks for numerical modelling.

DESCRIPTION OF THE MODEL AND TESTS CAMPAIGN

The physical model built in one of ARTELIA laboratory wave basin (30m long by 16m wide) consists in a Froude scaling at 1/80 scale of a LNG carrier vessel moored at a typical LNG terminal berth.

The LNG carrier vessel model (3.6m long) represents a spherical LNG carrier vessel of about 130 000m3 capacity moored at a berth composed of 6 mooring dolphins and 2 breasting dolphins in shallow water depths ranging from 14m to 18m. In addition, for some tests, some harbour structures (such as quays or rubble mound breakwater) are implemented into the model to analyse the impact of different kinds of structures (fully or partially reflecting the waves) on moored vessel behaviour. This mooring configuration in shallow water and in presence of harbour structures represents the context of typical harbour design project performed in ARTELIA.

Different wave incidences, water depths and wave conditions (in terms of Hm0, Tp) have been tested.

Tensions in mooring lines and forces in fenders have been measured by load cells based on strain gauge technology and motions of ship in the six degrees of freedom have been measured by Qualisys system infrared cameras. In addition, five wave gauges have been

installed in the basin to control incident wave conditions. All data have been monitored and recorded during the 3 hours (prototype scale) of each test.

Then, a corresponding numerical model has been developed using DiodoreTM hydrodynamic software for comparison purpose and further numerical model calibration on the basis of physical model results.

The paper will describe in details the model set-up, the instrumentation, the ship model characteristics to comply to Froude scaling and the results of the physical and numerical models.

68. Inland Waterways design Guidelines - InCom WG141 results in perspective

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One of the important results of WG141 was a table showing the recommended dimensions of waterways compared to the width of the boat.

For the Boeotian, the decision-maker willing to understand what he signs, or an engineer faced with a waterway design for the first time, this table is of great interest, yet they lack understanding on how to choose one value rather than the other, and why/how these figures were arrived at.

There are factors of utmost importance, and to be answered before starting to calculate.

First, what is the Design boat, its width, draught, length and vertical “draught”. Most of the rest is based on this design boat. (But to fix the Design boat, you may need to study the waterway, first, see below).

Second, is it a free-flowing river, an impounded river or a canal ? The table to use is different in every case, although the usual reference is the table for canals.

Third, what is the design traffic, calculated in boat/year. Of course the margins of safety are not the same in light or very heavy traffic, but quite often the table is read as if the traffic were 200Mt/year, while it may be less than a million.

Fourth, assuming the waterway is a canal, what is its shape ? Trapezoidal, rectangular, KRT ? For each, the speed obtained by the design boat for the same consumption will be different.

The paper will give insights on how to gauge each factor, leaving intricate details to further, modelling studies. At times, we know the size of the waterway rather than the size of the boat, and we try to understand what will be the largest Design boat which can be accommodated in it. The same rules apply, turned the other way. The rationale for that will be explained.

It may happen that it is only one bottleneck which will limit or size the Design boat, a bridge or a lock; again, we can use the same references, read in a specific way, weighting the impact of the bottleneck in the global voyage.

In this way, it will be easy for the newcomers to fully make use of the WG141 Report, leaving to the full text of the report to provide all details of the calculations, formulas, modelling process, etc.

69. Panama Trade Logistics Integration Platform

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The 2030 National Logistics Strategy sets out to establish Panama as a global logistics hub. With disruptive technologies driving the digital transformation of trade logistics, the Panama Trade Logistics Integration Platform is an essential piece of the strategy. It serves as a single point of access for all stakeholders involved in the trade logistics processes.

The digital platform offers a Web Portal for traders, shipping lines, airlines, railways, truckers, cargo agents, customs brokers, banking, insurance, and legal firms to conduct business with Panamanian government agencies. It integrates the transactional information systems of government agencies, to orchestrate the administrative processes related to the import, export and transit of goods, in order to streamline trade logistics operations, leading to performance levels comparable to the best in the world.

Efficient intermodal logistics is enabled through interoperability with the Panama Maritime Single Window (a joint service of the Panama Canal Authority and the Panama Maritime Authority), the Panama Civil Aviation Authority, the Panama airports company (Tocumen, S.A.), the national highways company (ENA), the Panama Customs Authority, the Ministry of Agriculture, the Ministry of Health, and other regulatory agencies.

The purpose of the digital platform is to expedite the handling of cargo by means of electronic data interchange for submission of trade documentation at the time of departure from the country of origin, to allow for risk analysis in advance of the arrival at the port of discharge. The adoption of these standards and technical specifications enables interoperability with customs authorities and other government agencies of all countries, and compliance with bilateral, regional, such as the Central America Economic Integration System (SIECA), and global trade agreements, such as the Trade Facilitation Agreement (TFA), established in December 2013, by the World Trade Organization (WTO) when members concluded negotiations. The TFA provisions to expedite the movement, release and clearance of goods, including goods in transit. In addition, it lays down measures for effective cooperation between the Customs authorities and other competent authorities in matters concerning the fulfilment of customs procedures and trade facilitation. Members of the WTO adopted on November 27, 2014 a Protocol of amendment to insert the new agreement in annex 1A of the WTO agreement. The Republic of Panama enacted Law No. 55, on September 2015, for the adoption of the TFA, which entered into force on February 22, 2017, when two thirds of the WTO members completed internal ratification process.

In line with the World Trade Organization´s guide for the implementation of the TFA, Panama has adopted the standards and technical specifications issued by the United Nations Centre for Trade Facilitation and Electronic Business (UN/CEFACT) for message exchange, and the World Customs Organization WCO Data Model. The WCO Data Model has the following information:

The context of information exchange: Business Process Models

The content of information exchange: Data sets and Code lists

The structures of information exchange: Information models

The technical solutions for information exchange: UN/EDIFACT and XML message design.

The key components of the trade logistics digital platform are:

Information Bus, consisting of an Enterprise Service Bus (ESB), with business rules engine and business process orchestration for job scheduling.

Collaboration Portal in multiple languages (initially Spanish and English).

Platform Management, capable of handling of data streams, data categories, solution bundling, pipelines, events, and application development with a built in Integration Development Environment (IDE), and testing tools.

System Administration, capable of handling user and role based authentication, Web Services, file transmission utilities (FTPS, SMTP, SSH, SMB y NFS), credential providers, topology, instance clustering, messaging bus, data casting, document database, and search engine.

Security Management for each layer of the platform, and applications running on it. E-signature certificates will be provided by the National Directorate of Electronic Signature, a unit of the Public Registry of the Republic of Panama, which is based on standard X509 (https://www.firmaelectronica.gob.pa/).

Interface Management, capable of handling application connectors, remote calls, database connections, user credentials, identity and access management certificates, XML documents and schemas, XSL transformations, templates, diverse data formats, file system connections, and endpoints.

Data Management, that includes Master Data Management (MDM), systems single point of truth management, query management, Extraction Transformation and Loading (ETL), Data Warehousing, Online Analytics Processing (OLAP), and Business Intelligence (BI) scorecards and dashboards.

The traditional point-to-point integration approach generates a tangle of application dependencies that is very difficult and costly to maintain. Orchestration means integrating applications and/or services together to automate a process, or to synchronize data in real-time. Application orchestration provides for decoupling applications from each other, message routing, security, reliability, and centralized monitoring and management.

To make applications integration possible, the digital platform´s data transformation capacity is key, because data in different applications resides in different formats. Therefore, it is necessary to make data from one application or database available to other applications and databases by converting data from one format to another. Data is extracted from the source application or data warehouse, transformed into another format, and then loaded into the target application. ETL is the core of data integration.

The digital platform´s API Lifecycle Management capacity enables agility to create connectivity. Developers will be able to access endpoints and build connections without having in-depth knowledge of the applications. The Enterprise Service Bus (ESB) provides API-based connectivity with real-time integration, isolating applications and databases from one another by providing a middle service layer. Developers will be able to use pre-built connectors to easily create integrations without detailed knowledge of source or destination applications and/or databases, and will be able to make changes without risk to the entire integrated system.

Shielded by APIs, applications and databases can be modified and upgraded without undesirable consequences.

The digital platform implementation is carried out using the DevOps methodology, which focuses on operations early in the development process, allowing developers to produce higher quality code. Therefore, the platform enables continuous integration and efficient deployment with capabilities that address the full API lifecycle. It is expected that the Panama Trade Logistics Integration Platform will be operational by the end of 2018.

70. Numerical ship-wave generation, propagation and agitation analysis, related with harbor downtime management

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A statement to conference attendees:

An innovative numerical approach for ship-wave generation, propagation and interaction with inner harbor basins (agitation) is presented. This new tool will help harbour managers to early assess and manage ship speeds, trajectories and possible impacts/ affections related with their downtime analysis.

INTRODUCTION

The present study describes the set of works related with the numerical evaluation of waves generated by passing ships within the harbor. Ship-waves (or wake waves), are generated by the disturbance of the moving vessel, which delivers a set of oscillations that may interrupt or interfere the safe-mooring activities.

Since the energy, form and frequency of ship-waves depends on: speed, accelerations, track and geometry of the vessel; overall bathymetric contours; and wharf/ pier/ quay geometries, it is necessary to design a reliable tool that integrates all these characteristics.

Activities such (safe) loading and unloading of materials or passengers, navigation and sedimentary dynamics adjacent to harbour infrastructures (silting), are closely related with ship-wave generation and propagation.

Thus, the present study presents a numerical alternative to characterize this new type of forcing, with the aim to provide a new diagnosis system for any harbour manager. This innovative tool will provide a decision tool based on a realistic harbour agitation model, forced by a ship travelling inside real basins and harbors' domains, for any vessel/ operator/ route/ navigation protocol/ speed, etc.

Harbour managers will be able to evaluate the agitation effects, know and limit ship speeds, change routes, manage hours, and even change the ship geometries and sizes, in order to satisfy the Port Authority safety limits and to improve the downtime records.

METHODOLOGY

The methodology deals with the modification of a wave propagation numerical model, based on the non-linear and dispersive Boussinesq equations, by including the effect of the passing ship and the subsequent flow perturbation, propagation, and interaction with bathymetries docks AND basins.

The numerical strategy requires the establishment of a complete working methodology: pre-processing and adaptation of the bathymetric, port and AIS data (ship Automatic Identification

System), in order to provide an easy-to-use, relocable and reliable tool ready to be applied in any real harbor at any stage: pre-design, design, construction, operation and modification (extension, improvement, etc.).

Hence the following tasks were developed:

1. A state-of-the-art review related with the mathematical and numerical generation of the waves generated by passing ships, in order to identify the best strategy that suits the numerical needs.
2. Adaptation of the numerical tool to be used for a good ship-wave generation, taking into account the most relevant physical characteristics of the ship (speeds and geometries), as well as the spatial trajectories physics. This task involves an exhaustive validation process of the numerical tool using benchmark laboratory tests and field data.
3. A detailed guideline to numerically assimilate the ship routes, sizes and speeds for an extensive catalogue of ships for any Port Authority is presented, based on realistic AIS databases. This catalogue is used in the following tasks.
4. Run of the catalogue of ships with the numerical tool (once modified, adapted and validated), in order to obtain the corresponding characteristics of the ship-waves (individual wave heights and associated oscillation periods), at different pre-established control points and ship maneuvering areas.

RESULTS

As an example, the numerical tool/system is adapted and validated (with in situ measurements) in Algeciras Port in Spain, based on 2-year AIS database, including the numerical propagation of 40 different ship tracks. The system is actually integrated into Algeciras Port met-ocean strategy.

71. Multifunction of Inland Waterways Social and Environmental Awareness of IW Managers

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Waterways are more than just channels for waterborne transportation. Canals and rivers can fulfill many other functions for the benefit of the entire society or of parts of it.

The new Working Group WG 203, established in 2018 and still in the stage of kick-off is to combine the multifunction of waterways, given by the manifold uses with the awareness of IW managers for social and environmental issues being necessary for operating and maintaining the waterways in a sustainable way. IW managers have the key role by taking into account those issues in their day by day activities.

In a first part, the WG is to focus on the general concept “Social and Environmental Awareness of Waterborne Infrastructure Managers”, also called CSR (Corporate Social Responsibility). Then, in a second part, subtitled “Multifunction of Inland Waterways – Chances and Challenges for IW Managers“examples and case studies showing how these concepts of “Social and Environmental Awareness” and “Multifunction of IW (also called Co-Creation)” are suitable to establish an useful guideline for IW managers will be given.

The session’s presentations will reflect both parts, as follows:

1. Introduction into the topic of WG 203, coming from the Terms of References (TOR)

2. What is "Corporate Social Responsibility (CSR)”?

This presentation gives an overview what CSR means and how this, at a first glimpse, more philosophical concept can be applied through the reality and further development of the Multifunction of Inland Waterways, which are chance and challenge for IW Managers at the same time.

3. Presentation on Values or Uses of Inland Waterways

The presentation reflects on the outcome of the former InCom Working Group 139 describing the 12 principal uses of inland waterways, which are navigational, but also non-navigational uses and how these uses can be evaluated in terms of economic, social or environmental aspects.

4. Context of Values or Uses of and Interests in Inland Waterways

The uses as described are suitable to make the waterways more attractive to large parts of our society, represented by a wide range of stakeholders. The presentation will show how the complex of interests and the belonging stakeholders challenges the regular acting of IW managers.

5. How to go on?

Concluding and summarizing the results so far. This part of the session will give thesis and open questions on how to use the concept of CSR for IW managers, giving them a guideline for working with people and their interests. The opportunity for discussion will be given.

72. Belgian Royal decree for sea-going inland vessels: a review for container and bulk cargo vessels.

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Statement :

The Belgian Royal Decree for the navigation at sea of inland vessels allows short trajectories in coastal waters, between two Belgian ports, given that certain safety requirements are met. This is a very useful approach to tackle lacks in the inland waterways network with temporal and economic scales orders of magnitude lower than the ones associated with a renewal of the waterways infrastructure. While the study is focused on Belgian coastal water, the general concept of the probabilistic sea-keeping analysis can be applied to any other area of interest where an extension of the operational range of inland vessels could benefit the total efficiency of waterborne transport.

Abstract :

The Belgian Royal Decree of 2007 [1] allows inland vessels meeting certain requirements to perform a non-international sea journey. In order to allow an inland vessel at sea, the Royal Decree stipulates stability requirements as well as the need to perform a full probabilistic analysis to assess the behaviour of the vessel in waves. The risk analysis is exempted for tankers and closed hatch vessels sailing up to 1.2 m significant wave height. For such vessels, deterministic requirements on the freeboard replace the probabilistic analysis of vertical relative motions.

After ten years of practice, the need to evaluate the performances of the Royal Decree arose, in particular with respect to inland container and bulk cargo vessels, for which the deterministic exemption is not applicable. In the present work, four reference vessels are selected as representative examples of existing container/bulk cargo vessels based on an extensive study on the current European inland fleet. For each of the four reference vessels, the possible range of loading conditions is investigated and three significant conditions are selected. Finally, the Royal decree requirements regarding stability and vertical relative motions are analysed in detail for each vessel and loading condition.

Based on the results of the analysis, a new set of deterministic requirements for the distance between the free water surface and stipulated reference levels is proposed. These rules are applicable to all types of inland vessels and could replace the existing exceptions for tankers and closed hatch vessels. Therefore, all types of inland vessels could obtain a certificate to sail in significant wave heights up to 1.2 m based only on deterministic requirements. This goes hand in hand with the new regulation imposed by Bureau Veritas, which allows all types of inland vessels to obtain a certificate for sailing between 0.6 and 2.0 m significant wave height, using the IN(x) notation. [2].

As for stability, the actual requirements in the Royal Decree mirror the ones prescribed for ocean going vessels by the International Code for Intact Stability. The present analysis points

out that such requirements are too strict to be met by standard inland vessels. Therefore, new stability rules are proposed which impose similar values for dynamic stability reserves, but up to the low flooding angles attained by inland vessels. Moreover, the environmental loads considered in the Weather Criterion, designed for heavy beam seas at ocean storm conditions, are replaced by lower figures, more appropriate for the met-ocean conditions expected along the coastal trajectory.

[1] Belgisch Staatsblad (2007) “Koninklijk besluit betreffende binnenschepen die ook voor niet-internationale zeereizen worden gebruikt”. BS, 16.03.2007, N. 2007 – 1187, p. 14699-14711

[2] Bureau Veritas (2014) “Rules for the Classification of Inland Navigation Vessels – November 2014 Edition”.

73. Spectral modeling of wave propagation in coastal areas with a harbor navigation channel

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This study presents a comparison of numerical model results and laboratory experiments of wave propagation in a coastal area with a harbor navigation channel. The results of wave models SWASH, SWAN and HARES are compared with physical model results in order to investigate the performance of these models. It turns out that HARES, a 2D parallel spectral wave model based on the Mild-Slope Equation with non-linear damping, yields the most accurate results and a computational time that is only a small fraction of the time needed by SWASH. It appears that the large computational effort and resolution required by full 3D time-dependent wave models like SWASH may prevent them from exploiting their full potential accuracy, even though they contain all relevant physics for wave propagation. Furthermore, the phase-resolving wave modeling approach used by both HARES and SWASH yields more accurate results than the phase-averaged approach used by SWAN when channel reflection and diffraction effects are involved, which can be important in the vicinity of harbor navigation channels. HARES combines the advantages of a stationary and two-dimensional calculation (enabling sufficient model resolution at low cost) with a phase-resolving modeling approach. This underlines the ongoing applicability of mild-slope wave models like HARES in practice and makes them a preferable tool for the design of harbor layouts.

74. Environmental and societal benefits of Onshore Power Supply for Inland Navigation in Flanders (Belgium)

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The use of the auxiliary engines by ships when at berth causes greenhouse gas emissions, air quality emissions and noise pollution in the port areas, which are often located in or near cities. Onshore Power Supply (OPS) is an option to provide electricity to the ships from the national grid and to reduce the unwanted environmental impact of ships at berths. In recent years, the interest in the use of OPS has strongly increased in the Flemish ports and inland waterways. One of the actions to encourage the expansion of onshore power facilities was the setup of the Flemish Shore Power Platform (www.binnenvaartservices.be) which coordinates all actions related to the use, implementation and expansion of this environmentally friendly technology for inland navigation in Flanders.

Data on electricity consumption by a specific ship from two European projects (TEN-T project “Shore Power in Flanders” and CLean INland SHipping project) has been used to quantify the benefit of reducing the emissions of NOx, SO2, PM and CO2 that would occur by using onshore power supply. Emissions through the use of auxiliary engines (diesel-related emissions), Emissions through the use of OPS (electricity-related emissions), and Net reduced emissions through the introduction of OPS have been calculated. The results demonstrated that OPS can significantly reduce diesel-related emissions from ships at berth. Through the introduction of OPS the emissions of NOX can be reduced by about 93%. The emissions of PM10 can be reduced by 99% and the emissions of SO2 by more than 96%. The emissions of CO2 can be reduced by more than 90%. The reduced emission of C02 in this study is high compared to other studies, this is due to the low CO2 emission factor for electricity production in Belgium that we applied in our calculations.

In 2016, the use of OPS at only two locations has generated a total societal benefit of € 53,814. The overall use of OPS for only inland navigation in 2016 in the port of Antwerp was 766 MWh, represents a societal benefit of € 108,381. We conclude from our analysis of the evidence that providing an onshore power supply for vessels at berth can result in significant environmental and societal gains. A communication strategy should be put in place, focusing on adequately informing and thereby stimulating the use of onshore power supply. The results of this paper can be used as basis information to convince the ship-owners of the environmental and societal benefits of OPS. River cruisers have higher power and electricity demand providing a better business case for OPS for inland navigation and a better prospect for market development. Policy makers could produce more net societal gain by implementing incentives and mandates to encourage more shift toward OPS.

75. Single Point Yacht Moorings, Working Group 168

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Single point moorings are often provided by port authorities and marina operators as a facility for visitors at locations where there is poor holding ground, deep water, insufficient slips at docks, or where there is a requirement to moor boats more densely than can be achieved using the yachts' own anchors. In addition, at some locations, anchor damage to sensitive seabed ecology can be minimized by the provision of moorings. Finally, at some locations, visiting yachts are an important contributor to the economy. If these locations are exposed, the difficulties of anchoring or unsafe conditions means that many yachts will not visit unless secure moorings are provided.

There is a lack of clear guidance for several aspects of single point yacht moorings. Therefore, PIANC Working Group 168 (WG 168) was formed to provide guidelines for the design, installation and maintenance of these type of moorings to designers and operators.

The presentation will provide a description of the work performed by WG 168 and an overview of the guidelines, which focused on the following aspects of single point yacht moorings:

- Design Principles
- Type of Mooring Systems
- Components
- Design
- Installation
- Maintenance
- Case Studies

There are several types of yacht mooring systems but, regardless of type, all must be designed following similar design principles. These include functional, regulatory, environmental, constructability, operational, maintenance, and economic principles. The WG 168 reviewed these principles, and provided designers and operators with guidelines that would achieve designs that balance all these principles.

Single point yacht mooring systems such as catenary, conservation and trot systems are described and application areas discussed. In addition, to offer a perspective and alternative systems, two-point and pile mooring systems are also reviewed.

Mooring systems have several components and the capacity of the system is often limited by the resistance or ability to perform of one of its components. Anchors can drag; chain links, ropes, shackles and swivels can break; buoys can sink; biofouling can increase loads and corrosion of metal components that can weaken the system. WG 168 reviewed typical mooring systems components and provided descriptions of alternative designs, application areas, standards and materials.

Just like for design of any structure, the design of mooring system requires a basis for design. As is typical in marine infrastructure, the basis for design would include the characterization of the site from various perspectives such as bathymetry, bottom conditions, wind, waves, current

and water levels. The basis for design would further include the definition of yacht parameters in terms of type (sailing or motor yacht) and the estimation of loads. WG 168 reviewed practical guidelines to characterize the site, from the collection of existing information and anecdotal evidence to detailed field investigations and numerical modeling, as well as simplified formulations for the estimation of loads. A description of the working principles of catenary and elastic moorings is included in the guidelines, along with methods for the estimation of mooring offsets and loads, and swing circles.

Just as important as design, are installation and maintenance. These would depend greatly on the type of mooring system and site conditions, contractor experience and equipment. The WG 168 guidelines describe the typical equipment and methodologies for installation, critical items for inspection and frequency to achieve an adequate maintenance of the system.

Finally, case studies that describe the implementation of the guidelines are presented.

76. Inland Waterway Management - The Times They Are A-Changin'

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viadonau (Austrian Waterway Management Company), Austria

Today inland waterway managers have to react on a number of new challenges which emerged in the previous decades or are still underway. Taking the European Danube River as an example, several typical such challenges will be presented and discussed, e.g.

- environment and nature as new policy priorities,
- growing efficiency and effectiveness requirements on the transport and logistics market,
- higher end-user expectation on services of waterways and waterway transport,
- unforeseen developments in international trade relations and supply chains and
- the fast progress of digitalisation as well as the high expectations from digitalisation.

The reaction so far taken towards these challenges will be presented from the perspective of one of the Danube riparian countries, Austria, together with first experiences and subsequent adaptations of the reaction. Examples of actions are very different, e.g.

- adaptations of the legal framework and organisations,
- the development of medium-term action plans encompassing all relevant dimensions,
- several kinds of cooperation in the international context of inland waterways,
- appropriate development of services for the (end-)users of inland waterways,
- the definition of multi-purpose projects embracing several categories at once (e.g. economy, environment and safety) and
- proactive measures towards emerging technologies as, for example, digitalisation.

On the basis of such examples - stemming from the specific situation of one country on one (international) river - the presentation will make an effort to generalise the lessons learnt: Examples for general principles will be discussed and might include e.g.

- the integration of requirements for environment, economy and safety in multi-purpose projects (and strategies),
- the elaboration of tailor-made services for users and
- the appropriate treatment of the high need for harmonisation of digital services.

The principles for encountering current challenges of inland waterway management developed in this way shall ease the selection, the adaptation and the eventual use of the experience gained in Austria in the context of other waterways, whether in Europe or on other continents.

77. Truck Emergency-Braking Impulse Effect on Moored Ferry

002

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Heavy trucks may have significant impulse loads on the moored ferry due to emergent sudden braking when truck move from linkspan to ferry deck. Therefore, its effect on motions of the moored ferry is studied in this paper to examine the ferry operations during loading and unloading processes involving the safety of cars and passengers.

The ferry crossing Thames river is moored by intelligent Docklocking System® (iDL), which is an innovative automatic mooring system replacing the conventional mooring lines. The feasibility and potential of this iDL system to minimize the horizontal movements of the moored ferry are presented in this paper based on numerical simulations of dynamic mooring analysis (DMA) in time domain.

The lorry impulse model is linked with a multi-body system including numerical models of the ferry and the jetties. Wind, current and wash wave are also considered, together with the impulse load of the lorry to represent a combination of possible loads. This paper first gives a systematic procedure to evaluate lorry impulse effect on moored ferry and then presents motion responses of the ferry moored by the iDL system.

78. Vessel-Induced Surge Model Validation Using High-Resolution AIS Data and Field Measurements in a Complex Harbor

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Large ships moving in narrow waterways generate complex hydrodynamic phenomena, which can cause extreme forces and moments on berthed vessels, and hydrodynamic hazards to small craft. Deep-draft cruise ships with large windage areas can maneuver at high speeds, and induce harbor seiche/oscillations. Particular focus is paid in the present paper to further validation of the Vessel Hydrodynamics Longwave Unsteady (VH-LU) modeling system (Fenical et al. 2006) for these complex hydrodynamic phenomena, in particular sloshing and resonance of vessel-induced waves in the harbor at Port Canaveral, FL. Over a period of many years, Canaveral Port Authority has participated in advanced analysis of these phenomena during multiple studies to ensure safe navigation and berthing/mooring in the harbor. This paper summarizes two field measurement campaigns and utilization of high-resolution AIS data to provide detailed input for model validation. Analysis indicates that the modeling system is able to reproduce water level oscillations generated by individual vessels, oscillation interactions within the harbor, and interactions between separate basins in the harbor over time. Previous publications have provided information on validations performed with the VH-LU modeling system (e.g. Fenical et al. 2011). The model has been shown to accurately reproduce hydrodynamics and berthed vessel forces on tankers in open water conditions, hydrodynamics and loads on berthed Panamax containerships against a vertical quay wall, and supercritical flow and broken bore formation and propagation. This paper will summarize the complete range of model validations with the highest-quality openly available laboratory data, and provide recommendations for future studies and research based on observed needs from practical applications.

Two field campaigns were performed, in May 2015 and May 2016, to provide high-quality water level data for use in model validation and provide greater confidence in model predictions. The field campaigns were conducted at multiple locations within Port Canaveral, FL. Surge effects are known to occur within the harbor, are regularly observed, and the large amount of passenger vessel traffic allowed a relatively short field campaign duration. Detailed passing ship maneuvering characteristics were used as input to the validation simulations for more accurate reproduction of measured surges in the harbor. High-frequency AIS data were collected during the measurement period to allow incorporation of accurate passing ship maneuvering behavior, such as complex passing routes, variable ship speeds and accelerations as a function of time and location, and varying drift (crab) angles. Cruise ship hull models were automatically generated for each passing event based on the vessel identification information in the AIS data. For all validation simulations, the latest hydrographic survey data were incorporated into the modeling domain which was representative of harbor conditions at the time of the measurements.

Modeling results for both validation periods indicate that the VH-LU model was able to successfully reproduce the measured surge effects (i.e. water surface fluctuations) in the field, within a very complex harbor and for a wide array of passing cruise ships. The validations

showed that the model successfully reproduced the initial drawdown and surge, as well as the surge wave free propagation in the harbor and interaction between the Middle and Trident Basis of the harbor. The successful validation of the VH-LU model has built strong confidence in its application, which has been instrumental in understanding the potential changes in harbor conditions that may be generated during channel deepening or introduction of new vessels to the harbor.

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79. Historical quay wall renovation in Antwerp, Belgium

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One of the most significant and characteristic features of the city of Antwerp (Belgium) are its historical Scheldt quays. Stretching about 5.5 km along the western edge of the city centre, the quays were constructed at the end of the 19th century. At several locations severe indications of instabilities have been observed as early as during the construction of the quays itself. Despite the multitude of efforts to alleviate these instabilities over the last century, they continue until today.

In 2005, the council of the city of Antwerp and W&Z (i.e. Waterwegen & Zeekanaal, the independent agency of the Flemish Government in charge of the management of the Scheldt river banks) have agreed to carry out the most significant renovation works in over a century. Three main goals are at the centre of this long-term plan:

- The stabilisation of the historical 18 m high quay walls.
- The protection of the city against increasing storm surges as a result of climate change. This goal is part of the integrated Sigma Plan and requires a new 2.25 m high storm surge barrier to be built on top of the existing quay walls.
- The city government has seized the opportunity of these large-scale renovations to give the quays a facelift. The intention is to restore the city's link with the river by incorporating urban development and mobility, by creating new public domains and by meanwhile preserving the historical monuments. The quay walls are a significant part of the latter.

In this paper, the focus is on the stabilisation of the historical quay walls. First, a brief overview of the history and the construction of the quays is given, along with a description of the stabilisation measures taken since their construction. Afterwards, this papers gives a description of two quay wall renovation projects that are being executed at the moment. Major design choices, innovative construction methods and lessons learned are discussed.

The first project is the renovation of the 700 m long quay wall situated at d'Herbouvillekaai and Ledeganckkaai. In 2008 there was still industrial activity ongoing on site. Stability calculations showed that the quay wall did not meet to the current stability standards and inspections showed that the wall was heavily damaged. Based on this determinations a load restriction was instituted and a monitoring campaign was started. Observations showed that the situation was getting worse so emergency measures were taken and industrial activity on the site was shut down. A quay wall renovation was necessary to allow for the construction of the new storm surge barrier and the establishment of the new public domain in a later phase. The existing gravity walls are entirely demolished and replaced by a tube combined retaining wall with 37.5 m long steel tubes. Two rows of anchors are attached to a second retaining wall located 38 m inland.

The renovation of the 900 m long quay wall situated at Cockerillkaai and De Gerlachekaai is the second project discussed in this paper. For this area of the quays a less invasive stabilisation technique is applied. A diaphragm wall with a depth of 30 m is installed behind the historical wall. The horizontal stability of the diaphragm wall is ensured with 2 rows of ground

anchors every 1.8 m. An additional ground anchor is installed every 20 m at the location of a bollard. Between the original gravity wall and the diaphragm wall, stress relieving platforms are additionally installed to reduce the loads on the original gravity wall. Four drainage tubes per caisson are drilled through the original masonry walls to allow the stress relieving chambers to follow the tide in the river Scheldt.

80. The First Phase of Expansion of the Kingston Container Terminal

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Kingston Freeport Terminal Limited (KFTL) owned by CMA CGM got awarded in April 2015 the 30 years concession for the Kingston Container Terminal (KCT). This Container terminal, with current capacity of 2.8 MTEU, is conveniently situated on a direct line between the U.S. and the Panama Canal, and between Europe and the Panama Canal, would ensure a leadership position for the Port as a regional transhipment hub.

The concession contemplates improvement works that will be implemented in a two-phased development:

- Phase 1 aims at accommodating the existing terminal (Quays and nautical access) to the Neopanamax container vessels, through deepening and realignment of the nautical accesses and refurbishment of 1 200 lm of existing quays. This will allow access as from end 2017 of Neopanamax vessels with 14.7 m draft ;
- Phase 2 will consist of the deepening of the nautical accesses to allow access to 15.5m draft vessels and of the expansion of the terminal capacity to 3.6 million TEU.

The presentation is proposed to focus on the first phase being implemented currently and more particularly the following challenges of the project:

The conception of the nautical accesses:

It consists in realignment and deepening for Neopanamax 14,000 TEU vessels, considering the technical and environmental constraints of the site:

- The 15km long channel passes through very sensitive environmental areas including but not limited to the Palisadoes-Port Royal Protected Area with reefs, heritage historical sites such as the Port Royal Sunken City and sea grass.
- The so-called inner channel is bended passing through very shallow areas with sustained regular transversal wind. The optimization of the realignment and deepening has been performed on basis of vertical detailed design approach as well as horizontal detailed design approach in the CMA CGM Fleet Center Full Bridge Simulator.

The planning of the works:

In order to ensure continuous operations of the Terminal, as well as its increase of throughput during the works started in 2016 and due to be completed by end 2018, the sequencing of the works has been established on basis of detailed modelling of the capacity of the terminal, during the expansion phase. The selected scenario was consisting in phasing in 3 upgrade stages as follows: 600m / 300m / 300m. The overall project, including quay upgrade, yard pavement rehabilitation and new gantry cranes delivery has been optimized in light of this best operational scenario.

The design of the quay wall upgrade:

As from the start of the Project, CMA-CGM has always looked at taking benefits of the existing structures (2 400 lm of berth with allowed draft of 13m) instead of building extension to the existing berths. This has required an innovative and state-of-the-art approach in order to ensure the feasibility of the project to go over the following obstacles:

- The seismic context with 475 year return period event seismic acceleration reaching 0.29g coupled with a complex geotechnical context (more than 12m thick liquefiable soils on top of stiff to hard clays without presence of substratum). The adopted approach -to confirm and optimize the seismic design criteria- has coupled seismotectonic analysis, PSHA to define site-specific response spectra and specific geotechnical investigation (cross-holes).

The nature of the existing quay structure, being a combi-wall structure designed for 13m draft vessels. Innovative solutions have been investigated and finally adopted to mitigate the increase of the dredged depth and by consequence of the associated reduction of the embedded length of piles and steel sheet and to cope with the loss of mobilized passive pressure in front of the quay no longer sufficient to resist to the active pressure due to earth and loading. The finally adopted structure will be presented.

81. Design of the Upgraded Nautical Access to the Snim Iron Ore Port in Nouadhibou

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Egis Ports, France

The “Société Industrielle Nationale et Minière (SNIM)” (National Industrial and Mining Company) has completed in 2013 the construction of a new export facility (berth and associated 10,000 tph shiploader), with the capacity to load iron ore carriers up to 250 000 DWT.

The existing channel is designed for vessels up to 170 000 DWT, but with load limitation (maximum draft of 16.15m).

The study aimed at upgrading the existing channel for Capesize vessels up to potentially 250 000 DWT

The new channel will be 25 km long and will require between 15 to 25 million cubic meters to be dredged, including cemented sand layers and potentially sandstone.

The presentation is proposed to focus on the detailed study performed for the new channel on basis of a state-of-the-art approach based on PIANC report No121. This includes:

1. Horizontal design through navigation simulation (over 100 runs in real-time on Full bridge Simulator and fast-time).
2. Vertical design based on Response Amplitude Operator (RAO) for ship motion assessment.
3. Hydrosedimentary impacts assessment and incorporation in design
4. Operational criteria derived from the detailed design (tugs, navigation aids), knowing that the Terminal was operated to date without tugs despite the size of the ships.

The challenges faced through the detailed design encompassed:

- An outer channel long of 20 km with various bends and exposed to strong offshore wave climate impacting the navigation transversally and longitudinally.
- An inner channel and turning basin exposed to longitudinal tidal currents (up to 3 knots), where the main interest was the reorganisation of the berthing operations and nautical accesses to cope with tug implementation, on port facilities where it was not used to date.

A transition area in front of Cap Blanc where tidal currents shift from longitudinally to transversally with intensity up to 4 knots with also sudden exposition to outer swell.

82. Construction Challenges for the Panama Canal Expansion Program Pacific Access Channel

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Panama Canal Authority, Panama

Panama Canal Authority (ACP) committed with the $5.25 billion Expansion Program with the goal of creating a new lane for larger vessels to be able to transit the canal. The Panama Canal Expansion Program includes the deepening and widening of the current navigation channel, the construction of two additional locks -one at the Pacific Ocean and another at the Atlantic Ocean-, and the construction of a new access channel at the Pacific end.

The recently completed Panama Canal Expansion Project required construction of a 6.1km long channel at the Pacific entrance to the Panama Canal, to provide navigation access from the new Post-Panamax three-level locks complex to the Gaillard Cut section of the Canal. This new access channel runs almost parallel to both original locks on the Pacific side and required the excavation of approximately 50 million cubic meters of unclassified material and the construction of four dams, known as Borinquen Dams 1E, 2E, 1W, and 2W. The dams retain Gatun Lake, the main reservoir and waterway of the Panama Canal, approximately 11m above the level of Miraflores Lake and 27m above the Pacific Ocean.

Execution of the Pacific Access Channel sub-program was critical to the Panama Canal Expansion Program and any flaw on its construction process would have a major impact on the Program and on the existing Canal operations. For its construction, the PAC was divided in to four 'phases', PAC-1, PAC-2, PAC-3 and PAC-4, the latter being the only one that includes excavation down to the design elevation and construction of Borinquen Dam 1E,

A key consideration for construction was the management of the earthworks under the local climatic conditions and the control of groundwater in the work area. Groundwater levels, which are near the level of Miraflores Lake over a broad area of the Pacific Access Channel, were lowered as much as 20 m to allow construction of the access channel and the dam in the dry. A 1,800-m-long, 20-m-high rockfilled cellular cofferdam was built to retain Miraflores Lake abovet the foundation excavation level of Dam 1E. Construction of the cellular cofferdam and the installation of a dewatering system allowed excavation, handling, processing, and stockpiling of finegrained residual soil materials during the 7- to 8-month-long wet season, which is characterized by an average monthly precipitation of nearly 250 mm, in addition, to also allow the placement and compaction of such materials in the dam core. The extensive system of dewatering wells, drainage ditches, detention basins, sumps, and pumps was installed to dewater the access channel area and to control surface runoff from precipitation during construction, while excavations on higher areas were being performed. Also, a 3.5km Diversion Channel built to divert the Cocoli River was critical to achieve dry conditions during the construction of the access channel.

Space constraints associated with navigation requirements within Miraflores Lake were a challenge during construction. The main challenge for performing these works was to have no impact on the canal operations. The alignment of the cofferdam was very close to the Pedro Miguel Locks, and the coordination for the works was very strict to achieve that goal, especially since the works included the dredging of a 335,000 cubic meters from a trench at the bottom of Miraflores Lake to properly embed the cofferdam into the soil by removing unstable material,

also several floating-cranes and auxiliary barges were on site once the sheet-pile driving started.

During the entire construction of the cellular cofferdam, there were no construction activities that affected the transit of vessels thanks to the continuous coordination and communication with canal transit and locks operations.

For building the Borinquen Dam Core, the material selected was residual soil. It has to comply with special characteristics to guarantee its function as an impervious water barrier. Compliance with these characteristics and installation processes is escencial for the life of the Dam and has been followed closely by the quality personnel involved on its procurement, treatment and installation.

The challenges related to the procurement of residual soils started with the depletion of the available material on the project identified sources. Several actions were taken to identify potential sources as soon as it was possible. The existence of the material both in quality and quantity was not evident on most of the cases because of the vegetation cover. For that reason, investigation areas were defined based on the geological information available from ACP engineering division.

This paper focuses on the works and challenges for the construction of the Pacific Access Channel, and intends to document the relevance of these challenges and the importance of effective Project Management.

83. Waitangi Port Upgrade – Providing a critical lifeline at the edge of New Zealand

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The Chatham Islands lie 800km off New Zealand's east coast in the south Pacific Ocean. The archipelago is home to 600 people and one of New Zealand's most remote communities. The islands are serviced by a single main port which provides a critical lifeline for the community through the provision of imported goods and export earnings. The port is at the end of its structural life and significant upgrades are necessary. The Waitangi Wharf Upgrade includes a reclamation, development of port infrastructure, dredging works and the construction of a breakwater. The NZ Government requested that the Memorial Park Alliance, which comprises government agencies, contractors and consultants, rapidly deliver the upgrade works using an alliance model.

- The remoteness of the site, and the culture of the Chatham Islands, presented some unique characteristic that influenced the project, including;
- A small community, but with real strategic importance to New Zealand;
- The workforce increasing the island population by up to 8% - bringing social challenges and economic opportunities for the local community;
- A need to establish a quarry and concrete batching plant on the island as none existed;
- A need to ship all construction plant and most materials to the island;
- Even more acutely than normal, a need to strike the right balance between robustness of design (given the remote location and desire to minimise maintenance), and capital outlay (given the size of island population);
- Opportunities to leverage off the project for additional infrastructure improvements such as a boat ramp and fishing wharf – taking advantage of the extensive mobilisation required;

The project progressed from concept design, through environmental approvals and detailed design within 12 months; an extremely tight timeframe for a project of this complexity. Extensive community engagement was undertaken throughout the process including requirements at the port and surrounding areas, existing coastal processes, the likely effects of the development and options for mitigation such as beach replenishment and additional options for social and environmental improvements. This built trust and established relationships, very important factors for a project this size impacting on a very small community.

Some specific aspects of the design, tailored to Chatham's remote context, included;

1. Design of the breakwater to accommodate very high return period design events with additional factors of safety resulting in the use of highly interlocking concrete armour units;
2. Improved resilience by removing liquefiable sands beneath the reclamation;
3. A minimal maintenance design, including:
    - Orientating wharf and approach paths to minimise future dredging;
    - Extensive use of concrete, including concrete H-piles and panel walls.

- Relocation of kaimoana or seafood from the project area and use of materials conducive to marine growth
- A flexible multi-use port, catering for additional uses such as the islands fishing and tourism requirements.

4. Physical model testing of the breakwater and the construction sequence with active involvement from the construction team – important in this exposed and remote location.

This paper will present an overview of the project, and the unique challenges and lessons learned by working in such a remote environment, including:

- The importance of both future-proofing the design and building in robustness to allow for growth and minimise future maintenance that would be impossible or extremely expensive to carry out after demobilisation;
- The relative importance of the project to its community reframed port development by highlighting the critical importance of ports to life as we know it. We consider that there is a substantial, albeit complex, opportunity for the industry to more strongly connect communities to their ports.
- How we must be sensitive to the communities in which we work, and strive to build strong relationships for everyone's benefit – particularly so with remote projects; and
- That physical model testing can add significant value in fine tuning a design, and providing confidence in the end solution for the funders, the builders and the end users.

Keywords: remote construction, port, breakwater, xbloc, collaboration.

84. Experimental Study of Tsunami-induced Forces on Onshore Seawalls

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1. Introduction

The Great East Japan Earthquake (magnitude 9.0) and the resulting tsunami of March 11, 2011, caused serious damage to Japan's fishing ports and villages. It is believed that the fishing port facilities suffered external forces that far surpassed the conventional design requirements.

Field surveys, conducted after the earthquake, reported that a large number of "onshore" seawalls, built behind the fishing ports to protect the villages, collapsed because of the tsunami attack. Although a major reason for the collapse was scouring due to tsunami overflow, frequent reports of the seawalls collapsing without the scouring were also confirmed. On the other hand, conventional methods used to calculate the tsunami-induced forces were often based on the hydrostatic pressure profile that corresponded to a tsunami's inundation depth. Although recent researches had examined the wave forces on breakwaters and onshore structures, the effects of the slope of bottom topography, the slope of seawall structure, and the distance of the structure from the shoreline were not fully understood. Furthermore, few studies also investigated the wave-force characteristics of the onshore structures under the tsunami overflow conditions. Hence, we had to consider the methods to calculate the tsunami-induced forces on the seawalls.

In this study, we conducted hydraulic model experiments to evaluate the tsunami-induced forces on the onshore seawalls, by changing the conditions of the slope of bottom topography, the slope of seawall structure, and the distance of seawall from the shoreline. Based on the results obtained, we explored the methods to calculate the wave forces under non-overflow and overflow conditions.

2. Hydraulic Model Experiments

The experiments were performed in a wave flume (100 m in length, 2 m in height, and 1 m in width) on a scale of 1/81. Beginning at the wavemaker, the bathymetry consisted of a 47–68 m flat-ocean bottom section, a 17–38 m slope section, and a 15-m flat-land surface section. We installed three kinds of bottom slopes in the ratio of 30:1, 20:1, and 10:1. The seawall was positioned 0–150 m landward from the shoreline (note that the experimental parameters mentioned here and thereafter are described according to the corresponding local scale). The seawall height was set to the one that satisfactorily exceeded the tsunami inundation height for non-overflow conditions, and at 4.6–8.3 m for the overflow conditions. The shoreward slope of the seawall was set to 1:0 (vertical), 1:0.2, and 1:0.5, whereas the landward slope was set

to 1:0.5. Using forward paddle movement, the tsunami was modeled as an idealized solitary wave with a half-period of 113–180 s.

3. Results

We analyzed the experimental results by focusing on the “maximum” wave pressure (p_{max}), which is the wave pressure when its vertically-integrated value (wave force) was maximum. Under the non-overflow conditions, we first examined the vertical profile of the normalized wave pressure, $p_{max}/\rho g\eta$ (where ρ is the density of water, g is the acceleration of gravity, and η is the inundation depth of the front of the seawall at a time when p_{max} was measured). We found that $p_{max}/\rho g\eta$ was not remarkably affected by the change in the slope of bottom topography, the slope of seawall, the period of incident wave, or the distance of seawall from the shoreline, and that $p_{max}/\rho g\eta$ is 1.0–1.1 times larger than the normalized hydrostatic pressure, z/η (where z is the height from the land surface). Next, we examined the vertical profile of $p_{max}/\rho g\eta_{max}$ where η_{max} is the maximum inundation depth obtained from experiments that did not use a seawall. It was shown that $p_{max}/\rho g\eta_{max}$ increased with the increasing distance from the shoreline. In the non-seawall experiments, along with an increase in the distance from the shoreline, an increase of the horizontal velocity (U), decrease of η_{max}, and the resulting increase of the Froude number (proportional to $U\eta_{max}^{-1/2}$) were also confirmed. Based on the results obtained, we proposed formulae to estimate the wave pressure on the seawalls by combining a function using hydrostatic pressure and its correction factor of 1.1 and a function using η_{max} and the Froude number.

Under the overflow conditions, $p_{max}/\rho g\eta$ did not show a significant dependence on the slope of bottom topography, the slope of seawall, the period of incident wave, or the distance of seawall from the shoreline, and the value was 1.0–1.2 times larger than the normalized hydrostatic pressure. As the magnitude of overflow became smaller, the ratio of the wave pressure to hydrostatic pressure, $p_{max}/\rho gz$, approached 1.0–1.1, which agreed with the results obtained from the non-overflow cases. Based on the results obtained, we proposed the formulae of the wave pressure for both the shoreward and the landward of the seawall as functions using hydrostatic pressure and correction coefficients.

These findings were mentioned in the design guideline for onshore seawalls, published by the Fisheries Agency and the Ministry of Land, Infrastructure, Transport and Tourism in Japan (November, 2015). We hope that the results of this study will provide useful information in promoting disaster prevention and mitigation measures that will be effective against tsunamis.

85. Evaluation of Marine Structures for Kinematic Effects

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In performance-based seismic design, a marine structure is designed for inertial loading effects associated with the dynamic response of the structure. Some waterfront structures also experience seismically induced kinematic effects, associated with soil liquefaction and lateral spreading. This presentation explores some of the approaches for incorporating these kinematic effects into the seismic design and analysis of marine structures.

Although most performance-based design provisions for piers and wharves require that kinematic effects be considered in seismic design, there is generally not detailed guidance on how these effects should be considered analytically. In addition, there are various opinions and practices across the industry in accounting for these soil-structural demands. Considerable judgement is required by the design professional in deciding how to include the kinematic loads into the structural analysis.

Combination of inertial and kinematic earthquake effects is one of the major decisions that need to be made in the analysis and design process. This presentation will discuss the various theoretical design methodologies; including, superposition of results, simultaneous load combinations, post-inertial kinematic response, and post-kinematic inertial response. This presentation will provide commentary on how these approaches can be implemented as well as how these combinations correlate to observed earthquake response.

This presentation will also include a ‘how-to’ component for incorporating the kinematic loading into an analysis. Some of the inertial and kinematic combination methods are straight-forward, but they could overpredict lateral displacements due to their simplified nature. More refined approaches involve a complicated staging of restraint and loading parameters in the non-linear finite element analysis models. This presentation will address the more practical considerations for performing these evaluations. It will discuss lessons learned in the authors’ experiences of doing these analyses, and provide recommended tips for obtaining trust-worthy analytical results.

For owners and developers, this presentation will provide background information on seismic design parameters: what the difference is between inertial and kinematic loads, and why these loading schemes need to be carefully addressed. For engineers and design consultants, this presentation will provide insight into the practical implementation of these seismic demands: how to combine inertial and kinematic loads in the structural analysis, and tips for modeling the behavior in a finite element structural analysis model.

86. Le Havre - Port 2000: A new Containerport with a simultaneous move towards environmental rehabilitation of Seine Estuary (1996 – 2016)

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1. Presentation of the project

The Port 2000 container port was studied at the end of the 90's, built starting 2001 and had its first commercial operations in April 2006.

It was born from the will of the French State to position Le Havre as a main gateway for the flows of containerised goods. It has nowadays 3 500 m of heavy duty container quays for vessels of 16+ meters of draught.

This huge port operation also provided the opportunity to initiate a real move towards the environmental restoration of the Seine Estuary with a budget of approximately 50 Million €.

To develop intertidal wetland (mudflat) there was in particular dredging of a purely environmental channel (More than 1,5 Million m3)

There was also the building of two bird resting areas, one on land using past hunting ponds and one in the south of Seine estuary with the creation of an artificial island.

Beyond these works, an important survey program is done to increase the knowledge of the environment of the Estuary and the port contributes to the management of "Nature Reserve of the Seine Estuary".

2. Port 2000, Working with Nature philosophy even before the position paper.

Port 2000 as a whole is quite a good example of the Working with Nature Philosophy applied to a huge project, even before the position paper was finalized.

Step 1 : Establish project needs and objectives

Port of Le Havre is very close to the entrance of the main navigation route to British Channel and North Sea. The idea of Port 2000 was therefore to use the opportunity of this nautical advantage to confirm Le Havre as one of the major entrance to Europe for all size containerships coming from Asia or America.

At the same time, even if the project did not have many adverse effects on the intertidal wetlands the environmental objectives of the project focused on wetland restoration as this ecosystem was recognized as Seine estuary weakest part.

Step 2: Understand the environment

Completely at beginning of project in the years 1990's, there were global environmental studies of the Seine estuary, also using the results of the studies conducted some years before for the Bridge of Normandy.

These studies were on currents, wave patterns and all sedimentological issues in the estuary. This was performed via on site surveys, physical and mathematical modeling.

There were also specific studies on fishes and fish nurseries and a complete survey on bird habitat and use of the estuary by birds, permanent or migratory. There was also complete survey on amphibians and plants in the global area of the possible future works.

Step 3: Make meaningful use of stakeholders engagement to identify possible win-win opportunities

Port Authority decided to go through very early stakeholders consultations to facilitate dialogue, understanding and acceptation of the project, avoiding therefore any stops and go.

There were many informal discussions with all stakeholders concerned starting 1996 well before the official “Débat Public” (Public Hearing) of four months performed in 1997-1998. This consultation of stakeholders continued during all study phase and later work period up to the start of operation in 2006.

Specific attention was given to fishermen interest as the fishermen associations were at the beginning declared opponents to the project as they feared big impact on fish nurseries in the river Seine and also reduction of fishing possibilities due to the works and the increased turbidity. All the continuing studies were conducted with sharing of results, thus building year after year good technical relations, proving the real capacities of port engineers to work with fishing data and even more important building trust between the individuals. During works, before any new phase, in particular for dredging, there were also meetings with fishermen and contractors to facilitate start of works.

Step 4: Prepare initial project proposal/design to benefit navigation and nature

There was a risk of natural transport of sediments south of the project due to acceleration of currents. These sediments could have moved towards existing mudflats with adverse effects. It was therefore decided to have morphological dredging of some 3,5 million m3 south of the breakwater to take them outside of the estuarine system.

Regarding the main breakwater of 5 km length an innovative design with a sub-base up to +3m marine level made with dredged pebbles permitted substantial re-use of dredged material and also financial economies.

The bird island south of the estuary was also designed to use a maximum of dredged material from the port.

Globally for all the different works, the design allowed use inside the project of some 26 Million m3 out of the total 45 Million m3 to be dredged for new channel and basin.

The fauna-flora survey demonstrated the presence of a very rare and protected orchid named “Liparis Loeseli”. The port modified some part of project to exclude all the area favorable for that orchid.

Stage 5: Build and implement

The use of mathematical modeling for the phasing of building the breakwater that was performed by all contractors during tendering permitted to choose an alternative solution much more progressive regarding current velocity increase and therefore movement of sediments in the estuary.

Also physical and mathematical modeling of the stability of the gravel sub-base of breakwaters permitted to work really with the natural currents and not against them thus achieving substantial economies and gain of time.

Stage 6: Monitor, evaluate and adapt

A more than 10 year monitoring program on a wide area from Bridge of Tancarville up to outer sea is still under way.

Specific attention is given to fish, birds and amphibians surveys but of course monitoring extends to sediments, water quality, benthos species and all type of species living in the estuary.

The Port Authority considers also of utmost importance to share the experience issued from all these works, in particular by organizing in 2015 an International Symposium focused on Port 2000 environmental measures in combination with the “Estuarine Coastal Sciences Association”.

87. Ocean wave energy period parameters conditioned on significant wave heights

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It is difficult to determine the distribution of wave periods even under the assumption that waves are linear and have narrow band frequency spectrum as they are often bimodal because sea states often have a certain percentage of cases with two wave systems. The existing wave period models due to their complexities are difficult for further mathematical treatments and hence their applications are limited to such as fitting to observed wave period distributions. In this study, the plausibility of finding the distribution of wave energy periods by modelling the empirical average conditional exceedances of energy periods are explored. Hence conditional mean functions (CMF) are derived from generalised Pareto, Erlang and three-parameter Weibull distributions. Since, CMF determines the distribution of energy periods uniquely, it is sufficient to find the functional form of CMF consistent with the data. This study utilises month wise clubbed every fifth day maximum significant wave heights (to mitigate serial dependency and to ensure sufficient sample size for analysis) and associated energy periods in winter (December to February) and extracted from 34 years SWAN generated data of a test site in the North Atlantic Ocean. The wave energy periods conditioned on significant wave heights < 4.0 m are considered since wave energy converters usually operate in shallow waters of depth < 4.0 m. The distribution of wave energy periods conditioned on significant wave heights is determined by modelling the empirically computed average conditional exceedance of wave energy periods with the CMF of generalised Pareto, Erlang and three-parameter Weibull distributions. Parametric relations are derived from Pareto and three parameter Weibull distributions to estimate certain energy period statistics of significance such as mean, mean maximum and most frequent maximum energy periods, average period of one-third the highest energy periods and the estimates are comparable with the empirical values. A general statistical formula is obtained based on order statistics to estimate the average period of one third the highest wave periods. A formula based on the general formula is derived from generalised Pareto distribution to estimate the average period of one-third the highest wave periods. There exists significant linear functional relationship between average period of one-third the highest wave heights computed from the data and average period of one-third the highest wave period estimates. The empirical ratio of significant wave period to mean wave period of 0.9-1.4 is well represented by the average energy period of one-third the highest significant wave heights to the mean energy period.

88. "Parana – Paraguay Rivers Inland Waterway"

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The Paraguay – Paraná Rivers Inland Waterway (from now on HPP, by its acronym in Spanish) is located in South America and flows through five countries: Brazil, Bolivia, Paraguay, Argentina and Uruguay. Its catchment area is about 2.605.000 km^2 (950.000 km^2 from Parana River (Corrientes) + 1.095.000 km^2 from Paraguay River +560,000 km^2 (from Middle Paraná River south of Corrientes) but without considering the part corresponding to Uruguay River) which integrates a bigger one or about 3.100.000 km^2 well known as Plata Basin, since it's finally discharge in Río de la Plata and the Atlantic Ocean.

The HPP is an inland waterway 3.442 km long counted from Caceres Port in Brazil to Nueva Palmira in Uruguay where it has its nominal end. It is not included in this length 700 Km pertaining to the Upper Paraná from Corrientes to Iguazu. In spite of this end of HPP project in Nueva Palmira, the connection between this inland waterway and open deep waters at the Atlantic Ocean is done by sailing from ports of Rosario area through Parana de las Palmas and Río de la Plata with deep draught ships for a channel 395 km long.

The Paraná River section of HPP is in one of the more populated and industrialized area of South America so it is a strategic link to facilitate trade between the southern Brazil, Bolivia and Paraguay and Rosario (Argentina) from where it can connect with deep draught ships with the Atlantic Ocean. It is considered the most important integration way of MERCOSUR since it is one of the most important way of transport needed to facilitate physical integration of the five countries. Its commercial area of direct influence (hinterland) is estimated at about 720.000 km^2 and of indirect influence at about 3.500.000 km^2 with a population of more than 40 million inhabitants.

From north to south, the HPP passes through important local ports as Caceres, Corumbá and Puerto Murtinho in Brazil; Puerto Suarez (Bolivia); Concepción, San Pedro, Asunción (Capital City) and Villeta in Paraguay; Puerto Pilcomayo, Formosa, Corrientes, Barranqueras, Paraná, Santa Fe, San Martín – San Lorenzo and Rosario in Argentina and finally Nueva Palmira in Uruguay.

In the stretch Sanfa Fe- Corrientes the project required a final navigable channel of 12 feet draught (including 2 feet of under keel clearance) that was achieved in 2011 and since then has been maintained that way.

Capital dredging required the mobilization of approximately 1.5 M cubic meters of sediment. It was installed a modern aids to navigation (AtoN) system integrated by 330 lighted buoys and beacons, all of them designed according to IALA guidelines.

The intervention includes the realization of frequent bathymetric surveys, the installation and maintenance of a network of 12 automatic water level measuring stations and the installation of antennae for the reception of AIS signals (Automatic Identification System).

The paper and presentation will describe The Paraguay – Paraná Rivers Inland Waterway, focusing on the improvements in transportation infrastructure already achieved and their impact on reducing transportantion costs, the works to be done to transform the whole waterway in a modern system of navigation that can produce an important effect on navigation costs and safety, aspects that the audience always appreciate as benefits.

89. Port Extension in Martinique, in the French Caribbean: use of observational method in a highly seismic area

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Grand Port Maritime de La Martinique (GPMLM), the public authority in charge of the port of Martinique, is rolling out an ambitious action plan to develop its container terminal "La pointe des Grives".

GPMLM has appointed Artelia to provide design and construction supervision services for its container's yard and quay extension in 2013. The project proceedings were decided in two stages: the South extension, realised in 2016, object of the present paper, and the North one, construction bid for tender under launching.

The original South terminal extension project consist in a 3 hectares' container yard increasing, and a 130 m extension quay construction, until a water depth of 10 m, the whole on a soft soil. Actually, the geotechnical sequence is called "madreporic" loose to very loose sands, with a thickness sometime more than 10 m, covered by a 2-3 meters layer of mud.

Otherwise, the French Island "La Martinique" is located in an important seismic area and combined with a compressive project soil conditions involve, in accordance with French standard Eurocode 8, a significant structural calculation constraint:

· the peakground acceleration parameter is agR = 0.3g

· the calculation acceleration amplified by the geotechnical condition is avg = 0.45g

Moreover, during design studies of the project, the French Government precises the environmental policy and decrees that there should be no dredging or substitution due to environmental protection and no using sea sand borrow.

The particular project challenge was to fulfill the recent French Seismic regulation in a bad geotechnical conditions and a very concerning environmental context.

Taking into account this constraints and due to the environment French regulation, the project have been revised, and the studies start over again.

The extension project has been separate in two parts North and South extensions. The North is still under design, and the South involves a 2.45 ha container yard extension without dredging.

Soil reinforcement was design as alternative solution. The first settlement assessment was carried out to secure the realistic geotechnical assumptions and earthwork design. It gave a one-meter amplitude, and a re engineered design conducted to 30 cm.

The successful of design and construction method was confirmed by monitoring the platform settlements (pore pressure dissipation, settlement, strain) and by using very good (angular and strength) granular filling and rock protection. Finally the measured settlements were about 20 cm, with a complete consolidation.

The owner construction cost management is also described in a French context of public works: the owner and its designer ensure the totality of the design (and the risks). The Owner organised a specific construction management contract, and it conducted to a cost effective approach.

The South stage is now completed and in service since the beginning of 2016.

This paper presents the project constraints and the construction methodology, and sets out the feedback obtained in regard to settlement upon delivery of the reclamation area after 12 months of work.

90. Environmental and Social Management in Port Dredging: A Case Study of the 2017 Kingston Harbour Dredging Campaign

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The Kingston Freeport Terminal Limited (KFTL), a subsidiary of the CMA CGM Group of companies entered into a thirty year concession agreement with the Government of Jamaica to operate the Kingston Container Terminal (KCT). As part of the concession agreement, KFTL is obligated to expand and upgrade the KCT by undertaking the capital dredging of the nautical access inside the Kingston Harbour to accommodate larger vessels traversing the Panama Canal since its recent expansion. The Kingston Harbour is the 7th largest protected natural harbour in the world and functions as receiving waters for treated and non-treated flows, conveyed by a network of waterways from surrounding urban centres and hinterlands. As a result, the biodiversity of the Harbour has declined over the last fifty years in tandem with the unmitigated growth of the Kingston Metropolitan Area. Notwithstanding, the Harbour remains a focal point for the fishing industry of over 1000 active artisanal fishers depending on the waters for their livelihood. The topic of Capital Dredging prior to KFTL's 2017 campaign has been highly controversial among fishing and environmental interests, with the former being vehemently opposed initially based on a reported decline in fish catch and habitat years after the last Capital Dredging campaign in 2001. As part of the company's obligation to its financiers as well as its own overarching commitment to operating in an environmentally and socially responsible manner, a multi-faceted environment and social intervention was implemented to ensure that the 2017 dredging campaign was executed with as minimal impact or displacement as possible.

Having successfully executed the 2017 Capital Dredging Campaign, the aim of the paper is to document a case study of how a dredging campaign can be conducted in a manner that facilitates Port and by extension National development without compromising the environment or the livelihoods of socially vulnerable stakeholders such as the fisher folk. To achieve this aim, the paper examines the social and environmental safeguards employed by KFTL to minimize the adverse impact of its dredging campaign. It outlines the methods used in the environmental monitoring programme and a snapshot of the data collected, which represents the most current characterization of water quality in the harbour. The paper also presents the social engagement methods employed by KFTL to engage and educate fisher folk, including the monitoring of pre and during dredging fish catch data. Further, it describes the process that was used to provide livelihood support to fishers in spite of the fact that the dredging was empirically demonstrated to have no significant adverse impact on their livelihood. Finally, the paper summarises the fishing community development initiatives that were sponsored by KFTL to promote sustainability and rejuvenation of the Harbour's biodiversity.

91. General Considerations on the Use of Inflatable Gates on Waterways

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PIANC INCOM Working Group (WG) 166 “Inflatable Structures in Hydraulic Engineering” held its kick-off meeting on September 2013 in Maastricht, The Netherlands. The work was influenced by current projects in Belgium, France and Germany, where inflatable structures will be applied to waterways. Rubber gates and steel-rubber gates have a number of advantages when compared with standard steel gates due to the simplicity and flexibility of the structure. Generally, capital and maintenance costs are supposed to be lower than steel gates. This paper describes the development of inflatable gates and steel-rubber gates in Europe, USA and Asia, introduces to the terminology and gives a basic understanding of the technology. A decision support is given related to useful dimensions, range of applications, filling media and costs. The paper presents also some general considerations regarding the boundary conditions, hydraulic characteristics, choice of filling medium, aspects of vandalism and environmental issues which have to be taken account when designing a weir with inflatable gates.

92. Flow-induced Vibrations at Hydraulic Structures

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An increasing number of flow-induced vibrations at hydraulic structures can be observed in the last years. They occur at old gates, such as roller or lifting gates, but also at new gates, such as radial gates or filling valves at mitre gates. Against this background a research and development project was initiated in the Bundesanstalt fürWasserbau, in order to analyze the different causes by measurements on site and by the use of numerical models. The aim is to identify the excitation mechanisms and to improve the currents construction standards. Operational measures are another option in order to avoid critical opening widths. In general, it is difficult for operators to identify the actual oscillator. Therefore, it is useful to provide a range of frequencies which are typical for a gate or gate parts such as springs or rubber sealings. Intensive investigations were carried out with different measurement systems but also by the use of cameras to sample audiosignals for a frequency analysis. In this paper, the aims, methods and first results of the R&D-project will be presented.

93. Proposal for a Sedimentation Statistical Approach for Navigable Depth Prediction Assessment in the St. Lawrence Waterway

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The St. Lawrence Waterway is a major route for waterborne commerce in North America. Navigation along this waterway can be difficult because of the shallow water sections. Therefore, ensuring a safe and optimal navigable depth along the St. Lawrence Waterway is a major concern for the Canadian Coast Guard.

The Canadian Coast Guard is implementing an e-Navigation system along the St. Lawrence waterway, including dynamic management of a ship's under-keel clearance. This system provides real-time data to ensure efficient and safe navigation. Bathymetric data and water depth may be among the most important information needed to optimize ship load and avoid groundings.

Owing to Quebec's cold climate, the St. Lawrence River is covered in ice during winter, making surveys impossible for several months each year. Consequently, real-time bathymetry is impossible to provide. Furthermore, many reaches of the St. Lawrence have a dynamic bed as a result of sedimentation and bed movements/transport. To predict a ship's "real" under-keel clearance, the water depth needs to include navigable depth, which takes sedimentation and the waterway bed movements into account.

This presentation proposes new statistical approaches for assessing a bathymetric navigational depth used to calculate and monitor the under-keel clearance of merchant vessels transiting through the St. Lawrence Waterway. The navigational depth is assessed from the most recent bathymetry. In particular, panel data analysis methods are very promising for modelling and predicting winter sedimentation. They are now applied to data from the St. Lawrence Waterway. This application characterizes changes in winter sedimentation over the past 15 years in the waterway between Montréal and Trois-Rivières, which can be used for sedimentation rate forecasting.

In addition, this presentation discusses the results of a spatio-temporal analysis of sedimentation based on clustering methods. These results can be used to recommend relevant navigational depth predictive model to use for dynamic, optimal and safe management of the under-keel clearance of merchant vessels in e-Navigation systems.

94. Dot.PRO: Proactive Management of Waterway Maintenance Projects

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DEME's company De Vries & Van de Wiel is executing a 5 year maintenance contract for the inland waterways of the Dutch region 'West-Nederland Zuid'. Due to the uncertainty in the morphological evolution of river and channel beds, typical management of such a maintenance project requires an intensive use of survey campaigns in order to prove compliance and decide when dredging is required. Hence, for this reactive management approach, the risk of non-compliance depends on the frequency of surveying. Moreover, the inaccuracy of estimating the optimal dredge date and volume leads to an increased number of dredge deployments when adopting a precautionary approach, hence leading to additional costs as well as increased hindrance towards ongoing waterway traffic in the river network. In addition to this, the current project involves the planning and execution of activities such as dredging, survey, rock dumping, soil investigation and retrieval of submerged objects, over a total length of about 160 km of inland waterways. The vastness of the project area as well as the great number of contract areas (200+) each with different specific navigational criteria (bed level, tolerance interval and maximal area of exceedance), requires a simple and clear overview of all parameters that are relevant for operational management, informing different functions within the project team. On top of this, the multitude of operations require an accurate follow up in order to be able to timely inform the client on the current project status concerning all operational and compliancy aspects.

The combination of the above issues creates the opportunity and even the necessity to implement an integrated management approach. Integration, meaning that different (predicted) parameters and aspects that are key for the overall operational management can be accessed at any location, at any time, in a simple, intuitive and well-structured manner. Therefore, a website serving as an ever-up-to-date information platform facilitates these needs by becoming an operational interface for the project management team. By doing this, it provides adequate input to make decisions in managing the operations, rendering it an effective online decision tool, named Dot.PRO: DEME's Online Tool for PRO-active operational management.

In order to timely and efficiently deploy dredge equipment, and eventually minimize survey and dredging efforts, regular predictions of the channels' bottom levels are modeled via state-of-the-art proprietary software (described in a separate paper by Van Leeuwen et al., also submitted for the PIANC Conference). Such morphological modelling is performed every month, predicting the project's waterways' bottom levels for the coming 6 months with a frequency of 1 result for each month. After upload to the system's database the new predictions are automatically compared with the imposed criteria for every contract area that has to be maintained. The platform provides priority dates before which each of the targeted maintenance contract areas has to be dredged in order to comply. The results are summarized on a dashboard that presents the order of dredge priority of all the project's waterways, each consisting out of a number of contract areas. The dashboard acts as a timeline integrating all

past, ongoing and planned activities and allows comparison with any operational deadline, which in case of dredging can be set to the model priority date.

For every type of activity, the dashboard can display the order of priority for execution. For survey campaigns, the survey data can also be uploaded to the database and compared with the relevant contract criteria. From the dashboard the user can zoom in on a specific waterway, providing easy access to all relevant limits and parameters per contract area in relation to any of the bathymetric predictions as well as any survey data, such as the required surface and volume to be dredged on the predicted date. An interactive GIS module displays a geographic overview of the whole waterway, and any of the predicted or surveyed bathymetric grids in relation to the contract areas. A detailed timeline allows the project team to easily keep track of all required operations and adjust planning accordingly. Many features are clickable and provide easy access through this intuitive graphical user interface.

The devised online integration of what, when, where, and why actions must be taken, results in an optimal proactive approach of waterway maintenance works. This includes facilitation of the decision-making process, easy data access to any stakeholder within the project team, and timely and optimal intervention of dredge vessels and other equipment, therefore also reducing hindrance towards ongoing waterway traffic. By granting access to the platform, the client is provided with an online up-to-date reporting tool, facilitating transparency and confidence in proper management and execution of the project.

95. Marinas Design in Areas of Highly Environmentally Sensitive (Case Studies)

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Introduction

The calm always comes after the storm and, in our case, after a period of economic circumstances which were unfavorable for us, the sharp improvement in the nautical sports sector has resulted in the need for new mooring points, whether it be through expansions or new locations. The latter, given the degree of occupancy on the coast as well as the correct environmental protection measures to be applied, are very complicated to place.

As a result, innovation, environment, development, land-use and sustainability must join forces in order to find products and solutions with a similar effect on society, significantly decreasing the environmental impact created.

Objective

After the recession in recent years resulting from the deceleration of the global economy, during which many sectors significantly suffered, a new phase of growth began in 2013. The nautical sports sector has been one of the stars, showing remarkable rates of improvement.

Economic progress, in addition to the traditional tendency for the population to flock to the coastal plains thanks to their milder climate, has caused the number of recreational watercraft to grow at an ever-increasing rate. In Spain, after a five-year period of decreased annual registrations, the nautical sector has recovered, as shown by the positive growth over the last three years.

In light of the progressive and immoderate evolution previously experienced, a balance between socioeconomic development and environmental sustainability needs to be reached during this new sector boom, providing innovative solutions which allow for the development of both public and private initiatives.

With this paper, we aim to open the door tourism development initiatives in those areas which were originally dismissed as being highly environmentally sensitive.

Methods

In recent years, we have had the opportunity to design several marinas in specially protected areas. The projects for nautical sports facilities in the Río Piedras natural marshlands and El Rompido sandbar in Huelva, Spain, the Archipelago of San Andrés, Providencia and Santa Catalina in the Colombian Caribbean, and the Topocoro Reservoir, in Santander, Colombia, are particularly noteworthy, all of which have been classified as highly environmentally sensitive.

Sometimes nature gives us a hand by offering us naturally sheltered areas which don't require rigid constructions to protect watercraft that could affect costal dynamics, provoking negative collateral effects. This is the case in the areas mentioned above. In the first case, we have the

El Rompido sandbar to provide a refuge for watercraft and, in the second, a coastal reef. In the latter case the marina is in a reservoir.

The area's own protection allows "permeable" structures, such as a floating breakwater, to guarantee marina operability. The energy dissipator gives way to the natural structures, leaving short period residual waves to the floating barriers.

The main design criterion in these projects has been minimal environmental impact, opting for fixed or floating jetties or ecological anchoring. This ensures minimal impact on the ocean floor, thus avoiding altering the ecosystem and ensuring costal dynamics in the area do not change.

We would like to share the following practical cases:

- A.D.N. Nuevo Portil nautical sports facilities, T.M. Cartaya (Huelva, Spain)
- Asociación Náutica San Miguel nautical sports facilities, T.M. Cartaya (Huelva, Spain)
- Club náutico de Rio Piedras nautical sports facilities, Punta de la Barreta, T.M. Cartaya (Huelva, Spain)
- Marina for yachts and sailboats on the island of San Andrés, Archipelago Department of San Andrés, Providencia and Santa Catalina (Colombia)
- Marina in Topocoro Reservoir, Department of Santander, Colombia

These marinas consist of approximately 400 moorings designed in Ría del Piedras and 160 spaces planned for the marinas in Colombia. They consist of sections of piled floating jetty, protected by a floating concrete breakwater anchored to the ocean floor.

These are ambitious marinas designed for customer use and enjoyment, while at the same time respecting the environment.

In addition to a structural design that is compatible with nature, it is essential that the marinas feature fixtures and facilities necessary to reduce possible environmental impacts. Among others, the following have been included:

- Implementing systems to use renewable energies for the power supply.
- Using energy efficient lighting.
- Bilge drainage systems.
- Removable anti-pollution barrier to avoid the escape or impede the entry of spills in case of accidental spillage and to facilitate marina cleaning.

Keeping the practices mentioned above in mind, we can assure our ability to offer modern and complete facilities for nautical recreation and its complementary activities, without any risk to the immeasurable environmental value of the location.

Conclusions

In summary, nautical activity does not have to oppose environmental conservation and suspected water pollution in the area where activity takes place. An example of sustainable activity can be set if it is properly regulated, designed and controlled.

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96. Spanish Ports Development from the Last Decade of the 20th Century

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SPANISH PORT DEVELOPMENT FROM THE LAST DECADE OF THE 20th CENTURY

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Abstract:

The purpose of the paper, summarised here, is to present an overview of the important port development which has taken place in Spain, within the Spanish State Port System (28 Port Authorities which manage 44 ports under the co-ordination of the State Ports Body), from the last decade of the 20th century. Special emphasis will be given to the design and construction of its breakwaters, including a general summary of its characteristics. A total of 34.46 km of large breakwater has been constructed in this period, most of them in depths ranging between 20 and 55 m.

The details of the Spanish State Port System development as well as other interesting ports enlargements belonging to regional governments (ten Spanish regional governments have coastline and are responsible for a great amount of minor ports: fishing and marinas) are beyond the scope of the paper, but the paper will include bibliographic references for more information.

An attempt will be made to describe a selection of the most important and innovative problems encountered. Port engineering in Spain is in general terms characterised by the need to site new port developments in exposed waters -outers ports-, not only due to the absence of areas of natural protection but also because of environmental considerations which make difficult developments in estuarine areas or river mouths, as has tended to occur historically with the world's great ports.

This situation, that is, of port development in areas with no natural shelter is nothing new in the Spanish coast. In this sense a historical mention will be included in the paper, highlighting the enlargements of the ports of Bilbao (1985), Gijon (1976) and Las Palmas (1975 and earlier), as an introduction to the activity since the last decade of the 20th. What has been a challenge for Spanish port engineering has been the magnitude and uniqueness of some of these developments.

In respect with the port development since the last decade of the 20th century, within the Spanish State Ports System, it is worth emphasizing the importance of the enlargements of the ports of: Gijón, Bilbao, Ferrol, Coruña, Algeciras, Málaga, Almería, Motril, Cartagena, Alicante, Valencia, Sagunto, Castellón, Tarragona, Barcelona, Ibiza and Las Palmas.

Among these it can be stand out the breakwaters of the new outer ports of Gijón, Ferrol and Coruña in the Atlantic Ocean, with lengths of 3.8, 1.0 and 3.4 km respectively; maximum heights of 48, 49 and 64 m; significant design wave heights of 9.5, 7.6 and 15 m respectively, of rubble mound and caisson type; the enlargement of Algeciras port with a 2.006 km long breakwater in 30÷40 m deep; the geotechnical problems derived from the limited bearing capacity of the seabed in the Barcelona port enlargement and the environmental issues relating to the enlargement of Cartagena port in the Escombreras basin.

Relative to all of these developments, the paper will described, with a certain detail, the enlargements of: Gijón, Ferrol, Coruña, Algeciras, Cartagena and Barcelona, including the design, construction and performance of its breakwaters, and also some information of the physical model tests carried out in CEDEX for the design and construction of this enlargements

97. Restoring forests for water related and other ecosystem services in the Panama Canal Watershed

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One of the biggest development challenges faced in the 21st century is access to abundant fresh water. While it is often assumed that forests regulate the hydrological cycle in the moist tropics by enhancing dry season stream flow, the evidence to support this has been limited and the ecosystem service itself is in dispute. Nevertheless, policy makers and practitioners call for reforestation in order to restore this ecosystem function, often referred to as the sponge effect. The Agua Salud Project was established in the moist steepland forests of the Panama Canal Watershed in 2008 to study the ecosystem services provided by seasonal tropical forests and how they change with land use and climate change. Nine watersheds that include mature forest, pasture, and different active and passive reforestation treatments have been monitored constantly since 2008 to both test forests ability to regulate the hydrological cycle and how these different land management techniques can restore this ecosystem function. All reforestation treatments were initiated in 2008. At the same time we monitored tree growth in forests and plantations as well as biomass of grasses in pastures.

During the 2013 dry season, the first pronounced dry season since the instrumentation of weirs at our Agua Salud site, we recorded a pronounced difference in stream flow between our forested and deforested watersheds and thus confirmed the sponge effect at our site.

In December 2010 we captured the flood of record in the Panama Canal Watershed and recorded markedly lower stream flow in our forested watershed as compared to our deforested watershed. The catchments at our Agua Salud site have the same soils and geology as the upper Chagres watershed within Chagres National Park. Thus if we do a thought experiment and deforest the park we can provide a first approximation of the value of the forest sponge.

Previous work published from our Agua Salud site suggests that we can start to see the effects of restoration of the sponge effect within the first several years of reforestation. We will discuss the potential to restore the forest sponge as well as the ramifications of projected changes in land use in Central Panama in view of the forest sponge.

98. Shipping LNG from an Arctic LNG Plant: some challenges in navigation, waterways, ships, port design and operations

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Novatek, Total, CNPC and Silk Road Fund are partners in the project named Yamal LNG located on the Yamal Peninsula (Russia) to produce the huge Gas reserves of South Tambey fields ; the LNG Plant is located at Sabetta on the west bank of the Ob River , in the North of the Arctic Circle; the extraction of gas and the building of a Liquefaction Plant on permafrost in these regions look less challenging than its transportation under LNG form from the production plant to the markets as the LNG & condensate Carriers have to use the Northern Sea Route , in ice-covered waters for about nine months a year ; a year-round accessible and operable Port has to be built.

To evacuate the 16,5 Mtpa LNG production from the liquefaction Plant , the shipping solution chosen to ensure the safe and reliable maritime transportation and operations year-round is to build a fleet of up to 15 arctic LNG Carriers , with sufficient ice-class notation (Arc7) and ice-breaking capability to operate without the assistance of the russian ice-breakers in the conditions of Barents and Kara Seas ; they will operate independently year-round to North-West Europe where the cargoes will be sold or transferred unto conventional LNG Carriers at selected trans-shipment terminals. But to accommodate these vessels in Sabetta, a new Port has to be designed in such a way that it is accessible and operable year round, meaning that compared to conventional marine facilities , the focus has been put on the ice management of the navigational waterways – dredged river channel and port access channels, the sheltering of the jetties of the port by ice protection barriers , the jetties and quays designed to sustain the ice loads , their winterization and their ice management through brash ice management system , and the sizing of a support fleet in order to ease the operations in the ice.

The lessons learnt during the construction phases of the Plant- dredging of channels, delivery of materials for site preparation and civil works during open water season and in winter , building the marine offloading facilities for delivery of the modules of the Plant , steps to the final design of merchant ice-breaking ships , construction of a future international airfield, current and future logistics solutions for using the Northern Sea Route for the Project purpose, and much more challenges will be described in the paper.

The first train of the Yamal LNG project is planned to start the production of LNG on end of year 2017, and the first ice-breaking LNG Carrier has been delivered after successful ice trails and the first voyages along the Northern Sea Route accomplished, breaking new records of transit and demonstrating safe and sustainable navigation in arctic seas.

99. Validation of 3D Underkeel Clearance Model with Full Scale Measurements

025

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INTRODUCTION

The continuing growth of commercial vessel sizes is putting increasing pressure on the world's port authorities to adopt effective expansion strategies to ensure that their asset is able to meet growing capacity demands. Channel capacity expansion projects usually involve the consideration of extensive dredging which introduces considerable constraints with respect to cost and environmental impacts.

This paper presents the full scale validation of an improved integrated approach for optimizing shipping channel capacity utilizing DHI's new state-of-the-art 3D under keel clearance (UKC) model Nonlinear Channel Optimization Simulator (NCOS). Measurements used for validation consisted of high resolution time series of UKC, roll and pitch obtained during vessel inbound and outbound transits through the Port of Brisbane. Vessels included a mix of large bulk carries, tankers and container vessels.

The aim of this validation exercise is to demonstrate the accuracy envelope of a 3D method for UKC prediction through various approaches for treatment of key input forcing parameters, wave frequency response, dynamic heel and squat.

METHOD

Serving as the bases for this validation are measurements taken during vessel transits through the Port of Brisbane. Differential Global Positioning Systems (DGPS) were located at the bow and on both the port and starboard bridge wings of the vessels to measure trajectory and the vertical position at each location. From these measurements roll, pitch and vertical excursion of the vessels throughout the transits were calculated and compared to the NCOS results.

NCOS belongs to a new breed of UKC models that converge towards the same level of sophistication and realism as Full Bridge Simulators. The NCOS model uses the numerical 3D engine in the Full Bridge Simulator SIMFLEX4 by FORCE TECHNOLOY for predicting wave-induced UKC allowance, which greatly improves the potential for using it in close integration with detailed maneuverability studies. The model uses a 2nd Order 3D panel method for evaluating vessel frequency response incorporating implicitly the effect of vessel forward speed and varying water depths. Adopting a Rayleigh distributed sea state; the probabilistic vessel execution is evaluated in each time step for various return periods.

Calculating accurate predictions of UKC relies on temporally and spatially varying environmental inputs such as wind, wave and hydrodynamic data to serve as forcing inputs to the model.

For operational UKC prediction purposes, there are often several practical implications associated with adopting a high level of sophistication and volume of environmental data that needs to feed the UKC model. In addition most ports have long term experience with the use

of empirical squat formulas when estimating basic UKC, which raises a demand for assessing how these can be incorporated into a sophisticated 3D UKC framework.

As a result we assess the performance impacts of incorporating an array of well-known squat formulations and we also investigate the effect of representing waves using either synthetic wave spectra from integral parameters to using full directional spectra as modelled by a spectral wave model.

RESULTS

In order to validate the model, results from NCOS have been compared to the measurements taken. The comparison includes timeseries of roll, pitch and vertical excursion. Comparisons to date show that NCOS has very accurately reproduced the measurements numerically which gives confidence that it can be used by ports to achieve target levels of channel operability, while potentially reducing required dredge volumes significantly compared to conventional estimates.

100. Berth Scour Protection for Single & Twin Propellers

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Introduction

A single propeller with a rudder is the most common arrangement of vessel propulsion and steerage with design guidance available [1, 6]

The use of twin propellers is common to ferries and cruise vessels etc. yet appropriate design guidance is needed. A programme of scale model testing for single propellers [6] has been extended to twin propellers. The results will be presented and a suggested basis of design proposed for rock and concrete mattress protection.

Thinner mattress protection types can produce significant savings in vertical quay walls which will be outlined in the paper.

Testing

Scale model testing was undertaken using two 150 mm Ø open propellers. To replicate actions in berths, the following effects were tested: -

- with and without rudders
- propeller clearance
- propeller separation
- relative propeller rotation

The testing was carried out with a range of model rock sizes and also with a sealed thickness of insitu concrete mattress protection. This testing was an extension of a previous testing programme for single propellers. [6] It has allowed the effect of twin propellers to be demonstrated and appropriate design guidance suggested.

Berth Scour Protection

Guidance for twin propeller actions is presently not well developed and often significantly overestimates the scour protection that is needed.

The paper will present an established design method for rock protection under single propeller action. [3, 6] This guidance will be similarly extended to twin propellers based upon the testing undertaken.

The performance of mattress type protections as ‘Sealed’ or ‘Open’ types will be described. ‘Open’ protection types allow flow entry and high trapped flow pressures underneath. This aspect significantly effects performance and the protection thickness needed. A design method of ‘Open’ protections by Raes et al will be referred to.

For insitu concrete protection formed as a ‘Sealed’ protection, design methods for both propeller suction and flow will be presented in a simplified format for both single and twin propellers. A beneficial combination of insitu concrete mattress protection to structures with

rock falling edge aprons will be described. The performance of rock falling edge aprons is well recognised and can be designed to cater for edge scour.

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101. Operational Analysis of Cruise Ships against Long Waves Action – The experience at Valparaiso's Bay

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The cruise industry is in constant expansion in South America, particularly in Chile. Valparaíso Port is planning to accommodate the cruise vessels at a dedicated terminal, in order to promote the cruise industry and provide a world class experience. The existing passenger terminal is located coincident with cargo terminals and a dedicated terminal would reduce overlap between cargo operations and passenger services. Valparaíso is a busy harbor with several ongoing expansion projects for the cargo terminals. The selected site for the dedicated cruise terminal provides separation from the cargo terminal, but places the moored cruise ships outside of the port breakwater protection. In this paper, we present the methodology for selecting the cruise terminal location, developing the swell wave climate at the site, and developing terminal solutions to minimize cruise ship movement and obtain a cost effective solution.

To characterize the wave climate at the proposed terminal, we used a 36-year hindcast of wave based on reanalysis of Pacific Ocean winds. The spectral hindcast was propagated using a methodology that allows the estimation of the spectra at the nearshore project site from the contribution of each component present in the spectra in deep water. This is important in bays like Valparaíso, because it considers the energy coming from all directions where it is possible for the waves to enter the bay. Wave simulations were developed using the Mike21 SW-FM (Spectral Waves-Flexible Mesh) numerical model which is able to solve the wave transformation processes such as refraction and shoaling, the energy balance of the inputs (induced by the wind or conditions of distant swells), and attenuations (background friction and wave breaking). The results of the wave modeling analysis showed that the terminal is exposed to long northwesterly swell waves, which are unfortunately present predominantly during the summer time cruise season. Peak wave period exceed 16 seconds during this time. Consequently, modeled moored ship response to the waves and the potential downtime due to ship motion behavior.

The aNyMOOR.TERMSIM model was used to determine the behavior of the ships under swell conditions. The model predicted the motions of the vessel as well as loads in mooring lines and fenders. The movements of the ship were studied through 6 degrees of freedom which are defined with respect to the ship. Through orientation of the berth and optimization of mooring arrangements, the cruise ship could be moored safely at the location. However, excessive motion at the berth may effect passenger safety and comfort.

To evaluate the potential downtime due to motion, we reviewed the literature in regard to guidelines and recommendations for acceptable motion of cruise ships. References available includes PIANC (1995), Spanish ROM, and Nordforsk (1987). The recommended ranges varied greatly between the references. For the purposes of the evaluation, we adopted a median criteria for lateral movements and the Nordforsk guidelines for acceptable acceleration. In conducting the analysis we identified a need for further investigation and developing guidelines and recommendations regarding the accommodation and the behavior of moored cruise vessels in locations where long period waves are present.

102. Renovation and redesign of the Malamocco lock gates in the Venetian lagoon

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[4] Costruzioni Mose Arsenale scarl, Venezia, Italy

In 1981 the Italian government initiated the MOSE project to protect the Venetian lagoon as well as the iconic historic heritage of the city of Venice from flooding. The MOSE project (MOdulo Sperimentale Elettromeccanico or Experimental Electromechanical Module) is an integrated system consisting of rows of mobile flap gates. These gates are installed at the three inlets to the Venetian lagoon at Lido, Malamocco and Chioggia to isolate the lagoon temporarily from the Adriatic Sea during forecasted acqua alta high tides. The Consorzio Venezia Nuova (CVN) is the concessionaire for all the works on behalf of the government and began construction works in 2003. At the Malamocco inlet a large navigation lock with a length of 380m and a width of 50.5m was constructed. This navigation lock is intended to ensure the accessibility of the Port of Venice during acqua alta, when the flap gates will be closed. Only months after completion of the Malamocco lock, the sea side lock gate suffered severe damage during a storm on the Adriatic Sea on 5th and 6th February 2015. The lock gates were taken out of service and precautionary measures had to be taken by CVN to temporarily stabilize the damaged lock gate. SBE was subsequently involved to investigate the cause of the damage and to propose design solutions.

To explain the physical phenomena that caused the damage to the lock gate, several numerical studies of the wave climate in front of the lock were carried out. It was concluded that the damage was instigated by the combined effect of the specific wave conditions at this location and the particular design concept of the original lock gate. The combination of these effects resulted in significant uplift forces on the ballast tank of the lock gate which eventually led to the observed damage. Based on these results, it was concluded that both gates of the navigation lock had to be adapted or if necessary entirely redesigned. This paper focuses on the redesign of the sea side lock gate. For this lock gate, various alternative design concepts were developed and their performance under wave action was compared by means of scale model testing. Although the proposed changes resulted in a significant improvement, the vertical uplift forces remained high. In the end, a dual solution was therefore proposed with specific design modifications to reduce the vertical uplift forces on the one hand and with an increased net operational weight of the lock gate on the other hand. As a result, the supporting system of the sea side lock gate inevitably also had to be redesigned and changes to the civil structures will have to be made as well. At present, the construction works of the new sea side lock gate are underway and the primary line of defense of the MOSE system is expected to be finished by the end of 2019. The Malamocco lock is expected to be operational by March 2020.

103. The Importance of the U.S. Inland Transportation and Navigation System for the Panama Canal Grain Trade

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Abstract

Traditionally for the Panama Canal Authority, grain flows are the number two commodity transiting the waterway, ranging between 33.4 and 53.1 million metric tons in the last five fiscal years and representing a significant 20% of total cargo tonnage on average[1]. At the same time, about 81% of the total grain trade through the Panama Canal originates in ports located along the U.S. Gulf, including export terminals in Corpus Christi, Houston/Galveston and several terminals along the Mississippi River, perhaps the most important transportation mode for crops shipped out of U.S. Midwest.

In 2016, about 31% of total U.S. grains exports, that is, 44.1 million metric tons out of a total of 141.4 million metric tons transited through the Panama Canal. The main destination of the U.S. Gulf grain trade is East Asia, mainly China, Japan, South Korea and Taiwan, although there are significant flows to ports located at both the West Coast of Central and South America. The U.S. Gulf trade, however, competes with grains originating in the U.S. Pacific Northwest (PNW) and from alternative grains sources such as Brazil, Argentina, Eastern Europe, Russia and Australia. In order for the grain originating in the U.S. Midwest and transiting through the Panama Canal to remain relevant compared to the PNW and alternative sources in other countries, it is very important that the grain trade from this region has reliable and economical means of transportation to remain competitive. This fact highlights the importance of a safe and reliable transportation system, including inland navigation waterways, railroads and port terminals.

This presentation will begin assessing the importance of the different means of transportation utilized in the movements of U.S. grain exports to the world market. These transportation modes include trucks, railroads and barges. It will discuss the U.S. Gulf versus PNW “competition” in attracting grains for exports, especially the relevant East Asian market. Most of the grains exported through the PNW involve railroads while grains exported through the U.S. Gulf involve railroad and/or barges. Depending on the location of an American grain producer, he may decide to sell his grains to either a grain elevator with access to a railroad yard that can reach either/both the Gulf ports or PNW, or may decide to sell his grains to an elevator that may reach barge terminals connecting to export terminals located on the Mississippi River. To keep it simple, this interaction is dictated by the relative prices that a grain producer may receive for his product and by the cost of transportation from origin to destination. We will attempt to highlight the importance of the U.S. grain transportation system to the Panama Canal with the following analysis:

- Approximate the geographical area in the U.S. hinterland where railroads may deliver grains for exports either to the Gulf versus PNW. This approximation will be based on transportation cost and representative grain originating points for shuttle and unit trains.

- Approximate and measure the geographical areas where the Mississippi river and the export terminals along this river can be reached through the barge system. This will include the transportation costs of grains delivered using this transportation mode.
- Once the geographical area in the interior of the U.S. where railroads may deliver grains to export terminal is determined, and the geographical scope of the barge system is determined, we will attempt to forecast weekly grain transit through the Panama Canal using weekly grain transportation data (barges passing Lock 27 in the Mississippi River, rail deliveries to ports, grains inspections, grain barges unloaded in the New Orleans region and vessel loading activity in port). This attempt will be discussed during the final oral presentation.
- The importance of infrastructure developments in the U.S., especially the one related to the grain trade, will be highlighted. Special emphasis will be given to the Mississippi River Locks System and the need for upgrades. Locks failures and unexpected closures are negative events that impact the flow of grains through the system.
- The main grain export terminals along the Gulf Coast will be highlighted.

This presentation will be of interest and benefit to conference attendees because it will explain and highlight the importance of the inland transportation system for the U.S. grain trades. According to some sources, around 60 percent of all American corn, soybean and wheat exports exit the country via the Gulf Coast. According to “A Reliable Waterway System Is Important to Agriculture” developed by the U.S. Department of Agriculture, “Agriculture will provide a $21.5 billion trade surplus to the American economy” and “Exports are responsible for 20 percent of U.S. farm income, also driving rural economic activity and supporting more than one million American jobs on and off the farm”.[2] Therefore, a reliable and competitive grain transportation system is beneficial for both American farmers and for Panama Canal grain trade.

[1] Based upon Panama Canal Authority Datawarehouse, comparing with USDA data.

[2] USDA, February 17, 2017.

104. Traffic management, reliability and economic transport on the Inland waterway Danube

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The analysis on goods transport in the Danube together with cost factors and infrastructure reliability revealed the strengths, weaknesses, risks and opportunities of the Inland Waterway Danube. According to the results waterway transport will stay competitive or may even regain market shares if continuous reliable fairway conditions with an available water depth of at least 2.5 m can be provided even in low-water periods. Improving transport logistics e.g. with fixed contracts using mixed modes of transport and optimal loading depending on actual conditions are necessary as well. For managing a dynamic river as transport infrastructure in a cost-efficient and environmentally friendly way viadonau has teamed up with Vienna University of Technology and Hoffmann Consulting in order to develop a holistic Waterway Asset Management System (WAMS).

In a first phase from 2012 to 2015 the principal methodological availability approach and a dredging management have been developed (WAMS 1.0).

In the second phase from 2016 to 2018 additional functionalities for sediment, waterway structures, and traffic management have been implemented (WAMS 2.0).

The development and implementation in a software tool has been work in progress providing constant feedback between theoretical considerations and practical results as new functionalities become available. Thus, the WAMS software tool is becoming the central database providing viadonau with the means to move from empiric reactive maintenance approaches towards quantitative asset management strategies with fast semi-automated processing capabilities and pro-active maintenance in a user-friendly environment. The focus of this paper is traffic management connecting the physical availability and its optimization with an analysis of actual traffic flows and utilization of the vessel fleet in real time.

To achieve this goal anonymized transponder data leaving only vessel type, position and draught loaded are imported for calculating encounters, traffic distributions and fairway utilization. Based on these data it is possible to generate traffic heatmaps and assess critical encounters in narrow sections at low water periods as a basis for aligning the fairway path and defined levels of service. Furthermore, the WAMS is capable of monitoring the progress of pro-active dredging measures allowing a fast implementation and communication of results to the transport industry.

With historic and actual data from riverbed surveys, water levels and traffic it is already possible to calculate the availability of any defined level of service for any transport route on the Danube in Austria in a matter of minutes. The possible loading of any vessel type can also be derived from calibration curves linking utilization and static draught with dynamic squat depending on vessel speed and necessary underkeel clearance.

With the Ministers of Transport on all riparian countries of the Danube endorsing a common Fairway Rehabilitation and Maintenance Master Plan in 2014 (FAIRway) the EU - project

WAMOS will lead to one common database on fairway conditions of the entire Danube. Combining these information with available traffic analysis capabilities will allow both efficient investments in waterway availability as well as competitive pricing and efficient transport planning on 2.400 river kilometre on the entire Danube until 2020.

105. Holistic dredging and sediment management on the waterway Danube

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Recent research on traffic development and transport economics in the Danube corridor revealed the importance of improved navigation conditions on the waterway Danube. The developed Waterway Asset Management System (WAMS) of viadonau allows a real-time calculation of fairway availability, planning of dredging measures, sediment management and budget estimations for various target conditions. The paper provides an overview on the dredging management in this software tool reproducing the entire dredging process, starting from an automated analysis of critical sections, planning of dredging measures per drag and drop, automated cost estimations based on economy-of-scale cost functions and an overview on the status of all measures. Prior to the developed solution estimations of dredging volumes had been based on single-beam surveys and the profile method or a more accurate "manual" assessment of multi-beam data in ArcGIS. With these new capabilities an analysis based on accurate multi-beam riverbed surveys is feasible accounting for deviations in billing of conducted dredging measures. Further functionalities include an analysis of dredging impact duration based on sedimentation and erosion rates, enabling an assessment of the efficiency of a dredging measure in comparison to other possible solutions (e.g. fairway alignment, construction of groynes). Thus, a much faster and efficient planning, implementation and controlling of dredging measures in order to achieve higher fairway availability has been realized. Based on the concept for a systematic sediment management the paper also gives insight into the key elements, findings and functionalities of an advanced sediment management taking into account both economic and ecologic factors. By facilitating an analysis of sedimentation and erosion rates on short sections for a fixed time frame as well as the development over time including dredging and dumping measures the developed WAMS provides an overview on all conducted dredging measures and related dumping sites for a given time frame as well as a total balance on all erosion and sedimentation volumes for any given time frame and river stretch (sediment balance). Instead of lengthy analyses and studies the Sediment Management allows viadonau to constantly assess and adapt their approaches by optimizing both the selection and the timing of appropriate measures. In summary, the developed functionalities enable an efficient balancing of both the interests of environmental protection and inland navigation at the same time. The comprehensive analysis and documentation system is constantly being updated based on previous results, thus becoming more accurate with every year.

106. Developments in Radio Navigation Systems - Present Status and Outlook to future developments (Maritime and inland Waterways) -

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Position, Navigation, and Timing (PNT) is part of the critical infrastructure necessary for the safety and efficiency of vessel movements, especially in risky or congested areas. GNSS (especially GPS) has become the primary PNT source for maritime and inland waterways navigation. The GNSS position is used both for vessel navigation and as the position source for AIS. The IMO e-Navigation concept supports the development of resilient positioning, navigation and timing (PNT) information. It is acknowledged that a number of technically dissimilar systems are required to ensure resilient PNT. The combined use of PVT relevant sensors (e.g. GNSS Receiver, DGNSS corrections, Multi-Radionavigation Receiver) and on-board systems (e.g. Radar, Gyro, etc.) could establish the required redundancy to enable the monitoring of data and system integrity and to improve the performance of provided PNT data. This enables the protection of the on-board process of PNT data generation (cybersecurity) against intrusions by malicious actors.

Unfortunately the mainly used GNSS is vulnerable to jamming and interference, intentional or not, which can lead to the loss of positioning information or, even worse, to incorrect positioning information. One potential source of resilient PNT services is the use of terrestrial backup systems (e.g. eLoran or R-Mode), using signals independent of GNSS. The concept of R-Mode, or ranging mode, was introduced to the IALA ENAV Committee many years ago, it is a novel way of using existing maritime radio systems (MF radio beacon as well as AIS) to provide GNSS independent PNT. R-Mode has the capability to support resilient PNT by providing terrestrial positioning in coastal waters or along inland waterways. First developments of this system concept were conducted in a feasibility study as well as a practical field demonstration within a transnational EU project named ACCSEAS (Accessibility for Shipping, Efficiency, Advantages and Sustainability) which ended in February 2015. A following up project (R-Mode Baltic) has just started (10/2017) to provide a large transnational testbed for dynamic tests and to further develop the R-Mode technology towards an operational system. The paper will present an overview of recent developments in the field of radio navigation systems to be used in maritime and inland waterways. Thus systems comprise existing and emerging GNSS, the various options of using GNSS differential corrections (e.g. IALA beacon, SBAS or AIS/VDES) as well as terrestrial radio navigation systems (like R-Mode). In addition, the paper will contain a brief description about newest developments regarding Resilient PNT concepts from IMO and IALA, based on latest published performance standards (multi- system radionavigation receiver, and associated PNT data processing guidelines).

107. Automating Mooring for Increased Safety and Security

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Many aspects of port operations, have been improved by automation in recent years. These improvements have increased the throughput of port and visibility of operations. However, in most ports mooring continues to be a manual time consuming and dangerous task. Indeed mooring and the required line handling is one of the few tasks left in modern industry that regularly exposes staff to life threatening risks on a daily basis. Furthermore, conventional mooring provides no feedback to the port or vessel regarding mooring performance or integrity.

Automated mooring system that do not employ ropes are able to eradicate the risks associated with line handling for all staff on board and land side. There are no handling injuries and snap back risks making mooring significantly safer for personnel and reducing lost time due to injuries to nothing.

Furthermore these systems are able to monitor environmental conditions and mooring performance with a high level of precision and provide real time detailed feedback on mooring performance and integrity. Data stored over time can be used to compare to current conditions to predict potential upcoming events and provide advance warning to the port and vessel. Also stored data can be examined and stored in much the same way as Voyage Data Recording (VDR).

This paper will examine the pros and cons of automated mooring implementation and provide real world examples of three ports and one canal system:

- Port Hedland Port Authority, Utah Point, Port Hedland, Western Australia, multiuser bulk loading facility

- Port of Salalah, Salalah, Oman, container terminal.

- Port of Ngqura, Port Elizabeth, South Africa, container terminal.

- St Lawrence Seaway, Canada

Port Hedland has been able to secure cape size bulk carriers on a berth originally only intended, and long enough, for panama vessels. This has enabled the port to realise a large increase in potential through put due to increased vessel size and speed of mooring while reducing risk to personnel. Additionally as the berth is very close to the busy port entrance the system has removed the effects of passing vessels at the berth and thus the removal of the risk to the moored vessel and personnel of parted lines.

The port of Salalah experiences a long wave during the Khareef (monsoon) season that can cause the vessels to surge back and forth in the berth. The surge often times resulted in ceasing of cargo operations and parted lines and the associated risks to port staff. The automated mooring system has reduced vessel surge to insignificant amounts removing all the risks associated with it. Furthermore the port can be kept fully informed of the longwave condition and how the mooring system is coping with it.

Similarly to the Port of Salalah the Port of Ngqura experiences vessel surge as a result of long wave. This combined with significant and steady winds resulted in significant risks to both staff and vessels while in the port. Again these effects have been completely removed through the implementation of automated mooring resulting is safe and secure vessels while along side and a safer work environment for the staff.

Finally we look at the St Lawrence Seaway, the river and lock system connecting the Atlantic Ocean with the Great Lakes of North America. Mooring vessels in these locks exposed staff to significant risks from falling and parting ropes as a result of gear failure. Additionally at low water level the mooring lines were extremely ineffective at preventing surge in the vessel and thus the risk to vessel or lock at this point of the lockage was very hazardous. Managing these risks was a major part of the operation of the locks. After the implementation of automated mooring not only are the risks to the vessel and staff reduced to almost nothing the locks can now be transited faster and the operation implemented remotely.

108. Motions of moored vessels due to passing vessels: full-scale measurements at a container terminal in the Port of Antwerp

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The Northsea terminal is a busy container terminal in the port of Antwerp which is located in the tidal river Scheldt along the navigation channel. At this terminal multiple deep-drafted container vessels in the range of Post Panamax up to Ultra Large Container Vessels berth on weekly basis. On the other hand, all seagoing vessels coming to and leaving the port of Antwerp pass this terminal. All passing vessels cause a displacement of the water resulting in forces working on the moored vessel. The size of these forces are dependent on the passing speed, the passing distance as well as the dimensions of the passing and the moored vessel [1]. The mooring lines as well as the fenders will try to absorb the forces working on the moored vessel, however the latter one will experience some motions due to the elasticity of both mooring lines and fenders.

The Northsea terminal was designed and built in the 1990's. However, due to economies of scale in the container vessel industry, the sizes of the seagoing vessels have increased a lot during the last 2 decades resulting in a situation which is different from the design phase. As such, the Antwerp Port Authority executed a full-scale measurement campaign at the Northsea terminal, the terminal in the port of Antwerp which is most exposed to ship-ship interaction effects. During a period of 3 months the motions of all moored container vessels larger than the Panamax class at this terminal where measured using 2 dGPS instruments mounted on board of the vessel. All information about the vessels passing the terminal, as well as the wind and the current conditions were monitored as well.

Analysis of this large dataset revealed some interesting results. First of all the importance of pre-tension in the mooring lines, which is challenging to obtain at all times in a tidal environment where it is not allowed to use auto-tension, was clearly seen. Secondly a clear difference in observed motions of the moored vessels was seen in relation to the quality of the mooring lines being used. Where the minimum breaking load of the mooring lines is always in agreement with the guidelines set out by IMO, there is no such regulation about the elasticity of the mooring lines. As such, a large difference in elasticity has been found, where a larger elasticity clearly results in larger motions of the moored vessel. Even with good pre-tension on the mooring lines, some vessels with mooring lines with an elongation at break of more than 30% showed rather large motions.

In order to guarantee the safety of the terminal operations at all times, it was investigated whether the so-called ShoreTension system could minimize the motions of the moored vessels equipped with elastic mooring lines. The ShoreTension system is a dynamic mooring system developed to assist large container vessels to stay safe at the quay wall during extreme wind loads. The system is used in addition to the regular mooring lines. During a period of 3 months, the motions of moored vessels equipped with the ShoreTension system were monitored. Different configurations have been tested in order to find out what is the most optimal configuration. The full-scale measurements have proven that the ShoreTension system can help in reducing the motions of the moored vessels considerably, however guaranteeing the

pre-tension in the mooring lines at all times remains a necessary condition for safe mooring even with the ShoreTension system.

[1] TALSTRA, H.; BLIEK, A.J., 'Loads on moored ships due to passing ships in a straight harbour channel, PIANC world congress, San Francisco, 2014.

Statement:

Due to economies of scale in the shipping industry on the one hand and expansion of ports due to increasing maritime traffic on the other hand, ports are often facing more as well as more intense ship-ship interaction effects. This might affect safety of port operations, which is of crucial importance for many ports.

With an extensive full-scale monitoring program, the Antwerp Port Authority investigated the effects of ship-ship interaction at one of their most exposed container berths. The effectiveness of the newly developed dynamic mooring system called ShoreTension was also for the first time tested for the purpose of ship-ship interaction effects. The results of this monitoring campaign will have the interest of both port authorities, as well as consulting companies involved in the design of port facilities.

109. Design Guidelines for Inland Waterway Dimensions

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The PIANC INCOM WG 141 was founded in 2010 to provide planners of inland waterways with design standards for inland waterways. The report with the title Design Guidelines for of Inland Waterway Dimensions will be published in 2018. In 18 meetings and three interim meetings on special questions, the group has undertaken a great review on guidelines and practice examples as well as analyzed methods for detailed design. International standards as well as practice examples show a wide variety of design cases. One reason for the differences is the great variety in traffic density but also the tradition of shipping in different countries. Furthermore, especially waterways with significant flow velocities as rivers are a complex system influenced by its varying bathymetry and currents to mention just a few aspects. So it is not appropriate to give just “one” design waterway dimension.

Instead a design method was developed leading generally to three recommended design steps: “Concept Design”, “Practice Approach” and “Detailed Design”. Special recommendations will be provided for designing fairways in canals and rivers, bridge opening widths, lock approach length’s and widths and the dimensions of turning basins, junctions and berthing places. The “Concept Design” provides basic dimensions for designing the necessary waterway dimensions. The data come coming mostly from existing guidelines. In a next step, called "Extended Concept Design", special aspects as wind or currents will be accounted for by providing formulae, derived from approximations of the driving dynamics of inland vessels. The “Practice Approach” collects and interprets data from existing waterways. It is mostly used for comparing and evaluating the results of the other design methods. If the design problem considered cannot be solved with the Concept Design, a Detailed Design will be recommended. It is generally basing on simulation techniques as Ship Handling Simulators.

Both Concept and Detailed Design will be supported by a new approach to account for the safety and ease of navigation demands on waterway design (shortly S&E). The report provides also Guide Notes on the optimal use of ship handling simulators for waterway design purposes. This paper provides a brief introduction into the structure of the report of WG 141. It outlines the main findings, especially concerning the consideration of the necessary S&E quality. Selected results will be presented concerning the Concept Design of fairways in canals, the Practice Approach for rivers and the Detailed Design for lock approach lengths and widths.

110. Methodology to Analyze the Moored Ship Behaviour Due to Passing Ships Effects

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This paper describes the studies carried out and the methodology developed to analyze the feasibility of a new solid bulk terminal from an operational point of view. The aim of the study is to analyze the effects of passing ships, selected from traffic data in the area, on moored vessels at the new terminal.

The study starts with the determination of the expected passing speed and passing distance to moored vessels in the new terminal of those vessels operating in the nearby berths for different wind conditions (direction and speed) using a fast-time ship manoeuvring software. The results (speed and distance) are used as input data to determine the suction forces andmoments generated by the passing vessel on the moored vessels.

The dynamic response of the moored vessels under different weather conditions together with lines and fender forces generated by the passing vessels are also simulated by using specific software. In view of all the previous results, different alternatives are proposed in order to improve the conditions obtained in the analysis and raise the operation limits. The final phase of the study includes real-time manoeuvring simulations in order to verify the results obtained along the process in a realistic working environment.

A complete set of simulation tools is applied sequentially in order to develop a global and precise analysis and elaborate a clear picture of the safety level of the operations. Fast-time manoeuvring simulation (SHIPMA), passing ship effects (ROPES), dynamic response of moored vessels (SHIP-MOORINGS) and Real-time shiphandling simulator. AIS data (Automatic Identification System) covering the vicinity of the new terminal were also considered and analyzed to define manoeuvring strategies executed by the current vessels in the area. The methodology is explained and developed based on a real case in the Port of Barcelona (Spain).

111. New Panama Canal Locks Rolling Gates Drive Mechanism Design and Construction Considerations.

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This presentation includes a brief description of the parameters (forces, speed, flows, drags, friction, water densities, etc.) considered to define the relevant characteristics of the drive mechanism to open and close a 4000 tons Rolling Gate in five minutes. Also we will comment designs discussions and decisions to define relevant topics such as the sealing systems of the gate, flotation considerations, etc.

We will make a general description of the rolling gates components and their functions to have a comprehensive understanding of the system to operate the gates.

A Brief description of the Guidance, Bearing and Sealing system (GBS) to maintain the gate on the rails during its displacements, support the hydrostatic loads, and minimize the leakage of water through the borders of the gates.

We will comment topics such as the wire rope engineering selection factors that were changed during the design process.

Innovative electro-mechanical concepts has been implemented to modernize the tensioning system using load cell, sensors, and hydraulic cylinders to reduce any slacks of the wire rope. Other innovative concept is the Load Limiting Device (LLD) design to minimize the effect of high vertical forces, carried by the lower and upper wagons, than can be induced during seismic movement or loss of buoyancy of the gate due to a ship impact. A plow system has been implemented to remove any debris ahead of the lower wagons, which could be deposited over the rails.

Design considerations for easy maintenances or repair of lower wagons will be addressed.

In this presentation will be mentioned a test that was developed at University of Udine to evaluate the gate seal performance. To displace the rolling gates many forces has been identified to be overcome. These forces which some are relevant others has minimal effect during the displacement of the structure but not all them interact simultaneal. The most critical force to analyses correspond to the friction caused by the head differences and the effect of the difference on water salinity. There was a considerable friction on the wagons wheel and the rail contact surface basically due to the installations constrains. Innovative wire rope tensioning system will be describe. The tensioning mechanism required to eliminated any possible slack of the wire rope.

During the design process particular decisions were made. The designer decided to select the “wheel Barrow” concept to the distribution of the positions of the wagons to carry the weight of the gate. Which consists in one lower wagon in the bottom at the front side of the gate. The supported wheel of the lower wagon are separated 1.6 meters and the wagon is located at the center of the gate. On the back side of the gate there is an upper wagon located on the top of the gate with wheels separated more than 10 meters. These wagons wheels carry approximately 15% of the total weight of the steel structure. The other 85% is supported with the flotation compartments.

Other of the concerns during the design process was the wear of the rail surface in the area of contact whit the wheels of the upper wagon at the recess entrance during the close position of the gate due to a small displacement of the center wall of the recces. To address this problem several alternative were analyzed.

112. BIM application in pier construction

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BIM (Building information modeling) is used in the construction of 3D model to adjust the 3D positions of the material and is being utilized as a database for design, construction planning and maintenance by recording the construction procedure and member specifications. Initially it was mainly applied for the construction of building structures. In recent times the wide application of BIM to civil engineering structures has begun to get progressed for utilizing in general infrastructures such as roads, bridges and tunnels. However BIM has not been applied to port facilities in Japan yet. This report presents the result of applying BIM in the construction work of liquefied natural gas (LNG) receiving pier.

Pier construction site is located in the northeastern part of Japan, at Soma port in Fukushima prefecture. In order to overcome the energy depletion immediately after the Great East Japan earthquake 2011, it was necessary to secure diverse energy sources. In order to advance the import of liquefied natural gas, a petroleum resource company has proceeded with the construction of mooring pier for the LNG import terminal in last 2 years. During initial stage of construction, there were few concerns such as, the abundant rise and fall in bearing layer under the seabed that drives the foundation pier, the facilities making up the pier were close to each other and the equipment installation of the platform was complicated.

In this pier construction, we aimed at achieving the following three points by applying BIM.

1. To predict and ensure whether the pile foundation certainly attains the bearing layer.

2. To confirm that the structures do not interfere with each other before construction and to explain the workaround to the workers in advance.

3. To calculate the vessel position where the pier could be constructed safely and to decide appropriate anchor placement position in advance.

By applying BIM in this construction work, we achieved the objectives by overcoming the problems by the following procedures.

1. At first the depth of the bearing layer is represented by the 3D model from the boring data. During driving a pile, the electric resistance value of the piling installation is then measured and the elevation of the bearing layer of the 3D data is corrected sequentially. As a result of repeating measurement and correction of 3D data as well as completely ascertaining the correct bearing layer height, we realized the necessary embedded depth that is required for all piles.

2. By inserting a jacket model into the reproduced pile shaped model in BIM, we confirmed that there was no conflicts between jacket and pile. In addition a surveillance camera was installed inside jacket sheath pipe to properly guide the jacket to the pile position.

A drone equipped with the digital camera flew and captured the shape of the wave dissipating concrete blocks under the bridge position. By superimposing the model of the bridge on this, we confirmed that these two do not interfere.

The reinforcing bars of the slab concrete of the platform of the pier were reproduced on the model and the embedded metal fittings of the equipment were superimposed on this and confirmed that both did not interfere. In case of interfering, we moved the rebar before attaching the anchor. Showing these work procedures in a 3D model enabled the workers to have a deep understanding of the construction procedures.

3. According to the work process, the vessel position during construction is reproduced on the model and the anchor position was reproduced at the same time. We confirmed that the crane ship can enter the installation position by hanging the jacket while the anchor of the work vessel can be placed in the required position beforehand. An illustration of the procedure was used to explain to the vessel operator. By applying advanced technology, the construction was implemented safely and smoothly through the procedure.

As described above, the construction site using BIM equipped with a built-in monitoring camera, equipment to measure the electric resistance of the pile and aerial photography for shape confirmation, was concurrently carried out. As a result, the construction was ensured to complete with high accuracy. In addition, the complex operation can be easily understood by the 3D model combining the BIM model and the field verification results. Thus, it is very effective in giving work instructions to the operator.

On the other hand, it is also a fact that the data input into BIM needs time and experience. In case of civil engineering work, it is necessary to combine the construction ground data and the surrounding landscape data with the structure model. Therefore, the number of programs to be handled becomes large which leads to the time requirement to learn the program operation. Moreover since the number of operator expertise in BIM operations are still few in the country, it is mandatory to train within the company for the time-being. While consensus on the application of BIM is progressing within the construction industry, the secured human resource is an urgent issue.

113. Applying PIANC Fender Design Guidance to US Design Codes

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PIANC guidelines for fender design (Report of PIANC MarCom Working Group 33—Guidelines for the Design of Fender Systems) was published in 2002. The PIANC document is a guidance and not a design code, while many designers worldwide utilize it as such. The PIANC document itself covers many factors related to calculating berthing energies, selecting a marine fender, and determining reaction loads on the supporting marine structure. Where the PIANC guidance could use some additional discussion is in the application with current design codes. In addition, since its publication in 2002 a number of items discussed within the PIANC fender design guidance have been research further including berthing velocities, the added mass coefficient, and the consideration of a more rational approach to developing factors of safety associated with fender selection.

This paper provides a proposed rational approach for marine terminal designers in the United States to accompany the PIANC document and apply the factors outlined within it to standard US design codes. In addition, this paper provides commentary on the various topics covered within the PIANC guidance to provide some additional clarity and updated information based on the latest information and research for various topics.

As an example, recent research has found that the berthing velocity criteria stipulated in the PIANC Guideline may be overly conservative. This has potentially led to waterfront engineers specifying fenders that may be overly conservative, while meeting all current design guidance.

114. Advances on the methodology for the Inland Waterways Classification for South America

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In most of the South American countries, there is no official classification of waterways elaborated for the navigation purposes which would account for the diversity of the types of navigation activities on the most South American waterways (from deep draught navigation to barges and pushed convoys to local and informal navigation). On major South American waterways in Argentina, Brazil, Colombia, Paraguay in Peru, only the values of the minimum water depths are determined and, in some cases, guaranteed. National classifications exist in Brazil and Colombia and they are currently being revised, in the context of the work on the countries´ national inland navigation policies. These basic classifications consider minimum water depth as the main criterion but are not sufficient for most of the planning and investment decisions or the work on the national strategic plans for IW development.

There is, therefore, a need for a common classification for South America which would result in a more efficient, transparent and sustainable use of inland water transport and logistics services, in general. Since October 2016, ECLAC and PIANC are working together in close collaboration with the experts from South American countries on a common classification for the inland waterways and the first results of this work will be presented in this paper.

The paper will offer:

- Overview of the inland waterways' classifications in South America
- Identification of the main parameters (i.e. metrics) for the harmonized South American classification
- Proposals on the classification methodology
- Guidelines and recommendations for further development and application.

115. The Port of Oakland's Vision 2000 Middle Harbor Basin Projects, Oakland, CA, USA

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Ellen Johnck

Ellen Joslin Johnck, RPA, San Francisco, United States

The Port of Oakland is the primary and only bulkhead container port for the San Francisco Bay region and northern California. It is the fifth largest in the United States based on TEU cargo volume.

The purpose of this presentation is to describe the Port of Oakland's Vision 2000 Middle Harbor Basin Projects (MHB Projects) as an example of how a port can work with nature to achieve its navigation efficiency and capability enhancement goals in concert with its environmental and community goals. The MHB Projects are also discussed as a case study in the PIANC Working with Nature (WWN) Work Group #176 Report currently in the Envicom review process prior to publication scheduled in 2018. ***

The MHB Projects evolved with the Port of Oakland's Year 2000 Vision Plan. The Plan was a $1.2 billion capital expansion plan to build a new modern port for the 21st century. It included several projects to fulfill both the Port's navigation mission by modernizing its terminals and deepening the Inner Harbor shipping channel; and its community and environmental stewardship goals by creating a public park space and shallow water habitat.

The Vision 2000 navigation projects included the dredging of the federal channel from -42' to -50'; building two new marine terminals, a joint inter-modal rail terminal, realignment of roadways, and conversion of the closed Oakland Army Base to maritime use.

The Vision 2000 community and environmental projects were: 1) a 38-acre Middle Harbor Shoreline Park (MHSP); and 2) a 181-acre Middle Harbor Enhancement Area (MHEA): a shallow water fish and wildlife habitat area to be created by beneficially reusing the approximately 5-6 MCY of sand and mud from the proposed -50' channel deepening project.

This presentation will explain the process of how the Port followed the basic WWN template in the implementation of its Vision 2000 projects: Step I: Establish project goals and objectives; Step 2: Understand the Environment; Step 3: Make meaningful use of stakeholder engagement; Step 4: Prepare project proposal/design to benefit navigation and nature; Step 5: Build/Implement; Step 6: Monitor, adapt, manage

The Vision 2000 plan called for a new modern port to ensure the Port of Oakland's future economic and environmental success. This meant expanding the Port's shipping operational capacity and improving its cargo handling efficiency while simultaneously achieving its environmental and local community recreational goals. This presentation will be of interest to both PIANC members and attendees as it highlights a universal challenge for ports and the maritime industry to succeed on multi lateral fronts in the 21st century and illustrates the path to success by working with nature.(based on PIANC's WWN position paper revised in 2011)

***PIANC published a position paper, first in 2008 and later revised in 2011 that describes the Working with Nature (WWN) philosophy. The position paper defined the WWN concept and discussed how the approach can be applied to navigation and port infrastructure. The WWN approach provides a basis for maximizing opportunities for working with natural processes to

deliver environmental restoration results that go beyond just avoiding or compensating environmental impacts. The Position Paper did not discuss tools and practices, and hence PIANC established Working Group #176 to write a Report describing WWN tools and practices.

116. Mitre Gates: Design and Fabrication

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Eric Johnson [1, 2], Frederick Joers [1, 2]

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Presentation of this paper will be given as part of the SHORT COURSE: Miter Gates, Rolling Gates and Operational Machinery Process Design.

The recently published PIANC WG Report No. 154 covers international mitre gate design guidance and guidelines. This presentation will summarize the current state-of-the-practice and best practices in mitre gate design and fabrication.

This presentation will provide design guidance and outline potential design issues that may be encountered during the design phase when approaching a new mitre gate design. Certain areas are also applicable to issues that may be encountered when repairing, retrofitting, or rehabilitating an existing mitre gate. With awareness of such potential issues, a more comprehensive design is expected to ease construction, lower maintenance effort, and extend the service life of the gate structure. Factors in gate design may also include proper adjustment of the gate upon installation or during service to ensure the gate is loaded properly and performs as designed. In addition to outlining general guidance, a secondary purpose of this presentation is to make designers aware of both normal and unexpected design conditions that can alter design approach, methodology, and detailing practices. In general, gates should be designed such that the failure mechanism is ductile and provides warning before failure. Various design guidelines are available including design references from several countries. Recently, there have been international efforts in standardising waterway infrastructure including lock mitre gates.

A summary of mitre gate fabrication around the world will be presented. There are quite a variety of fabrication methods depending on materials used and intended functionality and maintenance. Common fabrication challenges as well as best practices will be discussed.

117. Mitre Gates: Maintenance

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Presentation of this paper will be given as part of the SHORT COURSE: Miter Gates, Rolling Gates and Operational Machinery Process Design. The recently published PIANC WG Report No. 154 covers international mitre gate design, operation, and maintenance. This presentation will summarize the current state-of-the-practice and best practices in mitre gate maintenance. Mitre gates are critical components of locks for system reliability. The system reliability is strongly dependent on the successful long term operation of mitre gates. Maintenance is essential to reducing costly downtime and ensuring a long, successful life.

Starting with design, there are many features that can be included in how a mitre gate is constructed that can make future maintenance easier, less time consuming, and cheaper. Such features include easy-to-replace components (susceptible to wear and damage), accessibility to gate components with larger openings and ladders for maintenance personnel, and standardising replacement parts. Standardisation of river system mitre gate design helps to reduce part inventory, improves consistency in repair and replacement methods and reduces overall maintenance costs.

Methods of maintenance are also important. Smaller gates can be lifted out of place and worked on in-the-dry. Larger gates may require lock dewatering and jacking. Proper care to procedures and planning for these maintenance events is essential.

Debris and ice can cause operational and maintenance problems. High volume air bubbler systems have been used effectively to move ice and debris from the gate recess area such that the gate may fully move to recess position. High volume bubblers are also used across the lock chamber upstream of the gates to help limit ice movement into the chamber and gate area. Low volume air systems or propeller systems can be attached to the gates to prevent the buildup of ice on the gates. Permanent or portable steaming wands are used to cut ice from lock recess walls or gates.

Structural health monitoring, instrumentation, and inspection play important roles in proper maintenance of a mitre gate. When a problem is identified early, the resulting repair is often easier, less expensive, and less impacting to system performance than when a problem develops into a large and major issue. In addition to components, the materials used to construct the gate components can have a significant impact on performance and longevity. Recent advances in bearing and composite materials have lead the way to better performance self-lubricating hinges as well as corrosion-resistant and lighter gates made of fiber reinforced polymers (FRP). These materials can reduce the amount of maintenance required for a mitre gate.

118. Numerical investigation of the impact of inland transport on bed erosion and transport of suspended sediment: Propulsive system and confinement effect

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Inland transport is one of the modes of transport that recognizes these last year's a lot of attention. This mode of transport is known by its ecological quality in term of CO2 emission compared to road and rail transport. However, despite the reduced amount of CO2 emitted, this mode of transport still has a significant negative impact on the environment, which is the erosion of banks and the bed of inland waterways as well as the re-suspension of existing polluting particles and contaminants. This impact becomes more and more visible with the arrival of the new generation of ships with large size and their very powerful propulsive system.

The presence of suspended sediment in inland waterways leads to difficult problems for the development and maintenance of channels. To these problems are added the quality of the water. In fact, sediments trap many elements such as metals of industrial origin. There can be transport or accumulation of these pollutants which may be re-suspended under the effect of hydrodynamics of the water often disturbed by ships passage. These re-suspension can contribute to transport of pollutants from a polluted area to a unpolluted area.

The understanding and control of interactions at the water-sediment interface are extremely complex due to the presence of several processes of natures and spatio-temporal scales very different. The hydro-sedimentary processes are governed by the action of friction exerted by the water on the bed of the channel. It is generally accepted that sediment transport is carried out in two modes: bedload on the channel bed and suspension in the water.

Numerical modeling of the sediments suspension phenomena is often carried out on a large scale by models such as Saint-Venant or Boussinesq. The recourse to this type of model is mainly related to the simplifying assumptions adopted. These models use empirical formulas for estimating shear stress applied on sediments using average velocities. Recently, and thanks to the rapid development of computing resources, fully models based on Navier-Stokes equations are used to model sedimentary transport. The coupling between the fluid model and the sediments transport models can be strong (simultaneous resolution of the both equations) or weak (alternative resolution). The advantage of these models is the high precision of the shear stresses estimation on the channel bed.

Hence, in the present work a fine numerical study was conducted to assesses the impact of the inland transport on the inland waterways. The influence of the under keel clearance and the ship advance coefficient have been tested for several size of sediments. This study was carried out using a Computational Fluid Dynamics model (CFD) based on Unsteady Reynolds-Averaged Navier-Stokes (URANS) is used to simulate the flow around the ship as well as through propellers. This model is coupled with a sedimentary transport model to simulate the re-suspension of sediments. The both models were verified and validated using an experiment data. Flow is considered with free surface and highly turbulent. An inland ship with twice propellers is selected for this investigation.

KEYWORDS: Inland transport, environmental impact, Computational Fluid Dynamics (CFD), ship container, sediment resuspension, propellers effect.

119. Development of method of grasping distribution of coral reefs using remote sensing

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Coastal development activities – such as land reclamation for harbours and dredging for navigation channels – in coral reef regions of the world can have a negative impact on the habitats of diverse marine organisms and on tourism resources. Thus, for coastal development it is extremely important to evaluate its impacts, mitigate or avoid adverse effects, and consider alternative measures.

Here, we would like to introduce an accurate method to grasp coral distribution in coral reef regions using remote sensing. Using this method, the area – of up to several tens of square kilometers – of distribution and coverage of coral reefs can be accurately grasped and analyzed.

As an example, we will report the results of our work using remote sensing technology in Okinotori Island, Japan. Okinotori Island is an atoll – a ring-shaped reef and chain of rocks made of coral – that is roughly 4.5 km from east to west and 1.7 km from north to south and has a depth shallower than 10 m. As a result of obtaining satellite images of the entire island, and of assigning the teacher data(training data) of the coral reef coverage based on image clustering and on-site survey, it was possible to analyze the coral reef distribution and coverage with 80% accuracy. Moreover, we also obtained the satellite images from over several years, and using the same analysis method as above, we were able to grasp the secular changes in coral reef coverage. This technology is an effective tool to determine quantitatively the impacts of coastal development, such as dredging for navigation channels.

120. Latest in Technologies for Navigational Locks

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The deliveries of a modern navigational locks consist of design, manufacturing, assembling and commissioning of wide range of electro hydraulic and electro mechanical drive and control systems.

The latest technological innovation for the actuators as well as the latest innovations in the field of control systems and possibilities of IoT will be presented. As a local reference the hydraulic system for the navigational locks and the water saving system of Panama Canal Expansion ship locks will be also presented.

In designing of the navigational lock system both electro mechanical and electro hydraulic system should be taken into the consideration. The electro mechanical solution will be presented based on the existing references. The new electro hydraulic solutions like the hydro motor drives and self-actuating hybrid cylinder will be as well presented in this presentation.

The modern data analysis technologies have made possible to develop intelligent tools for total life cycle management. The new sensor technology together with the data analysis services provided will be used in creating IoT solutions. This makes it possible to build a system which does give you the needed information about your system to plan the predictive maintenance activities for the navigational locks.

121. How Navigable are Fluid Mud Layers?

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Fluid mud can be described as a mixture of water, organic matter and mainly cohesive mineral sediment that is usually found in estuaries and in rivers with low-intensity currents. It is in a transient state and will densify over time unless mixing energy is added to mud layers by means of mechanical and/or natural forces. Typically, fluid mud exhibits bulk densities between 1080 and 1200 kg/m^3. It has a weak strength that develops over time forming a structured bed of considerably higher rigidity.

The fluid mud layers can be substantial in harbours and waterways. Hence, the PIANC maritime regulations have been developed to guarantee safe navigation in muddy environments. The PIANC Working Group 30 defined the nautical bottom as “the level where physical characteristics of the bottom reach a critical limit beyond which contact with a ship's keel causes either damage or unacceptable effects on controllability and manoeuvrability.” Accordingly, the nautical depth was defined as “the instantaneous and local vertical distance between the nautical bottom and the undisturbed free water surface.” The application of these definitions requires insight in the physical characteristics of the mud that can characterize the effect of mud layers on the behaviour of a ship. Based on experimental research in the Port of Rotterdam in 1974, the density of 1200 kg/m^3 has been chosen in the harbour as the physical characteristic that defines the nautical bottom. In other harbours this density value is ranging approximately from 1150 to 1300 kg/m^3 or the definition of nautical bottom is determined by echo-sounding or rheological criteria. One of the goals of this paper is to compare the criteria that are used for determining the nautical bottom in harbours.

The fluid mud layers have to be maintained to ensure the entrance of ships to the harbours. Often the dredged sediment is relocated to the open sea making current maintenance method expensive. A remedial maintenance concept of keeping the sediment in place was applied at the Port of Rotterdam. The water injection dredging method was employed for liquefying the top layers of the sediment and mobilizing the fluid mud from the bottom of the 8th Petroleumhaven to a deepening of the total area of 500x100 m^2. In this paper we show that fluid mud layers up to 1.5m can be created using the water injection dredging method.

The detection and monitoring of fluid mud layers is of primary importance to safeguard navigation at ports and waterways. In our monitoring campaign the conventional low-frequency (38 kHz) and high frequency (200 kHz) acoustic sounding was compared to the output of Rheocable, Graviprobe and DensX. The SILAS system was used to enhance the low-frequency sounding. The Rheocable survey is based on the physics of a towing body. Towed within a certain velocity window the position of the Rheocable is then related to the interface between fluid and consolidated mud. The penetrometers DensX and Graviprobe are used to provide vertical profiles of the density and undrained shear strength, respectively. The Graviprobe instrument measures the cone penetration resistance and pressures while falling free in a water-mud column. The cone penetration resistance is then correlated to the undrained shear strength of the fluid mud layer. DensX is an X-ray based profiler that measures

the densities of a water-mud column between 1000 kg/m^3 and 1500 kg/m^3. The SILAS system correlates the measured acoustic impedances of a multi-beam echo-sounder to in-situ density measurements. Typically, this density measurements are done with penetrometer-type tools or mud samplers.

Our study provides a new insight into rheological mapping of fluid mud layers. The Rheocable and Graviprobe measurements showed a good agreement regarding navigable depth. The non-linear relationship between density and shear strength of mud was investigated by means of laboratory consolidation and rheological experiments. It was found that the undrained shear strength of mud develops slower with time than the density. This finding is confirmed by theoretical and scaled laboratory study. In particular, the output of the Graviprobe is linked to the critical yield stress (100 Pa) that is currently used as a critical parameter for determining the nautical bottom at the Harbour of Emden and indicated in PIANC (2014) as a reliable rheological criterion.

The water injection dredging method can be used for liquefying and mobilizing weak fluid mud layers. In-situ measuring tools are available for characterizing the behaviour of fluid mud. Based on experimental and theoretical investigation, we can conclude that new cost effective port maintenance strategy is feasible in the ports and waterways with muddy environments.

122. Expansion of Port Infrastructures

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1. INTRODUCTION

Ports on the Danish North Sea coast were built over the last 150 years to serve as basis for fishery and transport of goods to and from UK and Norway. These ports were all constructed on sandy shores in a dynamic morphological setting. During the recent past the ports have been challenged by new demands for increased activity in other areas than the traditional fishery and related industries. The exploitation of oil and gas resources in the North Sea and development of offshore wind require good and safe port infrastructures. Also the increase in handling other commodities and international trade has added to the demand for expansion of the port infrastructures. The present paper presents the challenges related to expansion of these ports which were originally planned and constructed for less demanding purposes.

2. THE PORTS AND THEIR SETTINGS

Port of Esbjerg The port is located in the shallow northern part of the Wadden Sea, an area dominated by tidal flats and off-lying sandy barrier along the the coasts of Denmark, Germany and The Netherlands. The approach from the North Sea is through a 8 km long dredged channel, presently dredged to a depth of 10.3 m. The port area developed in the shallow coastal zone taking advantage of the proximity of the deep tidal channels. Strong environmental restrictions have to be observed as the region is a NATURA 2000 area and since 2014 a UNESCO World Heritage site. The port was originally conceived as a gateway for transport of agricultural products to UK and during the 20th century it developed to become the major Danish fishery port. After construction of other fishing ports on the coast and particularly after exploitation of oil and gas resources started in the 80ies, the fishery activities gradually reduced and the port became the prime Danish offshore supply base. In recent years this transition has continued with services to the growing offshore wind industry. Port of Hirtshals The port is protected by breakwaters at a point on the open coast. The strong littoral drift from south is a major factor in securing navigational access to the port. The space for port facilities is restricted by the bluff created during the last glacial period. The available space between the bluff and the coastline is shared between the fishing related activities and the facilities for the ferry links to other countries. The ferry traffic is of increasing importance with larger ferries requiring deeper and wider access to the port. Port of Thyborøn The port is located behind the southern spit at Thyborøn inlet. The spit is low, sandy and has been the object of intense coastal protection. The inlet needs frequent dredging to provide safe access for fishing vessels. The port is a center for fisheries for human consumption and a number of fishing industries and supporting services.

3. CHALLENGES FOR FUTURE PORT INFRASTRUCTURES

The ports described above face a number of development challenges due to societal changes and changes in the sectors they are to serve in the future. • Fishing is concentrated on fewer and larger vessels which need efficient handling in the ports. • Increased offshore energy related activities (oil and gas, renewables). • International trade increases with demand for larger ferries and container operations. • Expanding cruise industry. • Separation of different port activities. • Improvements of transport corridors to the hinterland. The key issue for the ports is to create more space for the operations. This includes a.o. dredging and reclamation, new and deeper quays and improved navigational access. All of these developments shall respect actual environmental legislation.

123. Container Terminal Planning towards optimizing Supply Chains Logistics

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Ingrid Klimann

Exolgan Container Terminal, Argentina

Supply chains need competitive and efficient container port terminals that are up to the challenge of the dynamic cargo flows passing through them. Consequently, port terminal planning and its associated engineering strategies are the tools that let them achieving high operational competitiveness and leadership for any possible complex situation on land and on water side.

Furthermore, it is important to stress that each container terminal presents restrictions due to the geography where it is located. These site conditions can either influence the available operational areas or the connections to the hinterland resulting in potential inefficiencies for the supply chains that they support.

Thereafter, the following analysis focuses on solutions developed by container terminals located on the riverbanks of the City of Buenos Aires and its neighbouring Dock Sud, both located upstream of the River Plate estuary in Argentina. Moreover, the latter presents greater restrictions. Especially, on its harbour approach channel and its side-dock that limits the passage of ships. Hence, to overcome these physical constraints, it is required to develop creative engineering solutions that must be sought through optimizing the planning of the terminal and all the involved logistics.

Besides, to provide a larger picture, it is also essential to note that navigation on the River Plate presents complexities due to its low water depth with an available draft of 34 feet (using tidal windows) and where navigational channels must be permanently dredged. Despite this situation, main container terminals of Argentina are located in this area for historical reasons, but also because most of the origin-destination of the containerised merchandises are located within the Metropolitan Area of Buenos Aires, an urban conglomerate with more than 14 million inhabitants.

Therefore, this paper elaborates on how port terminal planning is implemented in a practical way, and under complex scenarios, to develop efficient operational management strategies towards designing all logistic processes and cargo flows from the containerships to the delivery out of the terminal and on the other way around. The port terminal planning strategies are defined for the three largest groups of containers: export, import and empties, which include the following processes: entry of export containers and their distribution on the yard, Verified Gross Mass (VGM), controls with scanner, unloading of import containers and those for transshipment, delivery of import containers, delivery and reception of empty containers, and at last but not least, adequate yard layout distribution of containers, loading and unloading strategies of containerships and the allocation of every operational resources. Thus, the optimal combination of all these planning and management strategies can make a container terminal extremely efficient and a case of success or not.

Different capacity models, tools and software, in combination with state-of-the-art engineering know-how, are required for optimising each of the aforementioned processes in order to achieve a successful planning and efficient operational management strategies.

As a direct result, a very high cost-effective business model is obtained to avoid any possible misuse of resources and to achieve maximum utilization factors.

To summarise, it can be concluded that appropriate port terminal planning allows the integration of various value-added services to enable a container terminal to be developed as a multimodal operations platform serving and optimising supply chains logistics that cross it. In this way, minimising operational times, through planning and management strategies in the short-, medium and long-term, positions a container terminal as a dynamic node of connections accompanying the development of more competitive markets in the region, increasing its economic value and strengthening the prosperity of the region that it serves.

124. The Implications of Panama Canal Expansion to U.S. Ports and Coastal Navigation Planning

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The proposed expansion of the Panama Canal has been viewed as a 'game changer' to the world's shipping industry and will have significant impacts on trade routes, port development, cargo distribution and a host of others to the U.S. maritime system. One of its greatest impacts will be felt in the fast-growing container trade where expansion will enable larger vessels to transit the canal. Vessel calls on the U.S. East and Gulf Coasts are also expected to increase significantly as cargo shifts away from the congested West Coast. The challenge is predicting the timing and extent of the impacts as well as the location of the impacts on fleets and cargo, i.e., which ports will be most impacted? Congress and policy makers in the U.S. have been concerned about these uncertainties and have looked to the Corps of Engineers and other federal agencies in developing strategies to meet the many challenges facing U.S. ports following the Canal's Expansion, particularly in an era of constrained budgets and heightened environmental scrutiny.

This presentation will highlight the research and several notable studies undertaken by the Corps of Engineers, private industry and academia in the years leading up to and following the Panama Canal's Expansion. This work provides key insights into the extent and types of data, maritime metrics, forecast methods, and outreach strategies when planning and evaluating port projects. And while the Canal's expansion has certainly been a catalyst, there have been broader implications of making sound investments in an even more uncertain world. For example, natural disasters, the unforeseen drop in oil prices, continued consolidation of the liner industry, and other world events have forced the Corps of Engineers to adapt its thinking when it comes to its national port infrastructure investments. Finally, the presentation will summarize the U.S. Port Modernization Studies, a Congressionally-directed assessment of the U.S.'s ability to accommodate the increased size and number of vessels following the Canal's expansion in the attempt of answering the compelling question, "is the U.S. ready?"

125. Ship & Barge Collisions with Bridges over Navigable Waterways

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Recent decades have demonstrated the potential vulnerability of major bridge crossings over navigable waterways to catastrophic collapse due to extreme event loads. This paper will discuss ship and barge collision with bridges over waterways using lessons learned from historical accidents worldwide and analysis procedures for vessel collision assessments for new and existing bridges in the United States. This paper also discusses the application of ship and barge collision risk analysis procedures to model complex navigation channel geometries near bridges and modern electronic navigation systems and port control procedures that potentially reduce the risk of collision.

126. Dredging for Sustainable Infrastructure, a holistic approach

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Matters Beyond Money

For the vast majority of dredging's history, there has been an almost exclusive focus on the economic benefits generated by infrastructure. Within the last 50 years, environmental and social factors have been increasingly incorporated into the decision-making and governance process, a shift regarded to be a relatively recent development. Also occurring during the last few decades, significant technological and operational advancements have improved the dredging process to reduce its impact on the environment.

Sustainability Drives Dredging

As a result of this present-day progress, an optimised way to increase the overall sustainability of the water infrastructure sector has emerged. A project's proponents, dredging contractors and relevant stakeholders invest time and energy at the beginning of a project's timeline to identify ways to boost its value by addressing sustainability's essential pillars: economic, environmental and social. With all three aspects considered, infrastructure's ability to generate economic benefits will not be diminished. On the contrary, opportunities to create additional economic value will be revealed. Early efforts are spent to identify and develop socially-oriented enhancements for recreational, educational and community resilience purposes as well as environmentally-minded prospects related to ecosystem services, habitat and natural resources. This approach will benefit dredging and infrastructure projects by avoiding unnecessary conflicts with stakeholders while simultaneously developing a larger number of project proponents, advocates and partners. A foundation comprised of three principles intends to inform the development of sustainable infrastructure while firmly supporting the aforementioned triad of sustainability pillars.

Principles Support Pillars

Among the trinity of principles, the first is a comprehensive analysis of the social, environmental and economic costs and benefits of a project. Dredging is just one facet of an infrastructure project, with its elements functioning as part of a larger network which engages with a surrounding ecosystem. Therefore, to understand a project's complete set of costs and benefits requires a system-scale view of the infrastructure as well as its provided functions and services.
The second measure involves improvements to the dredging process by conserving resources, maximising efficiency and increasing productivity as well as extending the useful lifespan of assets and infrastructure. Innovations in technology, engineering and operational practices can reduce fuel and energy requirements and so forth within the dredging process and eventual operation of the infrastructure.

Of utmost importance, all-inclusive stakeholder engagement and partnering is called upon to enhance a project's value. Stakeholder commitment plays an important, even critical role, in the governance of infrastructure projects. The elevated level of investment and sophistication employed in the collaborative process directly contributes to the degree of success achieved at every stage.

Upgrading Dredging Knowledge

Back in 2008, the International Association of Dredging Companies (IADC) and Central Dredging Association (CEDA) joined forces to create and release Environmental Aspects of Dredging, a book presenting the effects of dredging activities on ecological systems and ways to minimise the impacts. As the concepts of sustainability continuously evolve, the demand for a revised publication encompassing the current holistic approach became paramount, and will be presented in Dredging for Sustainable Infrastructure.
The dredging community aspires to realise projects which fulfil their primary functional requirement while adding value to natural and socio-economic systems. This can only be accomplished once a thorough understanding of these complexities in combination with the proactive engagement of stakeholders is acquired. By providing imperative guidance, this book strives to make this a possibility throughout the dredging professional community, from project proponenets to consultants, contractors and manufacturers. The publication aims to help professionals and stakeholders navigate the interrelated complexities involved in the development of coasts, harbours, ports. Case studies demonstrate the approach and implementation of the presented method.

An initiative of IADC and CEDA and written by a team of top experts, the book Dredging for Sustainable Infrastructure will be available in 2018.

127. Engineering the Levelling Systems of the Sea Locks in The Netherlands; Taking into Account the Effects of the Density Difference

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In The Netherlands two deep sea locks are being built, one at the entrance of the North Sea Canal and one at the entrance of the Ghent-Terneuzen Canal to allow larger sea-going vessels to call in at the main ports of Amsterdam and Ghent. At both locations the new lock is built next to the existing deep lock. Principally, the choice of a type of levelling system is determined by the maximum head difference, the required levelling time, main vessel dimensions and mooring configurations. Since these locks maintain the transition between fresh (brackish) and salt water, density currents in the lock during levelling lead to additional hydrodynamic forces on the moored vessel. Therefore, this density effect must be included when engineering the levelling system.

The Existing North Lock and the New Lock at IJmuiden

The North Lock has been built in the nineteen twenties. The lock chamber is 400 m long and 50 m wide. The sill lies 15 m below mean sea level. At IJmuiden the head difference varies between about 4 m and - 1.5 m. As the maximum head difference during mean springtide varies between only 1.6 m and - 0.3 m, differences during normal conditions are relatively small.

The design of the levelling system for this lock was based on the designs of the German sea locks built at that time. A scale model study was carried out in Germany to study the behaviour of several levelling systems considering different culvert lay-outs. In these model tests the density difference was not considered. Based on the test results, a system with short culverts in the lock heads was chosen. Levelling through gate openings was regarded as not feasible, mainly because of the impact on the steel construction of the gate, but also due to the expected flow forces on the moored vessel in the lock.

The new lock chamber which is now under construction is 545 m long and 70 m wide. The sill lies more than 17 m below mean sea level. For the new lock two types of levelling systems have been considered: openings in the lock gates and a system with short culverts in the lock heads. Now, based on the current state of knowledge in gate construction and lock hydraulics, it has been concluded that gate openings are feasible, provided that levelling times may be longer to some degree. Again, an extensive scale model study has been carried out, now including the effects of the density currents during levelling due to the density difference over the lock head. These tests showed that with the more extreme head differences the density currents during levelling produce the highest forces on the vessel. When the system with openings in the lock gates had been chosen for the final design, special valve lifting programs have been derived to keep the forces below the set force limits and to meet the required levelling times. The chosen system consists of 16 rectangular ducts through the gate, each 2.2 m wide and 3 m high and with a valve in the middle of the gate.

The Existing West Lock and the New Lock at Terneuzen

The West Lock has been built in the nineteen sixties. The lock chamber is 335 m long and 40 m wide. The sill lies almost 13 m below mean sea level. The water level on the canal is about 2 m above mean sea level. The head difference varies between 1.5 m and – 4.8 m. Compared to IJmuiden the daily maximum absolute value of the head difference is considerably larger, 4 m versus 1.4 m, corresponding to a mean water level on the canal of 2.1 m and mean low tide of - 1.9 m outside. Taking into account these higher head differences, it was decided to fill and empty the lock through two bottom grids, located at about one quarter and three quarters of the chamber length. By distributing the discharge over these two grids, the resulting translatory waves are significantly reduced, and the corresponding forces as well. This concept was originally worked out without considering the density effects. However, when this system was tested in a scale model, in a later phase also including a density difference, it showed that the density forces did not lead to extra-long levelling times. Not only the translatory waves are significantly reduced, but also the density currents.

The building contract for the new lock has been awarded in the summer of 2017. The lock chamber length is 427 m, the width 55 m and the sill depth 16.5 m. During the conceptual design of the levelling system a comprehensive study has been carried out focusing on the possibility of a through-the-gate-system with 12 circular ducts, based on the recent results for the new lock at IJmuiden. An exploratory scale model study has been carried out to determine the shortest levelling times which could be attained, and to solve the uncertainty regarding the density currents. These model tests indisputably showed that the density forces when filling during low tide, i.e. filling with fresh water, could only be reduced by prolonging the levelling times outside the acceptable range. Therefore, it was decided to specify in the requirements for the tender a levelling system which is more comparable with the system of the existing West Lock. In the requirements two alternatives were specified: the West Lock system with two bottom grids, and the Baalhoek system with four wall grids, two per lock head located opposite each other. In both systems the levelling discharge is distributed over two parts of the lock, thus reducing the hydrodynamic forces due to the density currents. The contractor of the new lock has chosen for the West Lock system. The final scale model tests, to determine the valve lifting programs are planned in May 2018.

128. Shunt-E 4.0 - Autonomous zero emission shunting processes in port and hinterland railway operations

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Preamble

Hinterland connectivity is one of the most competitive distinguishing factors for today's sea- and dry ports. Therefore innovations with a clear focus on autonomous and emission free port operations are crucial to safeguard a prosperous future of global ports. In this context the German Federal Government set up a program to support innovative port solutions and thus supports the project "Shunt-E 4.0 - Autonomous zero emission shunting processes in port and hinterland railway operations." This practical research program will be conducted together with Bremen's port railway which is regarding to the modal share of rail hinterland transport the leading European port railway system. Within the presentation the overall objectives ambitions and expected outcomes shall be presented at Panamas PIANC World Congress.

Background

Port railway operations today are comparably complex processes. The general process which involves different partners like railway undertakings, shunting operators, infrastructure providers, energy providers, terminals operators, port management organizations etc. is on the example of a typical European railway system (Bremen's port railway) divided in various steps as follows:

- Separation of main-line locomotives after train arrival in the port area
- Transport of train section or wagons with shunting locomotives towards forwarding groups and later on to the terminals
- Terminals have do conduct control and supervision works on the train and on the cargo (i.e. seal-check)

As a consequence of these steps the first cargo movements can and do only start hours after train arrival in the port area. A comparable long procedure is (still) needed after completion of train loading process. Trains with import goods need to have specific brake tests and load control works with following shunting processes. Just by these rules they remain in the port area for an average of two hours before they can start towards the national and European hinterland destinations. As a result port railway operation today is much more complex than truck and barge processes. The reasons are mainly self-made rules and regulations by the industry sector.

Need for action more than obvious

Innovations in cargo rail sector are rare, even if good ideas do exist. Many previous projects on automatization and process optimization failed or were stopped by various reasons. In fact technical solutions like automatic clutches, automatic brake tests, remote train control systems, automatic load controls, obstacle detection and many more rail related optimization measures are technically feasible and were successfully tested in the past. But, they didn't make it to the

broader market. As a consequence rail transport of goods until today is in most regions of the world very traditional and old-fashioned. Especially in comparison to truck transport the rail sector is falling back. Ongoing innovative projects like truck-Platooning or autonomous trucks endanger the system advantage of rail and thus the transport-political perspective of rail transport. If global ports want to improve railway transport they strongly need innovative port railway systems and processes.

Long-term perspective autonomous emission free shunting processes in port railways

With the support of Germans Ministry of Transport Bremen's port railway has been selected as a test bed for autonomous emission free shunting processes as an example for general port railway systems. On Bremen's port railway today various competing companies offer shunting services to the railway operators within Bremerhaven port area. It's their task to move the train sections and wagons between the forwarding groups and the terminals. The main-line transport to and from the national and European hinterland is conducted by currently about 80 different companies (Railway undertakings). These companies also take care that enough train drivers are in place at the time when they are needed for the port leave. The railway undertakings are the purchasers of shunting services. The aim of an totally autonomous shunting operation can and will be reached only with intermediate steps like process automatization. The expected effects of autonomous emission free shunting operations to date are the following:

- Simplification of operational processes
- Avoidance of empty-drives
- Reduction of the overall shunting stock (Savings of about 30 percent are expected)
- Avoidance of communication-interfaces
- Optimization of infrastructure use with savings on future investments
- Reduction of operational efforts and costs (on the locomotive and in the offices) through reduction of personnel
- Safety-Improvements
- Disruptions reduction in port railway operation

Relevance for the global port community

"Shunt-E 4.0 - Autonomous zero emission shunting processes in port and hinterland railway operations" is of high relevance to the global port community as it combines the necessary innovation approach for future port development with a sustainable greenports strategy.

129. New Technologies with Concrete Blocks for Tsunami Protection and Long-Period Wave Absorption

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1. INTRODUCTION

In recent years, among the various types of coastal structures, concrete blocks have been widely used as one of the important components due to their effectiveness against wind wave attacks. The design method for wind waves is well established and concrete blocks work best. On the other hand, tsunami and long-period waves also cause problems in Japan. Numerous breakwaters were severely damaged in the 2011 Off the Pacific Coast of Tohoku Earthquake Tsunami. Many ports suffered from disturbance in cargo handling due to ship motion caused by long-period waves.

In this paper, we introduce our new methods using concrete blocks for tsunami protection and long-period wave absorption as countermeasures to such problems.

2. NEW TECHNOLOGY FOR TSUNAMI PROTECTION USING CONCRETE BLOCKS

2.1 WIDENED PROTECTION COVERED WITH CONCRETE BLOCKS

Many composite breakwaters were seriously damaged in the 2011 Off the Pacific Coast of Tohoku Earthquake Tsunami. One of the causes of failure was a scouring of the rubble foundation on the harbor-side of breakwaters due to the tsunami overflow. This was a formerly inconceivable type of failure. One possible countermeasure is placement of a widened protection using additional rubble stones behind the breakwater to prevent the sliding of the caisson. Installing concrete blocks on the rubble mound on the harbor-side would also be required to prevent scouring around the rubble mound. We have developed a stability estimation method for concrete blocks against tsunami overflow. The method is based on a series of laboratory experiments conducted in a wide range of conditions.

2.2 EXPERIMENTS

The experiments were carried out by changing the shape of the harbor-side rubble mound, harbor-side water level, the shape of concrete blocks and the mass of the concrete blocks. A steady over flow was generated by a submersible pump. The stability limits for the concrete blocks were examined by gradually increasing the overflow depth. The main results are as follows. 1) The stability of the concrete block is greatly influenced by impingement position of the overflow jet. 2) The stability of the concrete blocks increases as the harbor-side water level rises. 3) The failure modes of the concrete blocks are divided roughly into two modes. One is the overturning mode caused by the rotation of the block. The other is the sliding mode caused by the external force exceeding the frictional force. 4) The overflow depth of the stability limit was almost proportional to the nominal diameter of the block in the case of the overturning mode, while it was nearly independent of the size of the block in case of the sliding mode. 5) The holes in the concrete blocks enhance the stability due to the reduction of the uplift forces.

2.3 STABILITY ESTIMATION METHOD

Empirical formulae for the stability estimation were derived based on the experimental results. The overflow depth of the stability limit corresponding to each failure mode can be obtained by the two formulae. These formulae involve the stability number of each concrete block determined through the experiments. According to this calculation method, it is possible to determine the mass of concrete blocks against the tsunami overflow. This calculation method has already been used for actual design.

3. NEW TECHNOLOGY FOR LONG-PERIOD WAVE ABSORPTION BY USING CONCRETE BLOCKS

3.1 SUBMERGED MOUND TYPE WAVE ABSORBING STRUCTURE COVERED WITH CONCRETE BLOCKS

In many ports, it has been reported that long-period waves cause trouble in cargo handling. As a countermeasure to this, a wave absorbing mound installed on the harbor-side of the breakwater has been proposed. Because of the low wave absorbing performance of such conventional mound type structures, the required width to absorb the long-period waves becomes more than 30m. It is important to reduce the size of the structure to apply to various site conditions. The crown height of a conventional mound type structure is almost equal to that of the caisson. On the contrary, we propose a submerged mound type structure covered with concrete blocks. The basic concept of this proposed structure is to level the crest elevation to the water surface to establish high efficiency in energy dissipation on the surface of the crown of the concrete blocks.

3.2 WAVE ABSORBING PERFORMANCE AND ITS MECHANISM

A series of hydraulic model experiments was carried out to evaluate the wave absorbing performance. Monochromatic waves with periods of 30 to 120s were used for the experiment. The reflection coefficient was obtained from the recorded water surface elevation. Throughout these experiments, it became clear that the reflection coefficient of the submerged type is smaller than that of the conventional type, independent of the wave period.

The wave absorbing mechanism was investigated using hydraulic model experiments and numerical analysis. It was concluded that the cause of effective energy dissipation of the submerged type is related to significant increase of the flow velocity around the concrete blocks due to the flow contraction onto the crest.

3.3 STRUCTURE WIDTH ESTIMATION METHOD

We obtained the relationship between the reflection coefficient and width of structure from the hydraulic model experiments and provided a calculation chart. The appropriate width of the structure under the allowable value of reflection coefficient is determined by using the calculation chart. According to this calculation method, it is possible to design the submerged mound type wave absorbing structure. This method has already been used for actual design.

130. Performance Verification of Marine Fenders

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Performance Verification of Marine Fenders

Marine rubber fenders play a critical role in the operation of ports. They enable vessels that weigh several thousand tons to berth against vital infrastructure without damaging the wharf or the vessel. Fenders are crucial as they turn the kinetic energy of a berthing vessel into known reactions when they absorb its energy.

Prior to the publication of “Guidelines for the design of Fender Systems” [PIANC 2002], there was a lack of standardization in the design, specifications, and testing of fender systems.

This paper will reference this publication and its role in ensuring proper testing procedures for fenders. For a fender to be designed and procured properly, consultants must perform each of the following steps:

- Determine the expected normal berthing energy of the vessel. Then, apply an appropriate safety factor to establish the energy requirement for an abnormal berthing
- Select an appropriate fender including all correction factors that affect the nominal performance of the fender
- Verify from testing that the fenders produced actually meet the project performance requirements specified

Failure to complete all three steps can result in serious consequences.

It’s critical that specifiers ensure fenders installed at their facility are actually able to absorb the prescribed energy. The current industry practice of verifying the performance of rubber fenders is carried out by suppliers themselves. This practice is readily accepted because suppliers own equipment capable of testing such large items.

The conflict of interest between the supplier and the port is obvious when considering the high cost of manufacturing some of the world’s largest rubber parts.

This paper discusses potential ways that the purchaser of marine fenders can independently verify the fenders and whether they meet project specifications.

Performance verification testing

Rubber fenders are almost always manufactured to order as there are too many models, sizes, and grades to keep in stock. Performance verification testing (or a Factory Acceptance Test), is a test performed on the actual fenders produced for a project.

To ensure fenders are produced correctly and in accordance with project specifications, 10% of the order quantity is usually tested. These tests differ from the scale model testing performed

to establish catalogue rated performance values, RPD, or for determining the various correction factors which are described in PIANC 2002, Appendix A, sections one to five.

How to perform verification test

Performance verification testing is usually performed in a large press or test frame with either load cells or pressure transducers. These are installed in the hydraulic circuit of the press to measure the load and a displacement transducer to measure the deflection. The sheer size of even just a mid-sized rubber fender must be taken into account. Aside from the large specimen size, the testing of rubber fenders requires a larger deflection capability than most frames can produce.

Around the world, there are only a limited number of publicly available test frames that are capable of testing rubber fenders. Therefore, performance verification testing is almost always performed at the manufacturer's facility. There are obvious reasons that should concern the customer when the manufacturer elects to test their fenders at their own factory.

The problems with industry practices

There are serious concerns with the way fender performance verification testing is currently performed. Some of these involve the authenticity of the reported performance, as very little thought is given to the need for independent certification of the reported results.

This is because, the fender being tested can easily be specifically selected for the test rather than randomly selected. Manufacturers can build test fenders that will pass the tests, while building the rest of the fenders with substandard materials.

Testing results can also be manipulated for commercial reasons. It is much cheaper to build low quality fenders that do not meet the performance requirements and manipulate the test results instead of building every single fender to meet the requirements.

An undisclosed truth about witnessed testing

The common practice in the industry is to rely on factory testing that is witnessed by either a third party or by the consultant. However, there are several reasons why this is inadequate.

There is no easy way for a witness to verify the results independently of what the manufacturer is reporting. Modern data acquisition methods rely on computers to interpret the data and produce a report. The witness rarely has any understanding of how the data acquisition system functions. It is easy for the manufacturer to manipulate the recorded data in the computer without the witness' knowledge.

Many project specifications require a third party inspection agency to witness the test. Unfortunately, these are not doing anything more than simply witnessing a test. They do not provide oversight on how the test data was acquired or if the report they are asked to endorse is even from the test they witnessed. The inspection agencies are not in any way guaranteeing the validity of the data they are endorsing. If the data being validated and presented to the customer for acceptance cannot be guaranteed then what useful purpose does the test serve?

Independent construction materials testing is a common practice in the construction business. It should be standard practice in the verification of fender performance, especially given its critical effect on safety.

Independently verifying fender performance during the performance verification test is not an easy task, but it is imperative if the specified performance is to be guaranteed.

Independent verification testing is possible with any one of the following methods:

- At an independent structural laboratory
- At the manufacturer's factory using their test frame but with independently recorded performance data

Each of the two methods has advantages and disadvantages.

The user shouldn't rely on simple witness testing to determine fender performance. Real-time data should be shown on an external display and the results printed in real-time, so the witness has direct access to the data.

The paper will go on to discuss how the industry could move to true independent testing and the pros and cons of the methods presented.

131. Unsuitable Fill Material Management in Port Terminal Construction: Example in Buenaventura Port, Colombia

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Building a new terminal on a narrow piece of land surrounded by water is a challenge for all parties involved in such project. In particular, when it comes to the management of cut and fill material with no stockpiling area available out of the project boundaries.

During the construction of COMPAS Bulk and Coal terminal in Buenaventura Port, Colombia, the design already considered to use the cut material above the yard final elevation to fill in the lowest parts of the Aguadulce peninsula. The cut material is mostly clay and after lime-stabilization process, it meets the physical properties required for fill. However, all excavated material was not suitable for backfilling purpose. The superficial silty clay with its organic content, high water ratio and plasticity index was considered unsuitable. Some bay areas were already designated as deposit inside the boundary of the terminal. On paper, the balance was achieved between fill volume, cut volume of suitable and non-suitable material.

But like all projects, the events did not exactly occur as planned. During the excavation works, the team had to deal with a significative increase in proportion of unsuitable excavated material. The area for stockpiling could not contain any more material.

The team looked for two ways to find solution.

The first one was to search for a suitable stabilization process to make that material compatible with backfilling. Different dosages of lime were tested on site. We even considered cement mixing or polymer additives. But the daily heavy rain that falls in the area made it impossible to reach adequate results with acceptable costs and production rate.

The second one was to change the design of the stockpiling area and their retention structures to come as close as possible to the statutory boundaries of the terminal to fit the surplus volume.

Some bulkheads were changed into sheetpile wall with tie-rods and anchor wall, others into geotextile megabags dikes filled with the same cut material. Inside the deposit area, due to the high seismicity in the region, it was also required to use ground improvement techniques to guarantee the stability of the bulkhead. Rigid inclusions or consolidation (wick drains with surcharge) were the two techniques employed.

This alternative was finally chosen by all parties because it was in line with the development plan of the terminal to expand the yard surface in future. Indeed, ground improvement was done over the whole stockpiling area to reach a bearing capacity of 2 ton/m2 or above at the final yard level.

This second alternative is the focus of the paper. It’s a good reference for a win-win project where design and site constraints are evolving in line with owner’s needs. For port planners, it is also pointing out the importance of leaving buffer zones in the terminal layouts and not to underestimate the soil investigation campaign for a more accurate quantitative and qualitative assessment.

132. Climate change challenges for management of natural resources in the Panama Canal watershed

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What climate conditions can the Panama Canal Authority (ACP) expect in the coming decades? What are the extremes of droughts and floods that we may experience? How might climate change affect El Niño intensity and frequency and the droughts associated with strong El Niño periods in Panamá? According to reports from NASA and the U.S. National Oceanic and Atmospheric Administration, “Earth’s 2016 surface temperatures were the warmest since modern recordkeeping began in 1880”, with 16 of the 17 warmest years recorded since 2001.

A warmer atmosphere contributes to more evaporation and convective storms, to deeper and more prolonged droughts and, when associated to increased ocean surface temperature, it can also generate higher intensity tropical storms such as those witnessed during the remarkable 2017 Atlantic-Caribbean hurricane season.

We live in an age of increasing uncertainty with respect to air temperature and precipitation distribution and accumulation. Past norms for seasonality and annual variability of these fundamental climate variables have become unreliable. In a landmark 2008 paper in the journal Science, hydrologists declared that “stationarity is dead”.

During much of the 20th century in most watersheds where a 30-year hydrologic record had been acquired, scientists were able to reasonably predict future key variables such as average and maximum precipitation amounts (both temporally and spatially), stream flow, flood peaks, etc. Climate and land use change have degraded the ability to make these predictions.

In this 21st century “non-stationary” world, managers of natural resources must be increasingly resilient in administering these assets. For water availability and quality, this means constantly searching for ways to be more efficient with our use. For land resources, it means minimizing human-caused disruption of natural systems, by planting and maintaining endemic tree species that are adapted to local natural disturbances such as storms, pests, and fire. It also requires collaborating with economists and social scientists to find ways that incentivize good stewardship by private and public land owners.

Good stewardship assures that the benefits we receive from natural systems, known as ecosystem services, continue to accrue into the future in spite of the vagaries of climate change. Watersheds provide numerous ecosystem services, such as good quality water, reduced peak river flow during storms, increased availability of groundwater and base flow in streams during seasonal dry periods and droughts, reduced soil erosion and landslide probability, enhanced resilience to wildfire, pathogens and invasive species, biodiversity, genetic resources and recreation.
The Republic of Panamá is highly dependent on abundant annual precipitation to manage the Canal, which currently uses more than 4 cubic kilometers of freshwater per year for lockages, hydroelectric power generation, and potable water supply. As climate change continues to intensify in the coming decades, it is incumbent on the ACP and the nation to optimize land and water management so that we can guarantee an economically and environmentally stable future.

133. Systematic Techniques for Fairway Evaluation based on Ship Manoeuvring Simulations

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Introduction

Over the last decades ship sizes have increased dramatically for different types of vessels (container carriers, LNG-carriers), while fairways often haven't increased at the same rate. As a result, bigger ships nowadays sail in areas designed for smaller vessels. Sometimes new infrastructures (locks) make it possible for bigger ships to sail on an existing canal resulting in the same issue: bigger ships sailing in a status quo fairway. The Knowledge Centre Manoeuvring in Shallow and Confined Water (www.shallowwater.be), which is a collaboration between Flanders Hydraulics Research and the Maritime Division of Ghent University, has a lot of experience in evaluating and investigating the possible bottlenecks in such a fairway. This paper presents a general methodology that is used to evaluate sailing in shallow and confined water using manoeuvring simulations.

Systematic investigation

Systematic investigation of ship manoeuvring in shallow and confined water is executed by Flanders Hydraulics Research (FHR) and Ghent University (UGent) through desk studies and simulation techniques. Desk studies take into account the parameter variation of positional, kinematic and/or control variables on isolated force components of the manoeuvring mathematical models. Simulation techniques use mathematical models in 3 to 6 degrees of freedom describing all hydrodynamic and external (due to banks, wind, current) forces on the ship's hull.

In real time simulations the pilot or skipper controls the engine's telegraph and rudder angles while in fast time simulations the human factor is excluded by using an autopilot that sets propeller rates and rudder angles based on a predefined decision scheme.

Each of the described methods has advantages and disadvantages. The advantage of real time simulations is the completeness of the simulation technique by introducing the man in the loop in the simulation process based on validated realistic mathematical models. Disadvantages of this tool are the relatively time consuming process for systematic investigation and variability of the human factor during the simulations. An exact repeatability is not possible and the number of different set ups that can be tested is rather low since only about 10 to 20 different simulation runs can be carried out per day.

As the number of parameters can be large during a systematic investigation the disadvantages can be overcome by desk studies or fast time simulations.

Desk study with parameter variation

All parameters are set to a fixed value before the start of the calculation for the desk study. The ship is forced to follow a predefined track, consisting of time functions of velocity, position,

heading, propeller rate, rudder deflection and other possible variables. Such track can either be an ideal track (centreline of the fairway) or a track derived from a full scale measurement of a ship.

Due to the forced character of the simulation run, in general there is no equilibrium between the forces and moments acting on the ship and the external forces. During the simulations horizontal forces and moments acting on the ship will be calculated based on the available mathematical manoeuvring models, and are available for further analysis. These forces are for example bank effects, ship – ship interactions , propeller thrust or (increased) resistance. Similarly, vertical motions due to squat can be calculated, too.

Systematic deviations from this track will result in considerations with respect to sensitivity of operational variables. For example, with a set of parallel tracks the impact of the lateral position in the confined fairway on the forces and moments can be investigated.

Fast time simulations

Fast time simulations make use of an autopilot, which is in this context a computer algorithm setting the control variables of a sailing vessel to obtain a realistic track of the vessel in the simulated fairway.

The autopilot which is in use at FHR has been developed for track-keeping in confined channels, specifically focusing on following a desired trajectory with minimum deviations. As a result, the outcome of a fast time simulation not only depends on the ship characteristics and intrinsic behaviour, but also on the control routine settings. As the complete hydrodynamic and external force model has to be solved, the exact position (and heading) of the ship is not known beforehand. As a consequence the settings of the autopilot have an influence on the outcome. Therefore it is of the utmost importance that these settings are handled with care.

Post processing can be used to check certain parameters, for example the rudder demand while taking a bend. As such the easiness or complexity as well as the margin to take the bend can be evaluated without the impact of the human factor.

Conclusion

Both investigation techniques for systematic parameter variation have their merits. In combination with full scale measurements, real time simulations and model tests, the Knowledge Centre Manoeuvring in Shallow and Confined Water is capable of evaluating on an objective and scientific manner the nautical complexities of a fairway.

134. Ship Simulation – Important aspects for consideration

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Ship handing simulators have been available in many forms since the 1980's and earlier. Since then simulators have developed significantly in realism and in the underlying mathematical formulation. There are, however, a number of factors that still need to be considered when using these tools, either as pilot training, scenario testing or for engineering design.

These factors can be generally divided into the following categories:-Human factors

1. Environment factors and
2. Model factors

All these factors introduce compromises into the simulations and need to be fully understood or the simulations may be compromised.

1. Human Factors

Simulators are becoming very sophisticated over time but they don't replace pilotage on the actual bridge of a ship. There are various human factors that can vary from pilot to pilot that can make pilotage in a simulator more difficult or easier than in real life

2. Environmental factors

Whilst every endeavour is made to make the 3D environment as realistic as possible it is possible that different pilots use different reference lines. In addition the simulator is essentially a 2D image of what the pilot usually interprets as a 3D image. The depth of view may be misleading in a simulator situation.

In addition the simulation if wind and currents are usually simplified in the simulator by removing natural gusting in speed, fluctuations in direction and shielding from buildings. This and other factors will be discussed.

3. Model factors

Not all hydrodynamic situations are modelled fully in simulators either because the research is not available or the hydrodynamics have just not been implemented. An example of this might be the change in the coefficient of drag on the vessel hull is a ship that is swinging in a confined waterway. Recent testing in Australia indicated if a ship blocked 75% of the waterway area at the most vulnerable part of the swing the Cd could be as much as 17 times higher that might be adopted in the model. Similarly research still continues on bank effects which will become important in the situation where the channel has only a single bank. These and other factors will be discussed.

The reason why the above factors are important is because the simulator can be either easier or more difficult than piloting in real life and it is important to understand how these factors might impact on the outcome of the simulations.

135. Punta Pacifica Man-made islands

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Two man-made islands were created in front of the impressive Panama City skyline. They have become integral part of the city coastline offering a benchmark for artificial islands around the world.

The islands were created using rock from a nearby quarry and sand from a concession situated offshore (lowest environmental footprint). The logistics of the creation of the island were complicated due to the fact that the constrcution took place in the heart of a city. All materials were therefore transported via water to reduce impact on the local traffic. This took a lot of preparation work and inventivity to ensure that it could be done.

The design of the contour was made based on specific wave climate consisting of swell and wind waves.

The presentation will provide information on navigation logistics and sustainable construction methods and -innovations for projects that are planned in or near (in front of) urban areas meant to reduce hinder for the residents as well as reduce emissions.

136. A Vision for French Guiana In 2025

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Philippe Lemoine

Port of Guyana in France, France

Build with the MOP a sustainable industrial future looking towards the maritime space, inter-regional integration and marine resources in a blue growth framework

The future of French Guiana, and more generally of the Guiana Shield (including Guyana, Surinam and northern Brazil) passes through the development of its maritime economy: a shared belief between the political and economic actors in a French region in search of new economic engines.

- In the short term: The GPM-Guyane is already engaged in its land development program to develop industrial activities and new services; particularly in support of oil and gas exploration phases that will be revived by oil companies such as Total, and gold mining projects.
- In the longer term : Limits of drafts for vessel in the existing port facilities will not allow to benefit from the lower costs resulting from the rise in the size of vessels and the opportunities of the new or improved maritime route, as proposed by Panama Canal.
- In addition, the diversity of local sustainable marine resources (fish, seaweed, renewable energies) represents a major growth potential: so far the lack of security doesn't allow their development in the offshore waters.

- The combination of industrial activities and services has been identified to give substance to this development:
    - The sustainable exploitation of marine resources (fisheries, seaweed, EMR), which represents a major growth potential, once guaranteed safe operating conditions,
    - A logistical support for oil and gas activities along the Guiana Shield,
    - A regional container hub for all the countries of the Guiana Shield and the possibility to offer an international container hub responding to the new East/west and North/South crossing maritime route,
    - A fourth activity has recently been identified, for which reflection has just started: Fuel storage (LNG, crude oil or refined petroleum, hydrogen) to facilitate bunkering operations and smooth the consequences of changes in energy selling prices.

This platform provides an ambitious response to all these issues:

- By applying international standards of containerships : a decrease of 30% to 50% of import costs from now by 2030, with a volume seized of 300 000 TEU (vs 55 000 TEU nowadays), knowing that half coming from crossing shipping lines transshipment
- The development of new and sustainable activities with: :

  - Aquaculture: over M€30/year in new revenue with annual output of 5,000 tons (starting hypothesis), and up to 15 or even 20 Ktonnes / year after 2030, an annual potential of more than M€100/year to run.
  - The OTEC, to make Platform autonomous in term of energy, who will endure like other isolated sites at sea the rising costs of diesel generators, which already exceed €250/MWh with an oil price of $80.
- By optimizing industrial and logistics systems of 2 or 3 platforms of O&G production next to the current reference to Port Of Spain: a saving of around M€200 over 30 years for the operators (at least one supply vessel of K$20/day).

- The socio-economic challenge of the project, whose investment is estimated at 1.6 billion of euros (1.2 billion of euros fot the first stage) , well beyond the direct benefits of activities implemented on the POMU platform:
  - In the operational phase, the POMU platform will generate over 3,000 jobs in French Guiana, and will help to increase GDP for over 3%,
  - More generally, the lower of import costs will open up the land potential for growth of all countries and regions of the Guiana Shield.
- The financial issues of this ambitious project are to validate the financial engineering approach for an infrastructure of this magnitude (WACC between 3 and 5%), with:
  - 75% of public funds, some funds which could come from specific loans and tools (like some actual offshore wind projects supported by the European fund for strategic investments) or even French and European subsidies.
  - 25% of private funds, dedicated primarily to the equipment that will be set up on the MOP, and whose provenance is mainly outcome of future operators of the platform, corresponding to them to an entry ticket to implement the qualified cost savings for each activities identified.
- The further development of this project, in line with European targets in the framework of H2020 Blue Growth Policy, is to clarify the following points, in an ecodesign and sustainable development approach:
  - Architecture and construction solutions to create and maintain at sea this modular hosting infrastructure,
  - Maritime space allotment policy, complying with the framework directives on the environment and maritime spatial planning,
  - Energy autonomy, from the energy of the sea,
  - Land use planning to allow the installation of this platform (Exclusive Economic Zone)
  - Adaptation of supply chains, including transhipment operations

Functional and financial description of steps one and two of the platform Phase One in 2026

Functional capacities Phase 1 in 2026 // Phase 2 1n 2030	Financial balance over 25 years

	Phase 1 in 2026 //Phase 2 in 2030
Aim: Offshore platform with 54 modules for a hub containers, O&G supply services and aquaculture // 79 modules for extended hub container, shipyard, solid bulk transhipment Capacities Shipping: 150,000 TEU/year: 120,000 TEU for Guyana Shield & 30,000 TEU for crossing shipping lines // 300,000 TEU/year: 150 000 TEU for Guyana Shield & 150 000 TEU for crossing lines Aquaculture : 30 cages, 5,000t/year // idem Oil& Gas services: for 2 production platforms // 3 platforms ETM: 10 MW (if technically available) // idem Surface.:14 ha // 20 ha Location: French EEZ /70 nm North/East of Cayenne, 75m deep waters / sandy bed Moorings: combination of spread mooring and suction mooring O/M and access: Ship and helicopter transfer	CAPEX 1197 M€ // 1601 M€ OPEX1372 M€ // 2030 M€ Loan cost at 5% 1036 M€ // 1385 M€ Total Revenues130 M€ // 183 M€ Container Hub 40 M€ // 60 M€ Logistics O&G 57 M€ // 86 M€ Aquaculture 33 M€ // 37 M€ Operation lifetime 25 years Simple payback 12 years Payback 22 years // 21 years WACC 5% NPV (year 0) -10 M€ // +19 M€ IRR 4.9% // 5.1%

137. A new in-chamber double longitudinal culverts filling and emptying system for high head and large navigation lock

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Xijin hydro-junction is a key project of the Xijiang Golden Waterway, a two-step single lane lock has already been constructed. The proposed 2nd lane lock is designed for the maximum passing vessel with the tonnage of 3000t. The new lock is located at the right bank of the river and also the 1st lane lock, and it is a single step lock. The effective dimensions of the lock chamber are 280.0m×34.0m×5.6m (length × width × water depth over the sill), and its maximum water head is 20.3m, the designed transit time is 10～12min. Due to its large dimension and high waterhead, the comprehensive hydraulic characteristics of the new lock is close to the Three Gorges Locks and the Gezhouba Locks, so it is quite necessary to determine and improve the layout of the filling and emptying system both by hydraulic analysis and model test study.

The chamber is quite wide, so the transverse flow distribution in the chamber during the filling phase is the main influencing factor of the ship berthing safety due to the previous experiences. At the beginning, the In-chamber longitudinal culvert system（ILCS） invented by the U.S. Army Corps of Engineers is been adopted for the new lock. A physical model with the scale 1:30 is been established for the hydraulic study, and the test results of the initial layout indicate that: under the ILCS layout, the transverse flow distribution in the chamber during the filling phase especially with single valve opened is quite uneven, the flow in the center of the chamber is more concentrated than other areas, there has obvious water surface slope and the transverse hawser force of the ship far exceeds the standard valve. Based on the test results, we change the energy dissipating type from flow jet collision to open ditch, which means we set a “T” type baffle between the two bottom culverts, and adjust the height of the ports on the “T” type baffle to improve the transverse flow distribution. At the same time, considering the uneven flow distribution problem under single valve opened or asynchronous double valves opening, we adjust the layout of the two separate culverts in the ILCS that we set two converge sections for the two culverts near the lock heads. The test results under the new layout indicate that the optimizations have achieved the anticipated goals, the transverse hawser force of the designed ship reduces by 50%, and the hydraulic characteristics under different conditions all satisfy the requirement of design and standards.

The new in-chamber double longitudinal culverts filling and emptying system has many advantages, such as obvious energy dissipating effect, high hydraulic efficiency, simple structure, economic construction and maintenance, and it is an safe and efficient filling and emptying system for high head large navigation lock. Compared to the ILCS, the new system adapts to more water head, which is recommended under 12m by the U.S. Army Corps of Engineers, and also has more efficiency and safety.

138. Application and Practice of In-Chamber Single Longitudinal Culvert with Double Open Ditches Filling and Emptying System in Large Navigation Locks

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Guiping navigation junction is a key project of the Golden Waterway of Xijiang River in Guangxi Province, South China. A 3rd Class navigation lock for the 1000t barge has been construction in 1989. Due to the rapid growth in waterborne economic these 20 years, the constructed lock can not satisfy the developing needs, so the 2nd lane lock has been constructed during 2007 to 2011. The new lock locates in the right side of the 1st lane lock, and the designed annual single direction traffic capacity is 31 million tons, which is 62% of the Three Gorges Locks. The effective lock chamber dimensions are 280.0m×34.0m×5.6m (length × width × water depth over the sill), which is same as the Three Gorges Locks, and that means the new lock is one of the largest inland navigation locks. The maximum water head of the lock is 10.5m, designed transit time is 8～10min, and the designed vessels are 3000t barge and 2×2000t pusher train.

The initial type of the filling and emptying system for Guiping 2nd lane lock is the side ports system, but during the detailed design phase, the geological exploration results indicate that the geological conditions of the lock site are quite well, the lock wall can adopt the lining type. So a in-chamber single longitudinal culvert with shallow open ditch filling and emptying system and its layout has been put forward, which have high hydraulic performance and do not need set the main culvert in the lock wall, also have smaller bottom excavation. The physical model tests show that, the adjustment of the lateral flow distribution is the key problem of this new filing and emptying system. Considering the large space in the chamber width, a new energy dissipating device — double open ditches has been invented to replace the former single open ditch. The layouts of the open ditches and the baffle wall between the two open ditches have been optimized on the basis of series model tests. The tests results indicate that the new energy dissipating device effectively improved the flow conditions and the berthing conditions in lock chamber, and obviously decreased the project cost at the same time.

After the 2nd lane lock has been completely constructed and before its formal open for navigation, the prototype observation and debugging has been carried out to know the actual operation conditions and the differences between prototype and model. According to the detailed analysis of the actual hydraulic characteristics, flow conditions and berthing conditions, a conclusion has been made that the new filling and emptying system guaranteed the lock's efficient operation, and greatly improved the flow conditions in lock chamber at the same time, which becomes a safe and rapid channel passing the dam, and has a broad prospect for its application.

The innovative results are as follows:

1. The In-Chamber Single Longitudinal Culvert with Double Open Ditches Filling and Emptying System has been adopted in large navigation locks for the first time among the locks home and abroad.

2. The relationship between the layout of the baffle wall and the lateral flow distribution has been studied in detailed by models tests, and the most suitable baffle wall layout for Guiping 2nd lane lock has been determined finally.

3. According to the actual geological conditions and the berthing condition test results, the layout optimization of the double open ditches has been put forward, which further improves the berthing conditions and reduces the bottom excavation, the mooring force of the designed vessel is only 25% of the single open ditch layout, and it saved the project investment of 43 minllion yuan.

4. The advantages of the new filling and emptying system have been validated through prototype observation, and the operation conditions have been further improved by prototype debugging.

5. Comparing to other In-Chamber Longitudinal Culvert Systems, the new filling and emptying system has the advantages of more sufficient energy dissipating, greater hydraulic performance and smaller cost.

139. Development of a ship eco-driving prototype for inland waterways

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Making inland waterway transport more efficient and more sustainable is one of European Commission goals promoted through the NAIADES II package "Towards quality inland waterway transport". Inland navigation faces many challenges such as over-aging fleet, increasing fuel prices, climate change, and stronger environmental regulations regarding air emissions. To tackle those issues, reducing ship speed is an adapted solution. Indeed, a ship sailing at a reduced speed will emit less greenhouse gas and consume less fuel. This practice, also known as “slow steaming”, is already used for many maritime commercial ship sectors such as tankers, bulk carriers and containerships, but rarely applied for inland navigation. A basic application of slow steaming consists in sailing at a speed lower than the vessel’s design speed. More evolved slow steaming practices involve speed optimization algorithm taking account of several factors (weather forecast, current, trim, draft and water depth) [Psaraftis & Kontavas, 2014]. Some industrial products such as “Eniram speed” (www.eniram.fi/product/eniram-speed/) already exist and are frequently used for maritime navigation. However, to the knowledge of the authors, no such products exist or are used for inland navigation. The aim of this article is to develop a speed optimization software for inland navigation allowing to reduce fuel consumption by specifying a recommended sailing speed for each leg of the travel. For a given route, the water depth and currents are predicted with a 2D hydraulic model (Telemac 2D). To each leg of the route are then assigned a mean water depth and current velocity. For each leg, resistance curves are obtained with a ship resistance model, based on a metamodel approximating CFD calculations for ship resistance [Linde et al., 2015]. The fuel consumption is estimated with the model developed by Hidouche & Guitteny [2015]. The gradient projection algorithm [Rosen, 1960] is used to minimize the global fuel consumption for the itinerary. This model is used to simulate a real case: the itinerary of a 135 m self-propelled ship on river Seine, between Chatou and Poses (153 km). The optimized fuel consumption is compared with the non optimized fuel consumption, based on AIS speed data gathered on this itinerary. Different river discharges (low, medium and high) and sailing directions (upstream and downstream) are studied. The effects of the ship trajectory and travel duration on fuel consumption are also investigated. The results of those investigations showed that optimizing the ship speed led to an average fuel saving of 8 % and that using an optimal track and including real time information such as lock availability and river traffic can lead to additional fuel savings. This model, although still at an early design stage, needs further investigation and validation, but could be a useful tool to make inland navigation more sustainable.

140. Resilience and Anti-Fragility of the New Jersey State-Maintained Marine Transportation System

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Following Superstorm Sandy, responsibility for maintenance and recovery of New Jersey's state-maintained navigation channels shifted to the New Jersey Department of Transportation's Office of Maritime Resources (NJDOT OMR). Immediately following the storm, NJDOT OMR implemented a system-wide data collection and prioritization program to restore the state-maintained marine transportation system's (MTS) channels and dredged material storage facilities to a state of good repair. In addition to the Port of New York & New Jersey, a multi-billion-dollar fishing industry, and hundreds of marinas, the NJ MTS consists of over 370 nautical kilometers of state-maintained channels and nearly 70 dredged material confined disposal facilities (CDFs). Bathymetric surveys and over 5,000 sediment cores were collected from 209 of NJ's 216 state-maintained channels within 5 months. To assist coordination of these surveys and sampling, OMR solicited the participation of numerous stakeholders, including the US Army Corps of Engineers, US Coast Guard, NJ State Police, and design consultants from WSP and Gahagan & Bryant Associates (GBA). To establish a sequential recovery plan for the NJ MTS, the state-maintained channels were prioritized based on economics, social importance, and other factors. After 5 years, the MTS recovery is still on-going, though significant progress has been made. The extent of impacts to navigation within the channels and dredged material storage capacity have been computed for pre-storm, post-storm, and current conditions using post-storm damage assessments, sediment core sample analysis, and bathymetric surveys.Analysis of these values for channels both singularly and system-wide, and for individual CDFs and system-wide dredged material storage capacity, portray not only the resilience but also the anti-fragility of the NJ MTS, as values have improved to better than pre-storm levels. The recovery efforts have also demonstrated a feasible link between resilience and sustainability by focusing on beneficial use of dredged material to restore damaged CDFs, restoration of habitat degraded from underwater slides, and restoration of degraded coastal marsh via placement of dredged material. A case study of a multi-agency cooperative marsh restoration pilot program in Fortescue, New Jersey is provided, which demonstrates significant additional potential for enhancing the resilience of the NJ MTS. As a result of the post-storm prioritization and recovery planning, a shift in public sentiment regarding dredging, OMR's focus on establishing a sustainable dredging program, and availability of recovery funding, the NJ state-maintained MTS is on pace to not simply recover to pre-storm conditions, but to recover to a higher level of resilience than before the storm. Keywords: Recovery planning, dredged material, beneficial use, marsh enhancement, thin-layer placement, confined disposal facility

141. Ways & Rails for Slipways for Dry Docking Small Ships

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The slipway is generally an economic system for dry docking small vessel up to say 1000 tons displacement and even up to say 5000 tons displacement.

The definitive characteristic of the slipway is the use of the inclined plane to bring vessels out of the water and dry dock them. This takes the form of ways beams to carry the load with anti-friction, usually rails, on which to move the cradle that carries the vessel out of the water. There seems to be little uniformity in the design and detailing of these systems and in the methods of constructing them. In general, these components seem to be undertaken on an ad hoc basis with little input of lessons from prior projects or of in-depth design. Commonly projects are undertaken by a process of “copy what was done last time and don’t ask any questions”!

In approaching the design and construction of a slipway it is essential to understand the limitations of the construction process and the conflicting requirement of the finished structure. Marine construction tends to be the roughest of all fields of civil engineering while to be effective, the ways demand very high quality of construction comparable to the ways for container cranes. Successful slipway projects are only achieved by the happy marriage of these two and that requires a lot of ingenuity. It is the lack of knowledge of ways and means of designing and constructing these systems that has held back the more general use of the slipway system.

This paper reviews the general issues involved in the ways for slipway systems and, where relevant, the interaction with the other two main components, the cradle and the winch. It then explores the various elements of the ways and the methods for designing and/or constructing them. The problems of meeting the requirements for the construction of the underwater portions are particularly onerous. Specialized and sophisticated equipment and temporary works are a feature of construction today. This is even truer in the construction of slipway ways but notably lacking in application: the field being treated as something of a “Cinderella”.

Specific topics treated in order to understand the field cover ship loads, ways geometry, ways structure, anti-friction, methods of construction, specialized equipment needed and methods of dimensional control and allowable tolerances.

142. Applying Working with Nature to Navigation Infrastructure Projects

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The PIANC working group 176 is developing guidance to support ports and other public and commercial maritime interests apply a “Working with Nature” (WwN) paradigm to navigation and infrastructure projects. The guidance document is expected to be released in advance of the 2018 World Congress. The guidance will provide a basis for maximizing opportunities for working with natural processes delivering environmental restoration and enhancement outcomes that go beyond merely avoiding or just compensating environmental impacts. In addition to providing guidance on how to apply the Working with Nature paradigm, the guidance will raise awareness and promote expanded acceptance of Working with Nature as applied to navigation infrastructure projects. WwN is defined as an integrated approach that involves working to identify and exploit win-win solutions that enhance or protect nature, and are acceptable to project proponents and environmental stakeholders (PIANC 2008; 2011). WwN provides an opportunity to:

1. Reduce demands on limited resources by way of using natural processes to maximize project benefits, thus minimizing the environmental footprint of projects while enhancing project benefits.
2. Reduce social friction and resistance by applying science-based collaborative processes to organize and focus interests, stakeholders, and partners.

The guidance draws from existing approaches and best practices worldwide. We will present various case studies that exemplify the WwN philosophy. By focusing on case studies, we hope to provide tangible examples of how WwN can be integrated into standard practice for navigation infrastructure projects. The presentation will discuss:

- The WwN paradigm
- Present Working with Nature as a process of shifting toward more sustainable practices for achieving multiple project benefits (i.e., environmental, social and economic)
- Incorporate adaptive management principles and practices, as appropriate
- WwN case studies

The primary audience in both developed and emerging economies is project engineers, contractors, ecologists, planners, and environmental stakeholders who have an influence on the decision-making responsibility pertaining to navigation infrastructure projects. This paper will provide an overview of the WwN guidance document. Concepts and approaches are illustrated through representative case studies.

143. Building a Decision Support System for the Terneuzen Locks : combining optimal management for water and shipping

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Introduction

The Terneuzen lock Complex in the Dutch city of Terneuzen gives access to the Ghent-Terneuzen Canal and thus to the port of Ghent (Belgium) from the Western Scheldt. Currently, the construction of a new lock is being prepared, which is expected to be operational in 2022.

In the context of the licensing process of the new lock, how to deal with the available (fresh)water in the most optimal way was examined. The quality values for water (mostly focusing on salt intrusion and taking into account the directions from the WFD) must be met, while respecting at the same time the shipping requests.

As a result of these questions, combined with the daily water management issues of the canal, the decision has been made to prepare for a Decision Support System for the Ghent-Terneuzen Canal, in a joint Flemish-Dutch collaboration.

The extended paper will give an overview and further detail on both the process that led towards the definition of the DSS, as well as the content of the DSS and the technical aspects of the implementation.

The Ghent-Terneuzen Canal & the Terneuzen Locks

The Ghent-Terneuzen canal is situated on Belgian and Dutch territory and was constructed between 1823 and 1825 and ended in the Western Scheldt, thus linking the hHarbour of Ghent to the sea.

At the Western Scheldt side, originally two locks were built at Terneuzen (Netherlands). Since the original construction, the locks have been enlarged several times, evolving towards the current complex. In the near future, a new lock will be operational. The new lock will be 427 meters long, 55 meters wide and 16 meters deep and is expected to be suitable for large seagoing vessels up to 366 meters long, 49 meters wide and 15 meters deep. In Ghent (Belgium) the canal is bordered by the locking complex in Evergem, which regulates most of the freshwater supply towards the canal.

The functions of the canal are shipping and water management : shipping for access to the harbours of Ghent and Terneuzen, water management as the canal provides a discharge capacity for water coming from the upstream rivers Leie (Lys) and Schelde (Scheldt) that join in Ghent.

A treaty between Belgium and the Netherlands (1960, revised in 1985) regulates the obligations and responsibilities, focusing on the canal level and the salinity management in the canal. The treaty defines the water level in the Canal and the minimal supply of freshwater on the upstream side and the minimal discharge capacity on the downstream side, as well as the obligation to minimize the salt water intrusion on the downstream side. The freshwater supply is important both for the water levels in the canal and for limiting the salt intrusion in the canal. The limits for the salinity in the canal are defined in the context of the Water Framework Directive (WFD).

The decision support system : background

During the permitting process for the new lock in Terneuzen, the Dutch Government issued a set of conditions to ensure that the finished project would comply with the WFD , and more specifically the salinity concentrations in the canal. One of those conditions was that a group of experts would draw up an advice on the optimal use of the lock, so that the salinity in the canal remains within the standards defined in the WFD, with minimal disruption to shipping.

The expert group, including representatives from both countries, from the water management, the lock management as well as the port authorities, considered the management of the salinity in the broader picture of water and shipping management and issued a set of practical management measures and guidelines for regular situations, situations with high freshwater discharges, situations with low freshwater discharges and situations with high salinity, as well as possible combinations of those four. Those measures and rules were defined for the entire lock complex (not only the new lock) and kept within the framework of the existing treaty. The underlying idea in the conclusions of the expert group was to provide longer-term gradual measures, with minimal disruption to shipping; and as such avoid that lock operations should experience an acute shut down because e.g. the salinity levels in the canal were too high or the water level in the canal too low.

The expert group also stated that a Decision Supporting System for the Ghent Terneuzen Canal could be an important tool in optimizing water management on the Canal with as little as possible disruption to shipping. A joint Dutch-Flemish collaboration was then set up to further define the content and technical specifications of the decision support system

The decision support system : features and applications

The DSS is designed to objectively process all relevant available information from the Netherlands and Flanders : shipping traffic information and planning, water levels, freshwater discharges, salinity, wind speed, … . Direct links and information streams are provided for the DSS with the existing tools for ship planning (both maritime and inland waterway transport), operational forecast models and in –situ measurements. With the operational forecast models, two-way information exchange is foreseen.

The first goal of the DSS will be to provide the lock operator with an awareness of the current scenario and then to provide him with a standardized, uniform overview of all relevant parameters for that scenario : discharge quantities, water levels, forecasted discharges, shipping traffic,…

The DSS will provide the operator with a proposal for the use of the lock complex over different time scales ; in addition to the proposal the DSS will, when requested, provide the operator

with all the underlying relevant information. The final decision on how to operate the lock complex stays with the operator, the DSS offers advice and feedback on the decisions.

The final content and technical aspects for the decision support system are currently being completed and the implementation will start shortly. The goal is to have the DSS in service before the newly constructed lock is operational, in 2021.

144. Joint development of hydropower and navigation on a major river: example of the Mekong River

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The study of the potential of the Mekong River for run-of-river hydroelectric development began almost 25 years ago, taking into account the joint development of navigation and other water usages, following the model of the multipurpose Rhône run of river cascade in France.

Guidelines for locks were established by the Mekong River Commission (MRC) in 2009.

Today, a first hydropower development is under construction in Xayaburi (Laos), with a lock allowing to cross a lift of 39 m.

Project reviews of high lift locks are being developed for several other developments under study in Laos.

CNR has contributed and is currently contributing to all these stages of joint development of hydroelectricity and navigation on the Mekong River, both on behalf of the MRC and on behalf of the Government of Laos.

The purpose of the paper is to highlight, along with the example of the Mekong at its various stages, the right principles and points of attention, to allow the harmonious development of navigation and hydroelectricity, on large rivers where modern navigation is emerging and where no major navigation works exist.

The paper will notably deal with :

- The importance of global conception of the cascade, on contrast with a succession of disconnected development schemes
- The search of the good compromise between the performance and safety for navigation, on one hand and the acceptable financial effort for the hydropower developer on the other hand, both at the guidelines adjustement phase and at the phase of guidelines enforcement for a new project review.

145. Increasing Berth Utilization with Alternative Technology

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As the demands for general cargo movements through ports and terminals can vary over time, operators are often left with valuable infrastructure that is underutilized, or even abandoned due to a lack of available customers moving product. Historically, some container or break bulk operations have entertained the idea of diversifying into handling bulk cargos over their dock, and while this has brought additional revenues, it comes with its own set of problems. Depending on the source of the cargo, on-site covered storage is often required to receive trucks, and loading ships requires mobile conveying equipment which needs to be moved on/off the dock. All this also requires additional clean-up efforts, as well as the risk of environmental contamination.

An alternative technology that is growing in popularity is known as containerized bulk handling, and this facilitates the movement of bulk cargo from source to ship without the need to provide interim bulk storage facilities at the terminal. This system utilizes specialized open top containers that are provided with locking lids to allow easy filling and sealing of the containers at this source, and their standard ISO footprint makes them easy to transport by truck or train to the terminal site. Because they are sealed from the environment, they can be accumulated at the terminal and used as temporary quayside storage for the bulk cargo until enough containers are accumulated to load a ship. When ready for loading, containers are moved to the dock by truck and lifted into the hold of a bulk carrier using either a mobile harbour crane (or even ship's gear) using a specialized rotary spreader unit. This spreader will automatically lift the lid from the top, and then rotate the container upside down to dump the cargo into the hold. As the unit is returned to the dock the lid is replaced on the empty container, and a new one is picked up to repeat the process.

This system offers a relatively low capital investment option to handle bulk cargos over a general cargo or container dock. It not only offers diversification that improves utilization of assets and increased revenue, it is fully flexible to be moved between dock operations or the assets sold to others when core business improves.

This presentation will discuss this system in more detail, and will also share some case studies of where it has been implemented.

146. Settlements monitoring on soil improvement by preloads in the reclamation area for a new port at Costa Rica Caribbean Sea

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Geotechnical monitoring is used more and more in engineering works. Successful monitoring requires, on one side, to understand which are the limit states conditions and principal variables to be measured, as well as instrumentation, data and comprehensive processing techniques to analyze and transform sensed data into diagnostics for decision-making.

The aim of this paper is present the settlements analysis based on geotechnical monitoring instrumentation for the preloads during construction of the reclamation for the new Container Terminal, in execution at Moin, Costa Rica.

The current phase of the project, comprises the construction of a 600 meters wharf, the dredging of 10 million cubic meters in the waterways and the reclamation of a 30 hectares island required for the operations areas, including storage yards, buildings and other facilities and utilities. Due to fat clay layer on the soil profile up to 45 m depth, if no geotechnical improvement was done, high settlements on surface could be expected.

Prefabricated vertical drains (PVDs) were installed all over the reclamation, which was then preloaded with several surcharges using the same dredged material. This was done to produce most of the expected total settlement, before the construction of the yard and structures, reducing settlements during the operation phase, maintaining them within tolerable service limits for the foundations. The preloads are sand fills of approximately 10 m high, which was calculated originally on the expected service loads during operations, but incremented to that height to accelerate treatment time.

The instrumentation used on site were surcharge plates and piezometers, placed on the initial filling of the land reclamation area at the work fill level of the port, and prior to the preload to measure the consolidation of the deeper clayey soils. For settlement control, the project was divided into 18 work areas, which were preloaded in a sequence using the same material, but moved from one area to another. In consequence, the treatment time at each area was critical for the overall construction schedule of the project.

Settlement auscultation plates were placed on the initial filling of the port area without preloads, to then survey elevations in the same plate to obtain the settlements produced by the preloads. The information was taken in weekly measurements. The measured settlements were used as a basis for model calibrations and predictions.

So, the main objectives of the settlement data analysis were: 1) to verify the settlements monitored on the settlement plates and 2) to predict the remaining holding times necessary to achieve the target consolidation. Based on the information from the contractor, the designer and inspector of the project decides when was adequate to withdrawn the surcharges at each area, for efficiency of the soil improvement and release of the areas for other activities on the construction schedule.

Also, CPT tests were executed before and after, to verify measures not only the consolidation degree of the soils, but also the resistance parameters for slope stability in the slope embankment below the pier.

The analysis included in this paper was realized as the government supervision, to revise the designer and inspector calculation, during the execution of the preloads in each area, at the Container Terminal Port of Moín. Consolidation was revised through the Asaoka Method (1978), which is a method based on the plates settlement measurements, to calculate future settlement.

As part of the geotechnical verifications, a computational analysis of settlements for the final scenario was performed in a critical area of the project, simulating the scenario after the construction of the project, and compared with analytical method of Asaoka (1978). This was a 3D model based on finite differences. The model includes stratigraphy and parameters for each layer, taken from the soil investigations, and representative boundary conditions.

The analysis evaluated if the required performance settlement would be achieved from the method, according with the technical project specifications. The relation between instrumentation and diagnostics is described as consecutive processes that are intrinsically related for effectiveness, according to that it´s shown that is necessary to keep the instrumentation points (plates points and survey points) permanently verify the predictions at least any 6 months and not just in the construction stages.

147. Strategic Planning for the Transfer of the Panama Canal from the United States to Panama.

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James McCarville

SmartRivers 2017 Conference, United States

In 1993, I was one of two consultants assigned to live five months in Panama to develop “The Strategic Transition Plan for the Transfer of the Panama Canal”. It was to take the Canal from US laws, customs and administrative procedures to Panama.

The transfer date had been set in the Treaty of 1979 for December 31, 1999. But, between 1979 and 1993 little planning had taken place. There was no mechanism. And memories were still raw of the recent US invasion. At best, the two countries were “frenemies”.

There were critics of the plan back in the US and even some senior US Panama Canal Commission (PPC) employees doubted that the transfer would succeed. Early interviews were punctuated with remarks indicating either the date they planned to retire or, in the case of those not retiring, the prideful boast that “I am staying here to turn off the lights”. Much of the world press and industry trade journals awaited a disaster.

If based only on past history, there was enough reason to despair.

Shortly after the 1979 Treaty, certain assets were transferred immediately to Panama. Among them was the Panama Canal Railroad. An asset, at the time, eagerly desired by the Panamanians. What the Panamanians could not know was that the Railroad was a money loser, subsidized by the Canal to get workers to lock assignments. It did not even connect to Panamanian industrial centers. Just prior to transfer, 50% of the previous employees, and nearly all of the technical employees, transferred to other departments of the Canal.

Panama soon learned that it had no alternative source of railroad expertise, no local suppliers of spare parts and that any imported parts would be subjected to high Panamanian tariffs.

Even worse, Panama had no specific body of law to govern railroads. Agencies competed for jurisdiction and, when successful, would apply rules by analogy.

For example, at the very first fatality (an unfortunate fell asleep on the tracks), the Motor Vehicle law had the crew arrested and the train impounded.

This was Panama’s wake up call. Panama now knew what it had to learn.

In 1993, President Endara created a Presidential Commission o Address Canal Issues (PCACP) headed by J.J Vallarino, Jr., and other prominent Panamanian businessmen. They undertook their task in earnest.

We were hired by Louis Berger International, Inc., under a contract funded by the US AID. Despite the history, there were good reasons we embraced the task with optimism; maritime traffic was lined up to transit the Canal; alternatives to the Canal were unrealistic; both nations wanted the transfer to work; and the professionalism of both sides was excellent.

Once the mechanism (the consultant team) was in place, things moved swiftly. The two permanent consultants were supplemented by short term area specialists and the PCACP

made all of their work readily available. Our job, taking our lead from the PCACP, was to document key concepts with phases, milestones, steps and timetables; insure that the existing PCC was on board for any changes that would have to be made in advance of the transfer; and then to document what needed to be learned, by whom, how and when. The cooperation of the US's PPC was of the utmost importance. Any changes that were anticipated to be made, for purposes of seamless operations, would have to be made well before the transfer rather than at the time of transfer.

In addition to the legal challenges to operate under new laws, there was a need to change the mission of the Canal to a profit generating enterprise. Under US management, since 1979, the Canal was operating on a "break-even" almost socialist model. They had no incentive to turn a profit.

One senior US official told me, pointing to his computer, that he didn't know how to turn it on, but, he "got a new one every year". That was the day I became convinced that the world maritime community would be better served by the new management.

The US management team was more than cooperative in recommending and effectuating changes to reintroduce entrepreneurial, financial and marketing improvements. They agreed to:

- Create funds, not hitherto provided, for initial capital, working capital and maintenance reserves to be available on day one (unlike in the days of the railroad);
- Undertake studies to determine the value of both fixed assets useful for the life of Canal as well as of unneeded equipment to be privatized for the benefit of Panama (i.e. the printing presses, the power generating equipment, etc.); and
- Work to repeal the prohibition of selling specialized services for particular customers and to repeal the "single" tolling system that charged all cargos the same.

For its part, Panama decided to establish:

- Its own Maritime Center Think Tank to explore what other opportunities the Canal would bring to the Country that the US owners had no interest in developing, such as ship repairs, licensing and suppling, etc.;
- Petroleum Export Zones and Export Processing Zones to eliminate the cost of high tariffs on fuels and other vessel supplies;
- Tolling strategies related to market demands; and
- Value added services desired by clients.

In addition, all of the PCC rule and regulations had to be studied and tested for compatibility with Panamanian law and business practices. In every case where a discrepancy existed, a decision had to be made whether it should keep the rule and change Panamanian law or change the practice to conform to the practice of its new owners.

I.e., the Canal had to operate with no ability to strike. Therefore, in the Constitutional Title for the Canal and its implementing legislation, no strikes would be allowed in the Canal. To convince labor to go along, convincing merit systems and trustworthy professional arbitration processes had to be created.

With this professionalism, the PCACP and their legislative allies were able to win labor support, win worldwide maritime support and, eventually, to win public support in the passage of a Constitutional Title to enable these recommendations.

At the end, just before noon on December 31, 1999, ships entered the Canal owned and operated by a US entity with US laws and customs and later the same day exited the Canal under the new Panamanian ownership and operation in almost perfect transparency. Most importantly, the lights stayed on.

148. Miter Gate Machinery and Controls

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This presentation will draw heavily on the Working Group 138 report, Mechanical and Electrical Engineering Lessons Learned from Navigation Structures. Four different types of linkages are commonly used to drive miter gates. Three of these linkages are closely related and consist of a sector gear and sector arm with a strut connecting the sector arm to the gate. These three linkages are referred to as the Panama Canal, Ohio River, and Modified Ohio River linkages. The original Panama Locks used the Panama Canal linkage. The fourth type of linkage is the direct connected cylinder. The direct connected cylinder consists of a hydraulic cylinder with its shell (or body) supported in the miter gate machinery recess by a trunnion and cardanic ring assembly (or gimbal) and its rod connected directly to the miter gate with a spherical bearing type clevis. The direct connected cylinder has become the most common type of miter gate drive for new construction and retrofits. This is because of a cost advantage in the fabrication, installation, and maintenance of these systems. The Panama Canal and related linkages offered some advantages that should be considered. One is that the linkage can be electrically or hydraulically driven. Another advantage is that the geometry of the linkages inherently decelerates the motion of the gate as it approaches fully open or closed. This advantage is useful when the motion of the gate is controlled by the input of a human operator. Also, shock absorption can be incorporated into the strut. Miter gates are now often controlled by electronic control systems with varying degrees of automation. The control of drives with direct connected cylinders can be programmed to automatically decelerate the gate as it approaches opened or closed position. The direct connected cylinder can also be a linear mechanical actuator within certain stroke and gate size limitations.

Advances in hydraulic power systems for miter gates have allowed for increased reliability and maintainability through compact hydraulic drive units and self-contained hydraulic that can be quickly and easily exchanged for maintenance with a spare. Also, environmentally acceptable hydraulic fluids and lubricants are available which are high quality and can have a long life if properly maintained.

149. Construction of Borinquen Dam 1E for the Panama Canal Expansion

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Panama Canal Authority (ACP) committed with the $5.25 billion Expansion Program with the goal of creating a new lane for larger vessels to be able to transit the canal. The Panama Canal Expansion Program includes the deepening and widening of the current navigation channel, the construction of two additional locks -one at the Pacific Ocean and another at the Atlantic Ocean-, and the construction of a new access channel at the Pacific end.

The recently completed Panama Canal Expansion Project required construction of a 6.1km long channel at the Pacific entrance to the Panama Canal, to provide navigation access from the new Post-Panamax three-level locks complex to the Gaillard Cut section of the Canal. This new access channel runs almost parallel to both original locks on the Pacific side and required the excavation of approximately 50 million cubic meters of unclassified material and the construction of four dams, known as Borinquen Dams 1E, 2E, 1W, and 2W. The dams retain Gatun Lake, the main reservoir and waterway of the Panama Canal, approximately 11m above the level of Miraflores Lake and 27m above the Pacific Ocean.

The dams were designed as rockfill embankments with central impervious cores of residual and alluvial soils flanked by filter and drain zones of processed sands and gravels sourced from crushed rock. Design and construction of the dams posed multiple challenges, including: 1) variable foundation conditions with occasional unpredictable weak features, 2) use of residual soils derived from rock weathering as core materials, 3) a wet tropical climate with a 4-month-long dry season, and 4) geologic faults across the dam foundations.

The largest of the dams, Dam 1E, was built as part of the fourth contract for construction of the Pacific Access Channel (PAC), which included excavation of 3.8km of the new channel. The contract was awarded in January 2010 to a consortium of ICA of Mexico, FCC of Spain, and MECO of Costa Rica (CIFM). URS (now AECOM) was engaged by the Panama Canal Authority (Autoridad del Canal de Panamá, ACP) to assist ACP with inspection and design engineering services during construction of Dam 1E.

Borinquen Dam 1E is 2,420m long and consists of a central vertical earth core and rockfill shells; the total embankment volume is 5,300,000 cubic meters. To prevent piping of the earthfill core materials and provide internal drainage, a system of zones of chimney filters and drains was included in the design. The dam crest is at elevation 32.00 m (project datum is close to mean sea level, MSL) and is 30 m wide. The inboard slope is 3H:1V and the outboard slope is 3H:1V above elevation 16.00 m and 2H:1V below this elevation. At the maximum section, the Dam 1E is approximately 32m in height. The north end of Dam 1E is connected to the Pedro Miguel Locks with the North Tie-In wall which consists of a 90-m-long secant pile cutoff wall extending from the embankment core to a monolith located between the northern set of lock gates. The southern end of the dam abuts against a hill.

Construction of Dam 1E also included the following main project elements: 1) erection of a 1.7km long, 19m high, cellular sheetpile cofferdam, 2) installation of a 30m long, 18m deep,

triple-row, jet-grout cutoff wall, 3) construction of a 460m long, 18m deep, cement-bentonite slurry cutoff wall, 4) dewatering and excavation of the dam foundation, 5) treatment and geologic mapping of the foundation, 6) injection of a 2.4km long, double-row grout curtain, 7) placement zoned rockfill embankment, 8) installation of performance monitoring instrumentation, and 9) construction of a 97m long, 26m deep, secant-pile wall to provide closure against the structure of the Pedro Miguel Locks.

Borinquen Dam 1E is a critical component of the Panama Canal and is vital to the Canal's operation. This paper provides an overview of the construction of Dam 1E including the sequencing of the works, borrow of the embankment materials from the required channel excavations and other sources, and the key aspects of construction of the above project elements. The paper will also describe the most important design changes required during construction of the dam.

150. Panama Canal Water Filtration Plants. Early 20th and 21th Century State of the Art. Key Elements for Canal Operations

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PANAMA CANAL AUTHORITY, Panama

Despite the continuous changes on regulations and engineering state of the art on Water Works Panama Canal Filtration Plants cope with these demands enforced by the local laws and engineering technology.

Introduction

The Panama Canal Authority (PCA) owns three Water Filtration Plants. One on the Atlantic Side named Mount Hope (1914) and two on the Pacific Side, Miraflores (1915) and Mendoza (2010). Having a Water Filtration Plant is a privilege that very seldom someone will find in marine facilities such as ports, navigation channels, marinas, ferry structures. But having three, people will be skeptical of this statement. Well, The Panama Canal is the exception to the rule. These three plants, besides providing potable water to Canal Operations, they provide water to the adjacent communities and partly the two main cities of the Republic of Panama. This is a pride that every company must brag about it. The main purpose of any water treatment plant (water filtration plant) is produce water that is safe for drinking. This means, water free of chemical and biological organisms that may cause harm to humans to the point of developing an epidemic. The early decades of the 20th century and the 21th century brought state of the art technology on the field of water treatment engineering. The Panama Canal took advantage of it. Once built The Canal organization has kept a systematic operation and maintenance plan, year after year, to maintain the 1900´s plant in good shape. Beside, innovation took place with the newest plant, Mendoza that began operation in 2010 bringing into the scene the dissolved air flotation technology.

Miraflores and Mount Hope.

The two filtration plants were design to process raw water with the conventional treatment process; the treatment is accomplish with chemical products for coagulation, flocculation, odor and taste control and for disinfection. The infrastructures have a gravity process starting at the aeration basin, continuing on sedimentation basins, and finishing on the filters pools. Both plants receive their raw water from Gatun Lake. Mira Flores intakes are located at Paraiso and Gamboa where raw water is pumped to the PLANT. Mount Hope, in the Atlantic side, has the advantage to receive its raw water by gravity. For over more than a century, safe and good quality water for human consumption has been provided continuously to the canal operating areas, the communities alongside de Canal and to Panama a Colon Cities . The biggest change in infrastructure during these time was accomplished in Miraflores where six (6) filters were added in the early 1940´s at the same time, the clear well was expanded accordingly with the capacity to be discharged by the new filters. Both plants sand filters, due to increase in potable water demand from these plants, the filters were renovated in the late 1970´s, anthracite was incorporated over the sand, the filter layer design was resized and a surface wash water system was installed. Treatment up to this time remains conventional on most of the stages, aluminum sulfate, liquid chlorine are the primary chemical products, activated carbon is used, fluoride addition is required by the Republic of Panama law, Miraflores uses

polymers in different times of the year when process results show that its use is cost effective and efficient in the quality of the water in process. Reservoirs are part of a distribution system that mostly has pumping stations, pipelines for filling tanks and transferring the water to the city of Panama at points designated as “delivery points” that also serve as the boundary for Canal responsibility which ends at these points. The outside view of these centennial plants remind the typical architecture from the past, however inside them the new technology has been incorporated by means of monitoring instrument, remote control for pumps and valves, electronic devices an equipment, pressure and level sensors, all interconnected to a Supervisory and Data Acquisition System (SCADA) that provides real time information for water treatment operators from Miraflores, Mount Hope and Mendoza.

Mendoza Filtration Plant

Innovation from the rest of the word anchored at Mendoza with the dissolved air flotation technology for treatment of the Gatun lake water that being the same lake providing water for the three plants operated by the Canal, offers slight differences in raw water quality at the Mendoza raw water intake, letting the new technology do their best at this plant.

Demand and Challenges

Potable water production demand covers the three Locks along the Panama Canal as well as all Canal Operation Facilities and Administrative offices. Potable water is also use for the Chilled Water Plant, and Canal operation Fire Fighting Stations. External demand represents 95% of the total potable water produced by the Panama Canal. Wholesale the potable water to the Panamanian Institute of Potable and Sewerage Waters (IDAAN), who is responsible for the distribution system to the final customer. A new challenged arrived during the Canal Expansion Program, providing potable to ACP workers during a nine (9) year–period. This challenge continues with the new Locks and other facilities. Despite the difference in age water filtration plants have proven flexibility with the changes in water quality and drinking water regulation through years. The presentation will show history, construction, operation, comparison, as well as data proven that all of them comply with the local regulations.

Trained Personal

Human factor remains as a critical element to assure the good operation of the three plants, administrative and technical teams work together to make sure potable water complying with regulation requirements is always available for the consumers.

151. Future Ports and Piloting in Panama

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Tommy Mikkelsen, Tommy Mikkelsen

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Statement

With so much talk about automation and data, and how they will impact ports, terminals and vessels in the future, this presentation will be of particular interest to attendees as it takes a more practical, sober look at the technologies that are available now, how they can be used in practice and how they might evolve going forward. It calls on real life case studies and examples to highlight how the future is already arriving, and could offer huge efficiencies and savings for ports and vessels alike.

TITLE: FUTURE PORTS AND PILOTING IN PANAMA

The 'Port of the Future' vision sees vessels, ports and hinterland transport becoming part of a connected eco-system. This will require collaboration throughout the supply chain, which necessitates a common platform for communication and data sharing, with shared standards and processes.

Trelleborg's paper will discuss how ports and vessels will be shaped by data and smart technologies, through current case studies, while highlighting new technical innovations the company is evolving to support data-driven best practices.

Collaboration and the tech stack

This paper looks at the importance of an open system to help the industry achieve a standardized way to collect, store and thereby benefit from data in its myriad forms. To achieve exactly that, the technology platform must be built around an API structure that enables collaboration with third party systems and assets, a step towards achieving a common platform for the industry. This allows customers to make more effective decisions through deeper, accurate insights across all operations, irrespective of supplier.

To be truly collaborative, technology solutions must work across different aspects of the supply chain, whether that's within ports and terminals, on board vessels or as they get into the landside logistics.

By adopting smart technology built around open system architecture, any port or terminal asset can be brought under one cloud based system. This enables the development of custom apps to access asset data, interrogate it and present it across a wider range of users, enabling more effective decision-making through deeper, accurate insights. Multi collaboration is at the heart of such systems as they use data from different suppliers of different equipment, to develop informative services that are as useful to the customer as possible. This requires all available data to be formatted, collected and stored in a common way, making it easier to analyze, identify and implement measures that enhance safety, efficiency and productivity.

The core tech stack framework consists of two layers. The cloud layer manages intelligent data collection, transfer and storage. While the application layer provides access to unique product functionality and data insights from within the cloud.

Smart navigation with AMP

The technology platform is designed to empower decision making and communication during port approach, docking and deberthing. A key part of this process is the piloting and navigation operation.

The Association of Maryland Pilots (AMP) are utilizing their Portable Pilot Units (PPUs) and a Port System server solution to facilitate consistent, real-time information sharing between almost 70 pilots.

The AMP serves the Chesapeake Bay, the longest pilotage route on the East Coast of the United States, with its nearly 200 miles of waters. The scale of the waters put demands on the operational battery time the piloting equipment requires. Vessels of almost 48 feet draft transit the narrow channels of the bay, which themselves are only 50 feet deep.

The PPU combines a Rate of Turn sensor with a GNSS high-accuracy positioning sensor. It is used in paired units, with one connected to the ship's AIS pilot plug and power adaptor for continuous charging. The other is located on the bridge wing, running on a built-in battery. When the battery is flat, the pilot simply swaps the two units, allowing a continuous operation.

All data is visualized on an iPad overlaying a sea chart. The iPad is continuously in connection with the cloud to exchange vital data.

The technology platform system server solution synchronizes data between pilots. Updates to information are made on shore, and distributed in real time to ensure accurate decision making during the piloting operation. Recordings of all operations are stored for future review and pilot devices backed up in the data cloud, enabling the data storage and sharing that will offer real insight for future operations, a key element required within the Smart Port model.

Adaptive Under Keel Clearance (AUKC)

Adaptive Under Keel Clearance (AUKC) systems have been integrated into navigation systems to enable more productive ship and port operations. As ship sizes grow and many waterways become more constrained, the need for precision tools increases. AUKC systems are used to describe the amount of water between the ship's keel and the seabed. This is mostly used to determine the optimum time for passing the constrained waterway, or the tidal window. There are a number of challenges associated with determining AUKC:

- Ship motion affecting displacement
- Accuracy of seabed survey
- Prediction of weather / tide / sea state

The AUKC system uses third party integrated data to overcome these challenges, by providing a planning tool to develop a Passage Plan that is specific to the vessel and its journey. It will then provide real-time measurement to ensure that the plan is still valid throughout the approach, updates when conditions change and alert if there is a risk that the AUKC will be too small further down the route. The paper will detail the three phases of AUKC: Plan, Monitor and Analyze, discussing why each has an important role to play in supporting real-time collaboration and decision making, and optimization. The paper will also discuss the customer benefits such as enabling ships to carry more cargo.

152. Navigation Improvements for the Welland Canal

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William Miles

Bergmann Associates, United States

The St. Lawrence Seaway Management Corporation (SLSMC) has recently completed two improvement projects for the Niagara Region of the St. Lawrence Seaway System on the Welland Canal in Ontario, Canada. Approximately $120M CAD has been spent on these facilities to improve transport for Seaway vessels and safety for ship and Seaway operations staff.

There are eight (8) locks and five (5) reaches in the Welland Canal, and three (3) of those locks are twinned for simultaneous passage. The canal runs from Lake Ontario in the north to Lake Erie in the south, and the modern canal was built in the 1930's with additional amendments constructed in the 1950s and 1960's. In addition to the eleven (11) lock chambers there are concrete approach walls and timber tie-up (open quay) walls as part of the navigation system.

The main purpose for the tie-up walls is to allow for vessels sliding into position for entrance and exit from the locks. Other functions include provisions for vessels to tie-up for traffic control through the locks, mooring during bad weather, ship maintenance or inspection and access for service vehicles. Mooring has been accomplished using ropes tied to bollards and winches.

The Welland Canal is regularly closed during the winter Non-Navigation Season each year, typically between the dates of January 1st to March 20th, although closure and opening times may fluctuate depending on vessel traffic. During the Non-Navigation Season, some of the canal reaches may be dewatered to facilitate construction, inspection and maintenance of marine infrastructure, including the quay walls. The year-to-year schedule for the dewatering of specific reaches is established by the SLSMC based on requirements and priorities.

During a closure period in 2010, a partial collapse of a portion of the quay wall at Lower Lock 2 initiated a four year repair program that was contracted yearly by the SLSMC. Due to the deterioration of the tie-up walls a more aggressive 4-year replacement program was then contracted for design to the Bergmann Associates Team, which also included Moffatt & Nichol, Ellis Engineering, Quartek Group and Terraprobe as subconsultants.

The scope of this new program included the removal and replacement of four (4) reaches of the open-quay walls totaling 1.88 km during the non-navigation seasons of 2014 – 2017. The design was completed in August of 2013 and the project, with all four wall replacements, was tendered later that month.

Over the next four (4) navigation closure periods (January 1 thru March 20) one reach of roughly 500 meters of wall was replaced with more modern steel and concrete structures using prefabricated sections and creating more resilient structures. The last of the wall replacements was constructed in early 2017, and the renewed docking system is now in operation.

This project was initially documented at the 2014 PIANC World Congress in San Francisco, USA for work through design and the construction period for the first segment of wall that previous season. This paper will include updates and lessons learned from the next three (3) construction seasons, as well as a summary of the project success story.

The second modernization project was also begun in roughly the same period by the SLSMC, and included the installation of a hands-free mooring (HFM) system within the lock chambers on the Welland Canal, as well as in locks in other sections of the St. Lawrence Seaway System. Following the design and installation of a system by the SLSMC in Lock 3 in 2013 and 2014, the balance of the HFM system design was contracted to the Bergmann Associates Team in 2014.

Concurrent with the reconstruction of the tie-up walls in the Niagara Region of the canal, a new hands-free mooring (HFM) system was designed and installed within 9 of the lock chambers on the Canal also by the Bergmann Associates' Consulting Team. The HFM system installed is manufactured and supplied by Cavotec Moor Master Limited, Kaiapoi, New Zealand. The purpose of the vacuum suction-type system is to make mooring inside the lock chambers easier for the vessel and safer for the deck line-handlers, since no lines would be necessary.

In order to install the HFM system in a lock chamber, slots at 3 locations that are roughly 15'-9" wide by 5'-8" deep by 65' to 72' high in dimension, with rails installed vertically in each side of the slots were installed in each lock. In the 2015 closure period the HFM system was installed in Locks 1, 2 and 7. In the 2016 closure period, the HFM systems were installed in the western lock chambers of the flight Locks 4, 5 and 6; followed in 2017 by installation in the eastern lock chambers. Each lock installation cost in the range of $2.4M - $2.8M CAD for single locks to $3.8 - $3.9M CAD for each twin lock, excluding the Cavotec unit and controls which were purchased by the SLSMC under separate contracts.

The presentation will provide some of the basic design details, analysis methods, system information, and lessons learned for both the tie-up walls and hands-free mooring system projects. Photographs of existing facility demolitions, new construction and finished projects will be provided throughout the presentation as well.

153. Corrosion Evaluation of Maritime Steel Structures in Costa Rica with Thicknesses and Cathodic Potential Measurements

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Luis Osmel Millan Solorzano

Millan Engineering. Maritime consultant., Costa Rica

Due to the easiness of construction, many maritime structures, principally, foundation piles and earth retaining walls are made of steel. It is then normal that these structures are subject to corrosion that could be severe because of the direct contact with seawater or spray. Usually, there are considered, one or more methods to minimize the effects of corrosion, such as barriers, cathodic protection, or structural over-thicknesses.

For such structures, some inspection and measurements, are performed as quality control during construction. However, in most cases, corrosion assessment of these steel structures, during service life, is negligible. Oversee of service evaluations of structures, normally imply lately discovers of damages and could lead, in the worst scenario, to structural major failures. Afterwards remediation countermeasures, are often costly and done with poor knowledge of which are the critical areas. Evaluation performed during the service life of a structure, or simply maintenance evaluation, could be done visually and include or not discrete measurements along the structures. Nevertheless, there are some advantages in doing measurements for maintenance evaluations. Maybe the most important is to detect differences in the behavior of similar-type elements, and i.e. establish the priorities for maintenance. This present paper considers some studies cases with evaluation and follow up of structures after construction, including thicknesses and electrical potential measures. The corrosion analysis executed in three maritime projects are explained: a cellular cofferdam breakwater for a marina, an earth-retaining sheet-pile wall for berthing in a commercial port, and a pile-supported trestle in a sugar-pier. These projects are all located at Pacific side of Costa Rica.

First case, is in Quepos. In 2010, it was constructed t he Phase one of a marina, which has two mix breakwaters, bo t h wi t h rubblemound and circular cells of sheet piles, on marine steel, and filled with sand and gravel. Breakwaters are 956 meters long and have 25 circular cells from 12 to 18 meters in diameter, with interconnection arches. An over-thickness was considered for the sheet-piles. The maintenance plan for the marina, considers tracking t he corrosion experienced by the steel sheet-piles, and comparing 'actual' against expected corrosion rates. An analysis is then required to check that the structural limits for the corrosion additional thickness are not exceeded. The plan includes the rule of implement countermeasures when potential areas of accelerated corrosion are identified. Specific control sections, distributed along the breakwater, both internally and externally of the basin, (or inside the marina), were considered. In each section, thicknesses were measured every meter from the top of the cell to the seabed. These measurements were made using ultrasonic equipment, with special underwater transducer, out of water, and in the submerged sections with divers. Update annual campaigns measurements, are from 2011 to 2013, and 2015 to 2017. From the analysis of the measurements, some recommendations regarding the barrier protection of the sheet-piles for certain sectors of the sheet-pile walls had been issued. Other case is for the major Port in Caldera. The principal bulkhead of the port, includes three berthing positions from depths -7.5 to -11 m LWL (Low water level). This is a steel sheet-pile retaining wall constructed in 1980. Above water, sheet-piles are protected by a concrete cap, meanwhile, below sacrificial

aluminum alloy anodes provide cathodic protection. Evaluations of sheet-pile thicknesses and electrical potential generated by the cathodic system were performed by others in 2003. Additional measurement campaigns, of thicknesses and cathodic protection were executed from 2011 to 2015, and the last one in 2017.

Steel thicknesses measures, with a similar methodology as in the previous case study, are done for control and to verify no important losses are experienced in the sheet-piles. Additionally, electrical voltage assessment is being used as maintenance evaluation to detect areas with low potentials, in comparison with was is required to suppose corrosion inhibition according to standards. On those areas, installation new anodes are welded to regain potential, and then new electrical measurements confirm the protection. The third case is, is the Punta Morales pier, constructed in 1980, which is a dolphin-type pier with a loading platform, all on piles, fundamentally for sugar export. The sugar is transported from a warehouse on land to the loading platform by means of a conveyor belt. This belt is supported on (9) concrete caps, each one with (4) H-beam steel piles embedded on ground. The piles of the conveyor support are protected from corrosion by painting and by an active cathodic protection.

During routinely inspections, sections losses were viewed on support piles, mostly near low water level (LWL). However, extend of the damages were unknown, especially below water. For assessment, in the five outermost supports, it were measured, steel thicknesses at each pile, every meter from top to sea-bottom, as well as a pile-per-pile electrical potential. Thicknesses measures helped to identify areas with severe losses, i.e with lower measurement thicknesses compared to others. This evaluation did show some piles below water with losses, not necessarily visible. Instead of recommending substitution of the piles, reinforcement of them with steel plates was proposed, according to the distribution of the evaluation measurements. This repair was implemented shortly after the evaluation, and included underwater welding in difficult current and visibility conditions.

In all these study cases, thicknesses and electrical potential determination, helps to differentiate sectors of steel structures, where the phenomenon of corrosion and/or abrasion occurs with varied attack levels. With several campaigns of thicknesses measurements, along the years, it is possible to estimate corrosion rates and useful lives, both general for structures, and specific for each level and section. In turn, this allowed to iden t ify maintenance priorities, defining possible sites where measures of corrosion protection should initiate, wi t h barrier protection, or active or passive, cathodic protection systems, as well in general, t o have confidence in the structural capacity and safety of structures. Moreover, evaluation with discrete measurements along the structures had shown to be cost-effective reducing the costs for repairs and maintenance of the steel elements and cathodic protection systems.

154. Innovative methods for waterway inspection : an application to canal-tunnels

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Inland navigation is a prime transportation vector, whether for freight or tourism, and represents a more environmentally friendly alternative to road transport. The maintenance of fluvial infrastructures is not only a matter of heritage preservation, but also a commercial necessity and a security issue. Their documentation and periodic inspection is challenging due to the variety and huge number of structures to be considered. For example, Voies Navigables de France (VNF, the French operator of waterways), manages more than 6700 km of waterways (including more than 4000 structures). Hence, filling in the VNF structure database (called BDO) which, for the moment, is performed through systematic and exhaustive technical surveys of structures, carried out on site by agents, is a major effort. For this reason, it is necessary to develop highly efficient methods that are minimally invasive to fluvial traffic and require as little human intervention as possible. In this presentation, we focus on a particular type of structures, namely canal tunnels. Although there are only a small number of them (e.g. in France, 33 tunnels are still in operation, for a total of 42 km of underground waterways), they are key to safe navigation. Located mostly on small gauge canals, they attract heavy touristic traffic. We illustrate how up-to-date technologies (3D reconstruction by photogrammetry, high frequency microbathymetry, pattern recognition techniques) may be used to design automatic tools for the detection of damages on structures, and to produce accurate 3D models including both under- and above-water parts of the tunnels, even in the absence of GPS signal. In 2009, a French partnership composed of VNF, The Centre d'études des Tunnels (CETU) and the CETE de l'Est (now the Cerema) in collaboration with the Photogrammetry and Geomatics Group (INSA) has developed a visual inspection system dedicated to canal tunnels from acquisitions of image sequences. A modular prototype, mounted on a barge, has been devised for recording images of the vaults and sidewalls of the canal tunnel. Pattern recognition algorithms have been implemented for automatically detecting defects in the infrastructure. We rely on supervised learning classification algorithms from different representations of the data used at the classifier entrance. As first results, we have shown that cracks, water leaks, exposed steel reinforcements and damaged masonry joints can be detected by the algorithm, which is also able to disctinguish several kinds of linings (e.g. masonry, concrete, rock). With regard to 3D modeling, Emmanuel Moisan's doctoral work (funded by a Cerema scholarship from 2014 to 2017) allowed us to explore the whole-tube 3D imaging of canal tunnels by

combining photogrammetry and high-frequency microbathymetry sonar surveying. More specifically, three aspects were studied:

- the evaluation of a recent technology in 3D sonar imaging: We took advantage of the emptying of a lock for maintenance purposes to survey it with a Terrestrial Laser Scanner (TLS). Once the lock was back in operation, a sonar inspection was carried out. For this purpose, a Multi-Beam EchoSounder (MBES), namely Blueview BV5000 was operated in a similar way as the TLS, using a Mechanical Scanning System (MSS). While 3D reconstruction from TLS data is straightforward, a specific processing pipeline had to be devised for dealing with sonar measurements. Finally the models issuing from TLS and MBES data were compared. The study highlighted the artifacts that must be dealt with in shallow and narrow environments. It also shown that defects as small as 5 cm may be detected using this technology.
- the development of a 3D reconstruction chain based on data acquired by a boat: Since GPS signals are not available in tunnels, traditional bathymetric techniques cannot be used to register the 3D profiles provides by the MBES along the trajectory of the boat. To overcome this difficulty, we proposed to take advantage of the properties of photogrammetry, which is a technique that reconstructs a 3D model automatically from a series of images of the work, and also provides the localization of these images. It is then possible, having previously calibrated the relative position of the cameras and sonar on the boat, to estimate the trajectory of the MBES. Finally, the 3D model resulting from photogrammetry and the series of 3D sonar profiles positioned perpendicular to the trajectory are juxtaposed to form the complete 3D model of the canal tunnel.
- the quantitative evaluation of the 3D model against a reference model of the structure built from static measurements: A survey of the entry of a canal tunnel was performed by combining TLS and MSS technologies. Here again, an original method had been proposed to localize the sonar scans taken from unknown static positions. The comparison shows that the resolution of the above-water model is millimetric (with centimetric accuracy), and that the underwater model resolution is centimetric, with decimetric accuracy.

Even if steps still need to be taken before a complete automation of the process can be achieved, this research has shown the feasibility of documenting engineering structures such as canal tunnels in 3D. The proposed techniques could also be generalized to areas where the GPS signal is inoperative. They are complementary to more classical bathymetry methods. Moreover, we have shown the feasibility of automatically detecting components or defects in the structure via pattern recognition methods, which may be generalized to other structures and to underwater elements. In line with this collaborative research, and as part of its evolution towards digital technology, the so-called RES' O FLUVIAL 2.0 project, VNF is launching a first innovation partnership for high-throughput collection of images of the linear components of its network (mainly embankments and dikes), from the waterway. The aim is to automatically pre-inform (using shape recognition technologies) the condition field in the VNF structure database. Moreover, the images will be made available through a geolocalized interface (similar to Google Riverview).

155. Oil spill probability map as a tool for environmental management

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As a highly efficient mode of transportation, marine navigation plays a key role in world trade. Compared to other transportation modes, marine navigation has a relatively low carbon footprint. However, with the growing volume of marine traffic, marine navigation presents risks to the marine environment that could have potentially catastrophic ecological consequences.

Marine ecosystems are rich and diverse ecosystems composed of estuaries, sandy beaches, rocky shore, coral reefs, mangroves, deep sea and sea floor. A healthy marine environment has critical importance for life on Earth.

To minimize or eliminate the negative impact of marine navigation on the environment, environmental management is required. Examples of environmental management in marine navigation include using clean fuel, using renewable resources, and reducing oil pollution. An important aspect of environmental management associated with oil transportation traffic is the management of risks. These risks include oil spills due to ship collision, illegal releases of ballast water, and leakages of waste from ports and other navigation facilities.

For effective risk management it is important to recognize the exposure of the marine ecosystem to oil pollution. Having accurate maps and data on oil pollution exposure can help environmental managers with more suitable placement of oil spill emergency response facilities. Using the oil pollution exposure maps, environmental management authorities can develop local guidelines for preventing or minimizing the negative effects of oil spills.

This presentation introduces a new methodology and tools for creating oil pollution exposure maps for any region using readily available data sources. The inputs for creating the map are the locations with presence of oil spill incidents, locations with absence of recorded oil spill, and several explanatory variables, including, 1) distance to oil platform, 2) distance to oil facility, 3) distance to coastline and 4) distance to high-density ship tanker traffic route. The oil tanker traffic density can be estimated from the automated identification system (AIS) for recording vessel tracks (marinetraffic.org). The locations of recorded oil spill incidents have been detected by airplane surveillance, satellite surveillance or local report. The locations with absence of oil spill are randomly drawn from the areas that were environmentally and geographically far from the presence locations.

The spatial prediction model is a generalized linear model (GLM) where the explanatory variables are used as predictors of the presence or absence of an oil spill event. The model has two main outputs. The first output is provided in the form of a probability map – for any point in the study area, a value of oil spill probability between 0 and 100% is provided. , indicating a relative risk of an oil spill incident occurring at that point. The second output is a

table showing the relative importance of the explanatory variables and their effect on the spatial distribution of oil spills.

For environmental management in navigation, the probability map and other model outputs can be used to pinpoint heavy-traffic areas where increased caution and surveillance of vessels may be needed. The map can also aid in decision where to place emergency response resources and in identification of sensitive coastal areas that have high oil pollution exposure and are in need of special protection. Finally, by learning about the causal factors of previous oil spill events, the map can be used as a resource for environmental management to develop local guidelines for preventing or minimizing the negative effects of oil spills from marine navigation.

The oil spill probability map and statistical model presented here are based on the location of previous events. Other factors such as the amount of oil and the time could be added to improve the predictive power of the model. While the presented map does not take into account the movement of oil by wind and currents, it can be used as a pre-requisite for more detailed simulations of oil spill scenarios. Multiple scenario locations of oil spill events at different times of year can be selected based on the probability map. Combined together, the results of these simulations can give us season-specific information about oil pollution exposure in the coastal zone and can be used as a decision support system in environmental management.

156. Exploring potential climate change impacts and adaptation strategies for seaport operability

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Introduction

As seaports are located in the coastal zone, they are susceptible to climate change impacts such as rising sea levels and increased storminess. For seaports to still be able to operate under these changing conditions, a deeper understanding of potential climate change effects and adaptation options is needed. Previous studies focus on climate change impacts for seaports at a regional scale, but there is a lack of understanding of the climate change impacts on specific, individual seaports. In addition, there is a lack of understanding of how seaports can accommodate or adapt to these impacts. We provide a conceptual framework for (i) quantifying risks for port operability and (ii) exploring adaptation strategies. Application of this framework to a specific port yields both the risks for port operability and potential climate change adaptation solutions. The framework is applied to a case study of the Port of IJmuiden in the Netherlands. While the framework is tested on a single case study site, it is believed to be a promising tool for exploring climate change risks and adaptation strategies for seaports worldwide.

Framework

The first step of the framework is a system analysis. Port operations and physical assets that are valuable to stakeholders and that may be vulnerable to climate change impacts are identified. The analysis is conducted by means of stakeholder interviews and desk research. The identified port operations and physical assets form the focus of the subsequent climate change risk assessment. The second step involves translating greenhouse gas emission scenarios into local risks for port operability. This risk assessment requires that assumptions have to be made with regard to scenarios of future greenhouse gas emissions, for example the IPCC scenarios. By using these emission scenarios as input of a global climate model, global climate change predictions are obtained. Subsequently, these global climate change predictions are downscaled into regional predictions, using a regional climate model. Then, the regional predictions are downscaled into local predictions at the port location using a numerical hydraulic model or modelling suite, such as SWAN (Simulating WAves Nearshore) and Delft3D. Extreme value analysis of the downscaled local modeling results is used to translate the predicted changes in hydraulic conditions into port operability risks, expressed in terms of an increase in port downtime. Next, the relevance of the identified risks is assessed and prioritized by port stakeholders. The final step involves exploring adaptation measures for the identified risks using a panel of experts from practical and academic backgrounds. This is undertaken in a workshop, consisting of a divergent brainstorm session in predefined categories: (1) operational: logistic and technological solutions, (2) institutional: economic, legislative and political options, (3) social: options in which the influence on the behavior of actors is considered, (4) grey: physical engineering solutions within the port area and (5) green: win-win solutions which are also benefitting the natural environment. In the subsequent

convergent phase of the workshop, promising alternatives are selected by means of voting and a panel discussion.

Application to the Port of IJmuiden

The system analysis identified the following operations and physical assets as relevant to the climate change risk assessment: (1) navigational activities of vessels shipping from and towards the North Sea and the locks of IJmuiden (2) operations on quay walls and (3) berthing and mooring of vessels at quay walls in the port basins. The risk assessment revealed that regional climate change predictions for the North Sea imply the following for port downtime without adaptation measures:

- Navigational delay. The yearly averaged downtime due to high waves will be doubled from 5 to 10 days in the high emission scenario. In the moderate emission scenario, the yearly averaged downtime will rise from 5 to 7 days.
- Flooding of quay walls. Frequencies of flooding of quay walls in the port basins are expected to increase from once every few hundred years up to once every few years in the moderate emission scenario, or to once per 1-2 months in the high emission scenario.
- Delay berthing and mooring. The yearly amount of days that vessels will experience berthing and mooring problems due to waves in one of the basins will be doubled from ca. 1 to 2 days in the high emission scenario. An increase of 15% is expected in the moderate emission scenario.

The risks identified are relevant since the port is operating 24 hours per day and continuity in the operations is required. Based on the expert voting and panel discussion, the following adaptation options are identified as most promising in dealing with sea level rise: (1) increasing the quay heights and (2) construction of a retention basin in combination with a drainage system for quay walls. To deal with increased downtime due to increased storminess, the following options are identified as promising: (1) a multi-purpose land reclamation offshore of the port to provide a shelter zone for high waves and (2) the application of navigable, wave-absorbing vegetation between breakwaters. Further studies on the feasibility and effectiveness of these options are still required.

Conclusion

The conceptual framework for quantifying climate change risks for port operability and subsequently for exploring adaptation strategies was successfully applied to the Port of IJmuiden. The results of this study show that, without adaptation measures, climate change holds significant risks for port operability in the Port of IJmuiden. However, climate change impacts on hydraulic conditions are projected to be more extreme elsewhere, for example wave heights are projected to increase more rapidly due to climate change at the German and Norwegian border of the North Sea, in southern Australia, Africa, South-America and the Caribbean. This implies that climate change risks for port operability may be even larger for seaports located in these areas, and calls for attention on this issue worldwide.

157. An online decision tool for workability assessment using operational wave modelling

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When dredging in exposed waters, wave conditions may seriously impact the workability of a dredging project. Especially stationary dredging equipment that makes use of spuds in order to remain in position and transfer the dredging forces to the seabed, like a backhoe dredger or a cutter suction dredger, is vulnerable for harsh wave conditions. The workability of such vessels is not only affected by the wave height, but also the wave period. Other types of marine operations, such as the construction of jetties, installation of wind turbines or the placement of scour protections are affected as well in their workability by the ambient conditions at sea.

Various regions all over the world are known for their problematic wave climate; the African west coast, the French and Spanish Atlantic coast, the Indian coastal waters, etc. are known for their long swell coming with long wave periods. But also less swell-dominated seas such as the North Sea may have severe wind sea systems with typical wave peak periods around 6 to 7 seconds. In extreme cases, even for large cutters, workabilities of less than 50% are not exceptional. Given the large stand-by costs of such specialized vessels, this can have a huge impact on the cost of a dredging project.

There is not only a considerable cost impact. Also the safety of the crew working on board of vessels in harsh conditions is at stake. Usually it is the responsibility of the captain to decide when the works need to be ceased in case of upcoming bad weather conditions. Therefore the captain needs to have a thorough knowledge of the limits of the vessel in terms of metocean conditions, and he/she should also have good insight in the current and upcoming weather conditions. When there is uncertainty in one of those elements, the captain's decision might be too subjective and lead to unsafe situations or inefficiency:

- Unsafe working conditions follow from the fact that the equipment is being exposed to conditions beyond its workable limits. This could lead to damage to the equipment, for example damage to the spud, and uncontrollable motions of the vessel. In such case there is a risk for unsafe situations for the crew.
- Loss of efficiency is caused by a captain's decision not to work, while in reality the weather conditions are below the critical limits. This often happens after a period of bad weather, and conditions start to improve again, but the decision to resume the works is dominated by over-conservatism. The quality of the consulted weather forecasts also plays an important role in this process.

In order to improve this situation, DEME has developed an operational tool in cooperation with BMT Argoss which aims to provide the on-board crew and site staff with information on the present and near-future sea states and whether operational thresholds are expected to be exceeded. The sea state is broken down in systems of common meteorological genesis which are considered to be statistically uncorrelated. With the use of response amplitude operators, key operators are determined and presented via a web application. Whenever the actual wave conditions are getting too rough the system will indicate that the workability limits are being reached and work should be ceased. Real time sea state data can be acquired from buoys

that are deployed near the works. Future sea states are provided by a combination of operational atmospheric and wave models that typically deliver a five to eight day forecast window. To be able to further increase the accuracy and skill of these predictions, the models are calibrated on the measured waves. The wave predictions make it possible to plan the works more efficiently and to optimally use available workable windows. It generally results in less downtime, less damage and a safer working environment.

This paper will discuss various project cases where the tool has been applied, such as the dredging of the access channel for Wheatstone Downstream project in Australia, the dredging works for a new highway at La Reunion island (Indian Ocean) and the dredging and offshore installation works for the offshore wind farm Rentel in Belgium. The focus will be on the quality of the wave forecasts by operational wave models and the continuous calibration efforts which are increasing their reliability during the project.

158. The port of Ostend: construction works for the widening of the inner approach channel

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The widening of the harbor approach channel inside the harbor of Ostend concerns the last phase of the works in the framework of the 'Integrated Coastal and Maritime Plan for Ostend'. One of the objectives of this plan was to make the harbor of Ostend accessible for ships with lengths up to 200m. Previous works related to this objective included the construction of two new breakwaters and the relocation of the outer approach channel, allowing ships to enter safely into the harbor.

At present the approach channel in the harbor of Ostend is enclosed by a timber pier at the western side, and a seawall with the harbor site 'Halve Maan' at the eastern side. As the timber pier is protected by law as heritage, extension of the channel is only possible at the eastern side.

In 2015 navigation simulations were performed with different vessels (cruise-ships, RoRo-ferries and cargo-ships) to optimize the design of the inner channel. It was concluded that the inner channel should be widened from 80m to 125m at the most northern point of the site 'Halve Maan' to 145m at the most southern point of the site 'Halve Maan'. As the northern part of the site 'Halve Maan' is part of a habitat directive area, the occupied space has to be limited as much as possible and a nature compensation is required.

The design wave conditions at the location of the new construction were determined by numerical simulations. Further an extensive soil investigation at the site 'Halve Maan' was performed (exploratory trenches, CPT testing, boreholes and laboratory testing). Due to the interference between nature, infrastructure and exploitation zones, the works were split into three main project areas: north, middle and south. A site-specific design was developed for each of these zones.

For the northern project area there is a geometrical constraint related to the present habitat directive area. Therefore, instead of simply shifting landwards the existing seawall, a structure with a steeper slope was designed. The northern zone is oriented towards the harbour entrance and hence exposed to significant hydraulic loading. In this area, a protection using concrete HARO blocks (weight 15 tons) was designed to resist significant wave heights up to 4m. The height of the seawall is limited to achieve an economically (less earthworks) and environmentally (minimize use of habitat area) acceptable design. Obviously, this results in significant overtopping in extreme conditions, which means that the landward side of the seawall also has to be protected with armour stone to prevent backward erosion of the revetment. Further landwards in the northern zone a berm will be constructed, consisting of sand protected with gabions, to protect the city against flooding during extreme conditions (1000 year event). Points of concern in this zone are the possible presence of debris (remains of an old lock) and munition (from the first and second world war) in the soil.

The middle project area is located near an existing exploitation zone used by the offshore industry. Intended as a handling area for heavy windmill components, pavement of a large part of this exploitation zone was designed for a uniform load of 10t/m² using deep foundation

techniques. Geotechnical conditions for this area are quite challenging with soft soils (clay, peat) up to depths of 15m. Based on the above, shifting the existing seawall landwards was considered not expedient and as an alternative a quay wall was designed. The quay wall consists of a heavy combiwall (tubular piles as primary unit and intermediate double AZ sheet piling) with inclined ground anchors (pre-stressed grouted anchors). To avoid interference with the existing deep foundations of the pavement area, the anchors have to be positioned quite vertically: resulting inclination angle is 60° with the horizontal. Due to this inclination, combined with the poor geotechnical conditions, design anchor loads were extremely high with service loads up to 165 tons. Since both load an inclination are beyond common anchor design, an extensive full scale testing programme is foreseen to validate the design loads for these exceptional ground anchors.

In the southern project area the existing seawall ends in a quay wall. This quay wall of the Danish type has to be preserved, as it is the loading area for the offshore exploitation zone mentioned in the previous paragraph. Since the widened channel comes quite close to this existing quay wall, a solution had to be found to reinforce the quay wall and allow for an increase in depth. Modifications to the existing quay wall were considered too complex, and preference was given to less invasive solutions. Since the main issue was an increase in depth at a certain distance from the quay wall, but within the passive wedge, it was decided to build a gravel berm in front of the quay wall. Using this berm made it possible to avoid an increase in bending moment in the retaining wall, and allowed for sufficient earth resistance (passive earth pressure in front of the wall). However, for the corner section of the quay wall the widened channel comes so close to the quay that a simple berm proved to be insufficient to provide the required degree of safety with relation to ground failure. Therefore, the design was developed further to take the 3-dimensional spatial distribution of soil pressures into account. Nevertheless, an additional reinforcement was necessary and it was decided to increase the passive resistance by construction of vertical gravel columns in front of the retaining wall.

Construction works will start in 2018. In total more than 170.000 m³ of earthworks will be performed. The full paper will describe the design of the new seawalls into detail. Further nature issues, specific design difficulties, anchor testing programme, planning, execution sequence, … will be treated.

159. Web based Operational System for Optimizing Ship Traffic in Depth Constricted Ports

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The continuing surge in commercial vessel sizes is putting increasing pressure on the world's port operators to adopt effective operational systems that can guarantee safe and efficient traffic from sea to berth.

In this paper we present the web based operational port traffic management model NCOS ONLINE. The system supports multiple concurrent users groups, which allows harbour master, VTS and Pilots to work more effectively together on managing the flow of vessel traffic through the Port and shipping channel through a series of highly intuitive graphical interfaces. The system focuses on the efficient management of a large number of vessels of which many relies on constricted UKC windows as well as passage constrictions caused by other vessels in certain sections of the channel. For this purpose, the system uses a new generation of highly powerful numerical engines for simulating vessel UKC response. The vessel response engine is equivalent to that used in the 3D full bridge simulator SIMFLEX and provides unsurpassed accuracy compared to conventional methods.

We will present our practical experiences with using the system for Port of Brisbane and other Ports through approximately 1 year of operation and discuss ongoing challenges and future development initiatives.

160. Construction and Operation of a Work Vessel Location and Navigation Information System for Fishing Port Construction

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Purpose of Research

When Tsunami and typhoon attack ports, a large amount of drifts materials and debris appears and fills in basin of port and waterway. The first work to do is open the waterway buried with debris and drifts by work vessels. Work vessels are dredger and crane vessels.

After then, cargo ships carry relief goods to the port. The work vessels carry out recovery work for the destroyed port facilities. In large-scale disaster ex. East Japan great earthquake disaster, the work vessels at the disaster area are destroyed, therefore work vessels must be dispatched from the other areas. In East Japan great earthquake disaster, it took nine days to dispatch work vessels to destroyed ports from another area.

In order to promptly dispatch work vessels, the following three conditions are necessary. (1) to catch the location of work vessels, (2) to determine the necessary work vessels and (3) to rapid navigation to the damaged ports under the weather conditions. Therefore, the location information of work vessels are acquired by GPS(Global Positioning System) and the location information are transmitted in real time via the Internet. We construct a system that accumulates the location information sequentially and displays the current locations and navigation history information of the each work vessels. In addition, the work vessels location and navigation information is accompanied with the weather condition information on the wind direction, wind speed, wave height and wave direction at the current location and the destination. Therefore, it is a system that can ensure the safety of the action of the work vessels at the time of a disaster.

In order to verify the effectiveness of this system with weather condition information, we installed GPS and transmitters in 35 work vessels in the Nagasaki prefecture waters area. After that, the system has been put to practical use.

Research Contents

Work vessels location and navigation information system is constructed in order to take quickly measures for large scale disaster of port and plan dispatching work vessels to construction site of port. The outline of the system is as follows.
All 35 work vessels in Nagasaki Prefecture were equipped with GPS antennas, GPS chart plotters and internet data transmission equipment for catching the location of work vessels. Location information is received from the GPS antenna and transmitted to data server by the

NMEA 0183 standard. In addition to location information, the data includes work vessels speed, course, and time are accumulated to server. The transmitter is equipped with a 3G transmission module, which sends the data of work vessels every five minutes via internet. There is the AIS(Automatic Identification System) that identifies the location of a ship. However the GPS and 3G-transmission method was adopted for comparison of expenses and convenience of construction of system program. In addition, the coastal area of Japan (distance of 22.2 km from coast line) is a communicable range of 3G-trannsmission.

The system is programmed so that when a work vessel is unable to send data outside of the 3G service range due to being in far open sea or in the shadow of a mountain, the data is accumulated in the transmitter and sent all together once the vessel returns within the service range. The data sent by internet are received on a server and accumulated in a database.

The system is constructed to display current location and navigation history from the accumulated data of work vessels, with weather information of every work vessels location. For weather information, forecasts issued by the Meteorological Agency are saved in the same database. Currently, the Nagasaki Harbor Fishing Port Construction Association manages the location navigation information system of 35 work vessels. Therefore, when the disaster occurs it is possible to dispatch work vessels quickly. And they have prepare the system that can efficiently dispatch work vessels to construct ports.

Main Conclusion

Construction of the work vessel location and navigation information system with weather information for port restore and construction port quickly. The Nagasaki Harbor Fishing Port Construction Association manages the location navigation information system of 35 work vessels. The Nagasaki Harbor Fishing Port Construction Association can dispatch the necessary work vessels to restore and construct port quickly. In order to take measures to large-scale disasters throughout Japan, it is necessary to participate in this system on not only 35 working vessels in Nagasaki prefecture's waters but also working vessels in waters all over Japan.

161. Characterization analysis on harbor siltation in Japan

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Port and harbors have been constructed more than one hundred for commercial use around the Japanese coast and still developed and utilized for the local and national economic activity. Several ports locate at the area of shallow coast and estuary, where inevitably suffer from back siltation in dredged navigation channels and turning basins. Minimizing the harbor siltation, therefor, is key factor for the efficient port operation by reducing the cost for maintenance dredging and for the requirement of the limitation of the damping site of dredged sediments as is often the case in the world.

The purpose of the study is reviewing the current situation of the dredging activities for the maintenance of navigation channels for the Japanese ports and analyzing the characteristics of siltation mechanisms of them. The target sites are mainly in the western part of Japan, where many ports are struggling with severe back siltation sediment by the sedimentlogical and topographical reasons.

The analyses of the study include not only characterizing the general aspect of the siltation problems under the typical conditions of surrounding topography and sediment supply processes but also illustrating the sedimentary dynamics and their transport process around the navigation channels dredged in the shallow muddy coast based on the field monitored data. We finally discuss on the application of the nautical depth approach for the case of siltation by muddy sediment.

Typical topographical conditions surrounding the ports in the study area include the shallow muddy coast with the intertidal mud flat developed under the macro-tidal condition with the tidal range of around 5 m during the spring tide period. In addition to the force condition due to the tidal current, wave forces are also key to the sedimentary processes especially during the storm events due to the passage of typhoons. The port, which is located near river mouth, should be affected by the sediment discharge through the river and it is also intermittent event rather than steady phenomena since Japanese rivers are of short length and steep slope. The siltation process in the ports are strongly dominated by the intermittent events and it is one of the reasons that the planning countermeasures are not straightforward.

Through the field monitoring in the specific site at the port of Kumamoto in the Ariake Bay, the characteristics of the sediment transport processes were elucidated due to the tidal current and storm event. The monitoring campaign during the two weeks captured resuspension dynamics of the bottom sediment due to the currents and waves by the measurement of near bottom mounted current and turbidity sensors. The sediment fluxes were quantitatively estimated through the data analyses and it provides the dominant effect of the storm event. Another specific finding from the monitoring is that the wave induced by the ferry boat cause the suspension of the sediment in the area.

We also show the sedimentary characteristics of the monitoring site with the measurement of bulk density of the bottom sediment. The data were obtained by analysis of sediment core samples and by an in-situ densimeter also. In cases of the mud with higher water content, the

data shows gradual increase of bulk density in vertical and the so-called fluid mud layer was detected. The measured fluid mud layers were around the thickness of 10 to 20 cm in the site. Due to the existence of the fluid mud layer, the difference between the bed levels of the acoustic bottom and the lead line detection and it becomes as much as 50 cm in the highest water content mud case.

In order to characterizing the harbor siltation and reveal sedimentary dynamics and structures in the Japanese ports, after the general classification of siltation mechanisms at the typical conditions of surrounding topography, the specific mechanisms of sediment transport around navigation channel were analyzed with the field data monitored in the Ariake Bay and the analysis demonstrated the relative importance of the intermittent storm event rather than the cyclic tidal event.

Finally, field data of muddy sediment characteristics were also demonstrated in the port of Kumamoto, where bulk density were measured with the in-situ densimeter. The data showed that the existence of fluid mud layer and it should make difficult to detect or judge the sea bottom with any acoustic devices. Since the fact is crucial for the maintenance of navigation channels and water ways, the present monitoring techniques can be applied for further discuss on the applicability of the nautical depth concept in Japan.

162. Study on the Functioning of Ports in Production and Logistics for Export Promotion of Marine Products

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1. Objectives

While Japan is now working on promoting exports of its marine products, the functions of production and logistics for export have yet to be fully studied. Among export commodities, marine products need especially hygienic management (HACCP management, etc.) and freshness-preservation measures in their production and logistics. This is a consideration in determining which ports and transportation to use when exporting marine products. Therefore, the authors first clarify the current status of the world's and Japan's supply and trade of marine products, and of transportation and its routes from production areas to consumption areas by analyzing related statistical data (FAO FishStat, Japan's trade statistics, Japan's research on flow of container and air freight), and by conducting site surveys. Based on the results of this analysis, the authors discuss how to improve the functioning of ports in connection with promoting the export of marine products.

2. Functioning of fishing ports, ports and airports for promoting the export of marine products

2.1 Analysis results

a. The world's edible fish supply has been steadily increasing, along with growth in the world's fisheries and aquaculture production, as well as marine products trade. Fresh or chilled fish lead intra-regional trade worldwide. By commodity type, fresh or chilled fish or fillets (value-added and ready-to-eat) have been increasing in both value and volume.

b. Japan's export value and volume are still at a low level in spite of export promotion efforts to secure new markets overseas and to keep the domestic production price stable. By commodity type, the volume of frozen fish (low-priced) is decreasing, while the volumes of cephalopods and mollusks and fillets are increasing.

c. Regarding overseas maritime freight transportation, the ports of Keihin and Hanshin are designated as international strategic ports with international freight transportation routes to all over the world. They provide outstanding export value, followed by the ports of Tomakomai, Shimonoseki and Hakata, which are designated as international hub ports, located in major fish production areas in Northern and Western Japan. In air freight transportation, the international airports of Narita, Tokyo and Kansai service international freight transportation routes, while the international airports of Chitose and Fukuoka in major fish production areas are heavily used for export.

d. In production areas, the principal fishing ports for production of marine products are now being updated to hygiene-managed fishing ports. EU or FDA-approved marine product processing factories are centered around the principal fishing ports.

e. Air freight transportation is used for live, fresh or chilled fish produce that require more careful preservation of freshness, or for high-priced marine products, while maritime container freight transportation is used for frozen fish, dried fish or other marine products. Reefer containers account for over 90% of all containers used for marine products. For the export of live, fresh or chilled fish to neighboring countries (South Korea and China), ferries and RORO ships (with trucks carrying fish on board) are used on short international transportation routes, along with carrier vessels dedicated to transporting fish. This method of freight transportation is referred to as maritime “non-container” freight transportation.

f. Maritime container freight transportation: longer transport time (6 hours to one month), lower cost and larger loads (average freight weight: 98 freight tonnes)

Air cargo transportation: shorter transport time (3 to 13 hours), higher cost and smaller loads (average cargo weight: 380kg)

Maritime non-container freight transportation: intermediate characteristics between the above two (6 hours to 1.5 days)

g. Live, fresh or chilled fish and fillets are exported globally by air freight transportation, and to the port of Busan from the ports of Shimonoseki, Hakata and Uwajima (Western Japan) by maritime non-container freight transportation.

2.2 Conclusions

a. Fishing ports and regular seaports perform significant functions related to the production and logistics of transporting marine products from producers to consumers overseas, serving as a base for unloading fish under hygienic management and for exporting marine products while preserving freshness.

b. It is beneficial to export more live, fresh, or chilled fish or fillets. It is concluded that stepping up freshness-preservation measures would accelerate global exports by air freight transportation and exports to neighboring countries by short international transportation routes directly from principal ports located in production areas.

3. How to improve the functioning of ports for export promotion of marine products.

3.1 Analysis results

a. A large amount of marine products is shipped to neighboring countries after being transported to the ports of Shimonoseki and Hakata by land or coastal ferry from Hokkaido, with a lead time of 3 to 3.5 days from producers to consumers, rather than being transported directly from ports in Hokkaido.

b. Located on Hakata Bay are Hakata fishing port and the port of Hakata. Most fresh fish from Western Japan is collected to the principal fishing port by sea and land, and is distributed to domestic consumers shortly after being auctioned off. In contrast, live or fresh fish shipped from the international hub port is collected by land from the North and West, not from Hakata fishing port.

3.2 Conclusions

a. Transportation and the routes used for export of live or fresh fish are carefully selected based on how well the port supports the logistics functions necessary for shipping safely and economically within acceptable lead times for maintaining freshness, in consideration of the products’ characteristics, necessary lead time, cost and lot size.

b. In order to promote the export of live or fresh fish, it is necessary i) to develop and introduce effective technology for preserving freshness in container freight as well as ii) to ease import controls on marine products from Japan, and to facilitate procedures for issuing export certificates and other required documents. These countermeasures would realize more use of ferries, RORO and container ships to improve the current functioning of ports.

c. It is more effective to combine the logistics functions of the principal port and production functions of the hygiene-managed fishing port. Sharing necessary information aspects among all parties and people concerned can leverage the improvement of ports to ship marine products reliably and efficiently.

163. Geotextile Tube and Gabion Armoured Seawall for Coastal Protection - An alternative

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The present study deals with a site-specific innovative solution executed in the northeast coastline of Odisha in India. The coastal state of Odisha is almost protected with saline embankment for a length of 475 km along the shoreline, which was constructed with locally sourced soil. A certain stretch of saline embankment has been observed to be regularly eroded during the, storm surge, tides, waves, and flood etc. The damage to the saline embankment was posing a significant threat to the lives and livelihood of the coastal communities. In addition to this, the coastline was also affected by two cyclones, viz. Phailin (2013) and Hud Hud (2014). The coast near the pentha village was subjected to severe erosion for the past 25 years, whereas the tidal ingression is around 500 meter into the land since 1999. The erosion of existing embankment at Pentha (odisha) has necessitated the construction of a retarded embankment. The retarded embankment which had been maintained yearly by traditional means of 'bullah piling' and sandbags, proved totally ineffective and got washed away for a stretch of 350 meters in 2011, so pertaining to the site condition it is required to design an effective coastal protection system prevailing to a low soil bearing capacity and is continuously exposed to tides and waves. Conventional hard engineered materials for coastal protection are more expensive since they are not readily available near to the site.Moreover, they have not been found suitable for prevailing in in-situ marine environment and soil condition. Geosynthetics are innovative solutions for coastal erosion and protection are cheap, quickly installable when compared to other materials and methods. Therefore, a geotextile tube seawall was designed and built for a length of 505 m as soft coastal protection structure. A scaled model (1:10) study of geotube configurations with and without gabion box was conducted to better understand the hydrodynamic characteristics for such configurations. The scaled model in the mentioned configuration was constructed using woven geotextile fabric as geo tubes. The gabion box was made up of eco-friendly polypropylene tar-coated rope and consists of small rubble stones which increase the porosity when compared to the conventional monolithic rubble mound. In such a configuration, multi-tiered geotextile tube seawall was constructed with three layers of 10 hydraulically filled geotextile tube as the core, while stone filled polypropylene tar coated rope gabion boxes acted as armor layer for the structure. The gabion was placed layer by layer in the form of English bond brickwork technique and perfectly laced together horizontally and vertically.

This scaled model was examined for full submerged and emerged water conditions for different wave heights and different wave periods. The geotextile tube with gabion showed good wave energy dissipation characteristics Futhermore, reflection characteristics of this model were also quantified. Thereafter, the design was implemented as a pilot project on Pentha coast with some modifications during construction that involved using double steel sheet pile wall protected by rubble toe to mitigate scour. This case study establishes geo-tube seawall as an lternative to the conventional method of coastal protection. Additionally, this study also highlights the design aspects and challenges encountered in construction.

164. ST-Lawrence Seaway Modernization

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The St-Lawrence Seaway has undergone a substantial overhaul in how it used to process vessels compared to how it processes them through its locks. The Modernization multi-year program includes the implementation of Vessel Self-Spotting (VSS), Hands Free Mooring (HFM), and Remote Control of its locks. Vessel Self Spotting has been developed internally and is currently deployed and being used at all deep locks. Hands Free Mooring has also been developed internally and is currently deployed to all deep locks.

The Traffic Control Centres have been re-designed to enable remote operation of deep locks. The topic covered would be titled "Modernization of the St-Lawrence Seaway, an Investment in Sustainability", and would cover the technical development of the tools which are now part of the new Seaway. The passage of a vessel through a lock normally involves the deployment of four mooring wires from the vessels onto the bollards fixed on the lock walls. Vessels need to be equipped with steel wires and rollers in order to be allowed into the Seaway system. The passage through a lock is labour intensive, slow and hazardous. It is labour intensive because the steel wires are 1.5 inch in diameter, heavy, and difficult to handle. Each vessel requires the handling of four wires over sometimes long distances.

The use of Hands Free Mooring, which uses vacuum technology, only requires the push of buttons in order to secure and detach vessels, without any manual labour. This eliminates the need for vessels to equip themselves with steel wires and rollers in order to come into the Seaway, therefore allowing more vessels into the system without the need for costly conversions. The handling of mooring wires is not a desirable function in the marine world. Fatalities continue to occur linked to the breaking of mooring wires. In the St-Lawrence Seaway system, it was common to see a mooring wire break every 13 days on average, potentially injuring employees on the lock or on the deck of vessels. Since approximately 3000 transits occur every year, each going through up to 13 locks requiring wires handled by deck personnel and lock personnel, the hazards and frequency of occurrence was very concerning.

The tying up of vessels is time consuming; with the use of HFM, faster mooring times and faster cast-off times have been confirmed. The recent success rate achieved by the fourth generation of equipment in 2013-2014 has led to a substantial investment from Transport Canada (almost $100M CAD) into the Marine Mode of transportation. Since the Marine mode is the most efficient and environmentally-friendly way to move cargo, Canada’s transportation system benefits when cargo is placed on vessels, alleviating congestion and wear and tear causing considerable investments and environmental impacts. The use of vacuum technology was never considered in a lock environment, until the St-Lawrence Seaway started its development in 2007.

The challenges resided in the fact that its locks either raise or lower vessels approximately 14 meters in 8-10 minutes, and the equipment needed to secure the vessels throughout the lockage. This was never done anywhere in the world. The use of vacuum pads secures the vessels very well and prevents the large movements normally witnessed in vessels secured with wires, and has eliminated the incidents where vessels make contact with the lock

structures such as the concrete walls or ship arresters. In addition, a function of warping a vessel forward was designed for moving the vessels to their Final Mooring Positions using the vacuum pads mounted on horizontal hydraulic cylinders, instead of using vessel engines or using the mooring wires for re-positioning the vessels.

This allows Captains to bring vessels in the vicinity of their final mooring position, and let the vacuum pads do the final positioning. The implementation of Vessel Self Spotting and Hands Free Mooring has recently enabled the possibility of executing lockages from a remote location. In Parallel with these improvements (VSS and HFM), the Operation Centres were re-designed as Remote Operations Centres, allowing the control of all aspects of lockages and Bridges to be done remotely. Today, lock and bridge operations are done remotely from the Remote Operations Centres, and the locks and bridges are generally unmanned. Since the approval of the project by Transport Canada in late 2013 early 2014, The St-Lawrence Seaway has received visits from the Panama Canal Authority, the Port of Montreal, BHP Billington, Port of Hamilton, Westshore terminals, and hosted a number of interested parties at our various installations. T

he ingenuity has been the focus of numerous interviews, newsclips, and was also presented at the PEO sponsored Oakville Transportation, the World Canal Conference in Rochester, and has received the Organization for Economic Cooperation and Development's (OECD) 2015 Promising Innovation in Transport award at the International Transport Forum in Leipzig, Germany .

STATEMENT: This subject is a great example of how Inland Navigation Systems can leverage technology to enhance safety and reliability, and solidify their sustainability into the future. I would be presenting this material myself as the subject matter expert. I have presented this material multiple times and have always generated great interest from the audience. With the use of images and videos, I always find the audience engaged and curious to ask questions at the end of the presentations.

165. Sustained by the Sea: How a Small Boat Harbor Study in Rural Alaska Produced Insights into Economic and Environmental Sustainability

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Introduction and Background:

In rural coastal areas of Alaska, there are long stretches of coastline that support some of the world's most productive, yet most sustainably-managed fisheries. However, these areas often do not have harbor (marina) facilities for commercial fishing vessels. The facilities that do exist are generally over-subscribed, which leads to suboptimal mooring conditions such as rafting and hot berthing. These practices are inefficient and lead to vessel damage and increased maintenance cycles on shoreside infrastructure such as floats, dock faces, and other mooring facilities.

Additionally, because craft cannot find safe moorage they are either forced to stay at sea or anchor offshore in areas that are relatively protected by natural features. These conditions are inefficient as well as the craft are forced to either keep engines and/or onboard generators running, producing additional emissions that would be nearly eliminated if the vessels had access to a harbor and shoreside electricity.

However, providing additional mooring facilities, especially in rural areas without road access, can prove difficult. In places with existing protected mooring, the places best suited to this use have been taken. In places without existing mooring, the cost to import rock or concrete and other items necessary to create a fully-functioning harbor can be cost prohibitive, especially in an era of shrinking budgets. This presentation will show that new harbor facilities can be developed responsibly, considering community sustainability, environmental impacts, and respect for native peoples.

One such case where suboptimal mooring conditions exists is in Craig, Alaska. This community of 1,200 people on Prince of Wales Island depends heavily on the sustainably-managed fisheries in the nearby Gulf of Alaska, which provide local fishermen with over $10 million in gross earnings per annum. The community's two existing harbors provide moorage for approximately 220 vessels. However, surveys showed moorage demand for 94 additional permanent slips and up to 385 vessels seeking transient moorage.

Objectives and Methods:

The City of Craig, Alaska approached the U.S. Army Corps of Engineers (USACE) with the interest of entering into a cost-shared feasibility study that would examine alternatives to alleviate this surplus demand. The study included:

1. Multi-disciplinary engineering surveys and design

2. Environmental and cultural literature research and field surveys

3. Economic surveys of fishermen, vessel owners, and fishing permit holders

4. Coordination with:

a. Other Federal agencies

b. State of Alaska agencies

c. The City of Craig

d. Craig Tribal Association (a Federally-recognized tribe)

Findings:

The logistical, environmental, and cultural conditions were challenging. In order to reach Craig, the team from USACE in Anchorage had to take four flights to reach the island. The City of Craig has over 220 acres of regionally-specific eelgrass (high-value subaquatic vegetation) in the area and it currently grows wherever habitat conditions are favorable, making potential compensatory mitigation efforts incredibly costly. Upon examination, many of the areas that provided natural protection for vessels were either off the limited local road system, did not have access to utilities, or were likely to contain cultural resources, as Prince of Wales Island is home to six Alaska Native tribes who have used the area for millennia.

The study team examined ten sites in a 20-square mile area to determine which site would accomplish the study's goals of alleviating congestion while minimizing or avoiding impacts to the environment, including historical and cultural assets. Through this examination, the team concluded that the best site for a new harbor was at the site of a defunct cannery. The selected site offered many advantages to other sites including:

1. Proximity to locally-sourced rock, which decreased transportation costs and emissions associated with delivering rock from quarries outside of the study area

2. Existing shoreside facilities associated with the cannery that could be reactivated or repurposed to support the fleet and the local economy

3. The least healthy of eelgrass beds in the area due to legacy industrial activities associated with the cannery

4. Proximity to existing local services including supply stores and lodging

5. Proximity to intermodal transportation connections (seaplane base)

6. Proximity to naturally-deep water

Through creative and collaborative harbor design, the study team was able to formulate a recommended alternative that:

1. Eliminated the need for dredging, minimizing the probability of mobilizing any legacy contaminants from the period (early 1900's) during which the cannery was operating

2. Minimized impacts to eelgrass (less than 1/3 of an acre) and ensured that only degraded beds were affected

3. Minimized impacts to uplands, which nearly eliminated Federal impacts to cultural and historic assets associated with the cannery site and any subgrade assets associated with prior Alaska Native use of the area

4. Provided for nearshore passage of juvenile salmonid species through an overlapping gap in the breakwater that provided three feet of water at 95 percent of tides

5. Avoided impacts to the seaplane landing area to the east and north

6. Provided a 10.1-acre mooring area that can accommodate approximately 145 vessels

Conclusion

When completed, this harbor will allow this small, rural community to be more economically self-sufficient by more efficiently taking part in sustainably-managed fisheries that provide organic, high-quality food to its people and to the greater North American and Asian seafood markets. It will be an economic engine for the communities and tribes of Prince of Wales Island, helping to sustain a unique blend of cultures that does not exist anywhere else in the world. It will also help lower emissions from idling vessels or vessels that would have otherwise traveled long distances to participate in the fishery. In short, when properly formulated and designed, small boat harbors can contribute to economic development in a sustainable way that also protects our historical and cultural assets.

166. Selection Strategy of Failure Modes for Repair and Maintenance Activities

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Risk assessment is an essential step towards minimizing eventual consequences of infrastructure failures. Yet, numerous conceptual frameworks have been developed in various disciplines of social and natural sciences for examining the risk associated with extreme events and climate change. However, the assessment of the perceived risk of infrastructure failure, in connection with continuous deterioration mechanisms, for instance fatigue fracture due to vibration-crack-corrosion of aging waterway infrastructures, has not been extensively addressed yet. Designed for an expected service lifetime of 100 years, the bulk of navigation locks and weirs of the German Federal Waterways and Shipping Administration (WSV) were built between 1850 and 2014. More precisely, about 12% and 18% respectively of navigation locks and weirs of the network category A have already reached their desired service lifetime and these percentages are likely to reached approximately 36% and 44% over the next two decades. Also, increasingly complex structures have emerged as a result of tremendous developments in construction materials and technologies, coupled with significant advancements in designed standards. Again, with respect to the structural system, construction type and applied loads of navigation locks, gravity retaining walls, constructed with mass concrete brick- and stonework were progressively abandoned from 1960 for half-frame constructions, built with reinforced concrete. The infrastructure portfolio of the WSV consists of over 4500 objects of various construction types and materials, distributed through 67 groups of objects, ranging from navigation locks to dykes. This immense and heterogeneous infrastructure portfolio is confronted with different deterioration mechanisms, which might seriously undermine not only the structural reliability, but also have far reaching social and economic consequences in case of failure. While some of the deterioration processes might be associated with ageing, others are rather consequences of environmental stresses, construction and structural shortcomings and deferred maintenance activities, due to budget constraints or. Indeed, as waterway infrastructure become structurally and functionally deficient, the likelihood of time –dependent structural failures, including concrete corrosion and steel reinforcement corrosion, erosion and fatigue or embrittlement increases. Nevertheless, the service lifetime of these structures could be extended through advanced inspection and monitoring technologies, innovative maintenance and repairs. However, the implementation of such strategies will require substantial funds that are not always available, as well as the closure and replacement of various infrastructures, with tremendous economic consequences. A deteriorating infrastructure is likely to draw increased operation and maintenance costs, reduced safety and could also result in catastrophic failures with devastating environmental, social and economic consequences. Thus, based on its Maintenance management System (EMS-WSV), the Federal Waterways Engineering and Research Institute (BAW) is seeking for genuine and effective maintenance strategies to address the mounting burden of repair and renewal activities. Decision –making for the prioritization of the neediness of the aforementioned activities lies on condition ratings, which stem from damage data, recorded during visual and cyclic inspections. Beyond merely describing the degree of structural and functional deficiency of the infrastructure, including the load carrying capacity, serviceability and durability, in relation with various deterioration

mechanisms, this condition assessment does not specifically address the emerging risk of infrastructure failures. Again, although the prioritization of maintenance activities is increasingly granted a great attention, neither the perceived risk of infrastructure failure, nor the vulnerability of waterway infrastructures to various deterioration mechanisms have not heretofore been incorporated into the EMS-WSV. Indeed, much of the German waterway infrastructure is rapidly ageing. This situation could unfortunately exacerbate the risk of failure of structurally deficient and functionally obsolete structures, in case of any extreme events (floods) or natural disasters. Therefore, a comprehensive condition assessment method that simultaneously addresses the age of the facility, the vulnerability to various deterioration processes, the risk of potential failure and observed damages becomes an adequate tool for effective decision making related to repair and renewal activities of our aging infrastructure. Decision support tools are needed to enable practitioners and policy makers to make rational assessments of threats to infrastructures, to evaluate the consequences of the structural degradation and failure at various facilities under different circumstances and to propose effective corrective measures. This paper provides an insight to current research on the development of key figures for the assessment of the load-carrying capacity of existing waterway infrastructures, based on analysis of damage data, recorded during regular visual inspections. Thus, the purpose of this study is to shed more light on both the vulnerability of waterway infrastructures to various deterioration mechanisms and the perceived risk of infrastructure failures. In this paper, we propose a combined Failure Mode and Effect Analysis (FMEA)/Analytic Hierarchy Process (AHP), which is used to qualitatively assess the risk of infrastructure failure, and thereafter, to enhance decision-making with respect to prioritization of repair actions. Thus, using a Multi-Criteria Decision-Making approach, for instance integrated Analytic Hierarchy Process (AHP), various failure modes, identified in line with the conducted traditional FMEA are prioritized taking into account their potential risks of structural failure and loss of functionality. Interestingly, uncertainties, associated with damage data, collected during regular visual inspections and several aspects of the criticism to the traditional FMEA are well covered by the employed methodology. We also describe how individual score values obtained for each criterion can be used to establish guidelines for appropriate maintenance strategies for different classes of infrastructures. Equally noteworthy, much further research must be conducted to investigate the reasons and consequences of potential causes of failures with high risk-scores and to understand their effects on the functional and performance requirements of the structure as a whole. Ultimately, it is important to stress at this point that if German´s waterway infrastructure are not resilient enough, if we continue to defer maintenance activities, if we cannot meet coming societal and business transportation demands, if we cannot effectively document observed structural and material deterioration (digitalization) and if we try to run Germany on a shoddy waterway infrastructure, we are doomed to a downward spiral in our economy, standard of living and world stature.

Keywords: Risk, EMS-WSV, multi-criteria decision-making, Analytic Hierarchy Process (AHP), failure modes, uncertainties, prioritization

167. Numerical simulations of a longitudinal filling system for the New Lock at Terneuzen

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The lock complex at Terneuzen in the Netherlands is the link between the Port of Ghent in Belgium and the Western Scheldt. The current lock complex consists of three locks: the Eastern Lock, the Middle lock and the West Lock. The West lock is the largest and was constructed in the 1960s. It is sufficiently large to accommodate the Panamax class of sea-going vessels. The Flemish –Dutch Scheldt Commission (VNSC), a cooperation between the Dutch and the Belgian governments, is executing its plan to build a new large lock at this complex, which will replace the Middle lock (see Paper 126 PIANC SMART RIVERS 2015). When completed, the New lock will rank among the 10 largest locks in the world and will be sufficiently large to accommodate the Neo Panamax class of sea-going vessels.

Recent hydraulic research at the scale model facility in Deltares, Delft, The Netherlands, on the levelling system of the new lock has shown that a system of openings in the gate, as is being employed in the new sea lock of IJmuiden near Amsterdam, was not appropriate for the new lock at Terneuzen. This conclusion is due to the large mooring forces that the density currents can cause on the moored vessel during levelling (this research is presented in a separate presentation at PIANC World Congress). Instead the choice was made for a longitudinal filling system, similar to the one present at the West lock in Terneuzen. The principle behind this choice is that the density currents are generated at both the bow and the stern and that the forces will therefore be reduced.

The final design of the lock is to be made by the contractor who will build the lock. Prior to the tender process, completed in the summer of 2017, additional hydraulic research was conducted at Deltares for VNSC to investigate the hydraulic dimensions of the longitudinal filling system of the new lock. This research, conducted solely with numerical techniques, was used to define the hydraulic specifications of the filling system in the tender process. A combination of 3D Computational Fluid Dynamics (CFD) of different components of the culvert system and dynamic 1D culvert simulations with WANDA were used to simulate the levelling process. This approach cannot account for density flows in the lock.

The research studied two alternatives for the longitudinal filling system. One where the lock is filled via bottom grids in the lock floor at ¼ and ¾ of the length of the lock and one where the lock is filled via openings in the wall at both sides of the lock and at both heads. The first system is similar to that at the current West lock, the second system does not have direct antecedents, except a scale model investigation of the filling and emptying system of the Baalhoek lock, which was never constructed.

For both alternative filling systems detailed flow patterns and hydraulic resistances of the various elements were calculated with 3D steady state CFD simulations. Only those for the system with bottom grids are presented here as the constructor who won the tender has chosen for this system. Emptying and filling situations were considered owing to the asymmetry

of the system. Consideration was also made of the flow patterns in the approach harbour for the design of the intake openings. Subsequently, the calculated hydraulic resistances were used in the 1D dynamic model to simulate a levelling process in the lock. The water level slope in the lock chamber could be calculated during the simulation to give a first estimate of mooring forces and achievable levelling times. This model was also used to assess the inertia effects of the large culvert system, such as overtravel. This is the phenomenon whereby the water level in the lock can overshoot that in the approach harbour and can affect the force on the gates during opening at the end of the levelling process. Similarly the time-dependent asymmetry of the system was also studied. Unequal discharges through different branches of the culvert system can lead to large forces on the moored vessel.

The simulations showed that this type of longitudinal filling systems is feasible for achieving the desired levelling times whilst maintaining a safe levelling process. The final verification, taking into account density currents will be made in a physical scale model after the final design has been completed by the constructor.

168. AI Port Initiatives - Possible modernization of port operation and management through modern cutting edge IC technologies -

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Improving port productivity may be currently one of the most common and prioritized agendas for international port business community, particularly for the global container terminal operators. This is likely a reflection of recent change in business environment at ports, which have been traditionally essential logistics infrastructures in a global trade and industry networks. There is no doubt that the modern world economy fully depends on the global production network and sophisticated supply chain management. Nowadays, materials, parts and components for automotive assembly lines, for example, are gathered across oceans in a regular basis, hence ports, as essential connecting nodes of waterborne and land transportation networks, are one of key players of global production activities. In this context, extremely sophisticated but complicated modern supply chain management requires more time and cost consciousness to the port community, resulting in introduction of recent cut-edging information and communication technology (ICT) for improving port operation efficiency and productivity. The global port operators are now facing the client's strong requests to provide more quality logistics services with less port charges.

Recently, a new policy reform, Industry 4.0, were launched by Germany, which aims at introducing automation and data exchange in manufacturing technologies. It includes cyber-physical systems, the Internet of things (IoT), cloud computing and cognitive computing. An artificial intelligence (AI) based on deep learning programing, accurate sensor technology and big data attracts now a biggest attention of the world business community. In line with this recent trend, port community are going to step in the more ICT based and client oriented port operation and management.

An example may be the smart-PORT logistics (SPL) concept initiated by the port of Hamburg, Germany, which includes IT based traffic management system and real time information on traffic and port infrastructure along with the demand-oriented networking via a central public cloud. While the services have been just started after several years pilot phase, the SPL may be thought to pave the way of dramatically changing the future port operation scene.

Considering to these global trend of creating more smart and competitive ports , the government of Japan decided to launch, as a part of port policy reforms, a new policy, namely "AI port initiatives", for improving port operation productivity and port traffic traceability through employing AI for port terminal operation system configuration. The new terminal control system is expected to enable AI independently to operate container yard cranes for minimizing crane movements. AI controlled terminal operation system is also expected to manage container dray traffic at port for realizing quick container check-in and delivery.

An advantage of introducing AI into container terminal operation is considered to allow port terminal operators: i) collecting, processing and storing a bulky data without no terminal staff

intervention, because the data is generated from daily terminal operation on 24 hours and 365 day per year basis (big data), ii) providing an indicative optimum solution and best practices including best stowage and yard plans with terminal staff for assisting prompt decision making based on the past experiences and big data and iii) quickly controlling and processing container cargo traffic by fully automatizing container yard and gate operations.

Major challenges however may include: i) smooth introduction of the newest sensor technologies for efficiently and effectively collecting all terminal operation related information as digital data, ii) materializing an accurate big data transmission between on-site sensors and the terminal control host computer through IoT, iii) appropriate man-machine interface for assisting operator's prompt decision making, iv) renovating current terminal operating system by employing AI based architecture, and v) appropriate countermeasures against computer virus and hacking. A variety of deep learning software is currently available including many open software. Mobilizing these existing software resources may save the project time and cost, and enable to input more human and financial resources for developing AI loaded terminal operation system. Most advanced sensor technology such as image processing techniques also may contribute, as eyes of AI, to the system development.

The ICT based management and operation system may provide us with an attractive solution to dramatically increase port efficiency and competitiveness, to contribute to the global logistics innovation, and to improve business profitability and working environment at ports. At the same time, however, we must carefully consider and discuss the best course to invite AI into our ports as a good partner. The port community are not welcome to build a robot port. What needed in a practical viewpoint may be how to create a well-designed human-AI collaborative system for making our port operation and management smart. This may be a common business interest of the global port community and a common challenge, therefore to be discussed accordingly.

169. Engineering and Environmental Impact of Sand Dredging for the New Container Terminal Development, Bayport ("Hamifratz Port"), Haifa, Israel

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Bay Port is adjacent to Port of Haifa (Figure 1) built in the thirteen of the past century along the southern part of Haifa Bay. Carmel Port was built between 2005 and 2007. Start order of Bay Port, now under construction, was on January 2015 and will be operational on December 2020 .Bay Port was designed for EEE vessels(400x59x16m,18,000 TEU) with an entrance channel of-20,5 m water depth below Israel Land Survey Datum(ILSD). The project is executed concurrently with HaDarom Port project at Ashdod(Israel). Both projects are commissioned for Israel Ports Company Ltd(IPC) and designed by HPA Engineers P.C.(USA). Bay Port under construction by the Contractor Ashtrom Shapir-Construction of a new Port, Ltd (Israel), includes the following main structures(Figure 2):

•880 m extension of the main rubble mound breakwater,.• 2150 m of lee breakwater(1550 m of rubble mound type and 600m r.c. rectangular cellular concrete caissons).• 805 m main Quay 6 for EEE vessels,• 447m Quay7 for Post Panamax vessels,• 715 m Quay 8 of which ca 400 m for Panamax vessels. •15,5 million m³ dredging(10,5 million m³ sand for the reclaimed area of ca. 710,000 sqm and 5,0 million m³ of unsuitable material, clay/silt layers and fines content.

For breakwaters, a total of 43,300 armor units of concrete Antifer cubes of 4,7 and 12 m³ each and 5,3 million tons rock of different sizes(0-1 ton,1-3 ton,3-6 tons)are required.

A staging harbor in the near Kishon port was allocated for contractor`s work. Total project cost is approximately 1,2 billion USD. During the design phase of the structures, extensive marine and land surveys as well as model tests were carried out including exploratory boreholes for soil and foundation investigations to depths up to 80 m below sea bottom, soil laboratory tests; 2D and 3D hydraulic physical models of breakwaters and revetments stability; harbor wave agitation and ship motion ; numerical wave pattern at different scenarios ; fast and real time maneuvering simulations for nautical design.

Three main issues required special attention for the proper and economic design of the project . An Environmental Impact Assessment of engineering and biological issues , approved by the Ministry of Environmental Protection (MEP), was prepared by foreign and Israeli institutes and laboratories mainly focusing, inter alia, on the following aspects:

marine sand resources: along the coast of Israel ,offshore sand deposits generally contain high fines content which are unsuitable for engineering purposes as hydraulic fill for reclamation. The used fill material partly originates from a sand borrow area adjacent to the Works, dredged to sea bottom levels between-15 to – 25 m (1 to 3 m depth below it). The remaining sand quantity for reclamation shall be dredged within an area delimitated by the entrance channel, turning circle and along the areas of Quays 6,7,and 8. Unsuitable dredged material from all dredging areas shall be dumped offshore at disposal areas at Haifa Bay. An Environmental Management Plan for Dredging (EMP) of the suspended material including continuos

Monitoring Plan was coordinated with approved by the MEP. With the aim to minimize expected short and long-term settlements of structures in the reclamation area and liquefaction of the sand fill, ground improvement techniques like Vibrocompaction and /or Vibrostone columns were considered.The reclamation area was divided in three sub –areas : Type ‘1’ to be compacted with Vibrostone columns at ARR(Area Replacement Ratio) of 23%, Type “2” to be compacted with Vibrocompaction(at 70% relative density) and/or Vibrostone columns at ARR of 12% and area Type ‘3’ to be compacted with Vibrostone columns at ARR of 25%.

short and long-termimpact of the new Bay port`s structures on the surrounding sea bottom and the adjacent beaches of Haifa Bay. The coastline evolution, based on mathematical models like Spectral Waves, Hydrodinamic, Sediment Transport and Coast Line, has been assessed during the 30-year period after the Haifa Bay Port construction and results presented every 5 years An artificial sand nourishment along the Haifa Bay beaches already started to compensate the impact of the new port`s structures during and after its construction .

seismic impact because the northwestern coast of Israel lies in a seismically active eastern Mediterranean region. Design response spectra were developed based on seismo-tectonic studies and ground shaking analyses and time histories developed for two design levels of return probability, the Operating level earthquake(return period of 1 in 72 years,50% probability of exceedance in 50 years) and a Contingency level earthquake(return period of1 in 475 years,10% probability of exceedance in 50 years).For the OLE event, a PGA near the top of the upper rock stratum of 0,11g and for the CLE event a PGA of 0,38 g were used.

170. Panama Maritime Single Window (MSW) Challenges, Benefits and Lessons Learned

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Around the world, many countries are progressively implementing information systems that exchanges electronic information for work efficiency and information exchange standardization. However, Panama Canal faced difficulties in introducing the Canal Single Window because few practical guidelines and technical specifications exist. In full recognition of the absence of Single Window guidelines for maritime transport, the Panama Canal defined its own formats and standardization and implemented the first Canal Single Window in the year 2004 to declare all formalities and requirements to the Panama Canal. From there on, the Panama Canal made many upgrades to the system based on business changes. By the year 2015 the Panama Canal implemented a whole new Canal Single Window, including changes to the infrastructure and development tools. Furthermore, the Republic of Panama, as OMI member state, was called to facilitate the reporting formalities in electronic format via single window, among other challenges in the Logistic Sector. Therefore, Panama decided to re-used the current Canal Single Window and upgrade it to the Maritime Single Window of Panama (VUMPA). The VUMPA is the place where all information is reported once and made available to various competent authorities and other services provides. More than automate processes and its complexity, the most difficult part was to change the processes of people. In the first implemented phased, all government formalities are declared in VUMPA, and the declared information is shared among all government authorities. Highlights of the implementation (1) solve issues on regulatory procedures, legal matters, implementation methodologies; (2) redefine collaboration processes among the stakeholders of maritime transport; (3) Change Management, among others. Benefits include significant savings in cost and time for users.

171. Understanding risk-driving factors, their indicators and resulting decision criteria: The interdisciplinary approach in Germany

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This paper presents an interdisciplinary research programme in context with the reliability of transport infrastructures. The programme initiated by the German Federal Ministry of Transportation and Digital Infrastructure (BMVI) aims at understanding the underlying risk-driving factors, their indicators and resulting decision criteria. Using the example of the federal waterways in Germany illustrates the innovative approach.

The condition of the German transport infrastructure is increasingly deteriorating due to a variety of reasons. The reliability of the infrastructure is thus perceived as a risk factor for private and commercial enterprises. Actual figures substantiate this perception showing an immense maintenance backlog. Hence, there is an urgent need for new methodological approaches and innovative techniques to find adequate strategies in coping with the actual situation and future challenges. Thus, the BMVI initiated the innovative interdisciplinary research programme “BMVI Network of Experts” pooling the expertise and skills of its departmental research facilities and executive agencies.

As technical advisor to the BMVI, the Federal Waterways Engineering and Research Institute (BAW) is part of this network. The research activities of BAW consider the particular requirements of the waterway infrastructure. The waterway infrastructure features a high diversity and large number of structures. Thus, the determination of meaningful structural indicators is essential for an efficient prioritisation of maintenance measures. In combination with other data sources like geographic information systems, such indicators allow an estimation of the consequences for environmental, social and economic values located close to waterways. The knowledge about the consequences evokes an increasing demand for new technologies helping to reduce both the actual impact of disruptive events on the infrastructure and the potential risks of failure scenarios. Hence, innovative maintenance methods are studied and adapted for usage in waterways.

Amongst others, the interdisciplinary research activities in the “BMVI Network of Expert” show first results regarding several aspects of the structural reliability of waterway infrastructures:

- Essential risk factor is the precision in the prediction of extraordinary events and the subsequent control of the resulting effects. The development process of a smart discharge and water level control for navigable waterways aiming at minimizing the effects of such events shows the benefits of a close cooperation between institutions providing competences in meteorology, hydraulic engineering and control technology. Heavy precipitation can cause large water level variations in impounded rivers, as urban runoff from impervious surfaces is discharged to the receiving waters almost immediately. Given a discharge prediction of several hours, the local control system of the effected weirs calculates the ideal set value of the water level using optimization procedures. In this way, water discharge surges are homogenized, which improves the safety of shipping and adds to the reliability of affected structures.

- The detailed, i.e. quantitative, assessment of the structural reliability is a complex task and considered unfeasible when dealing with a large number of structures. In the field of mechanical engineering, qualitative methods are often used to assess the reliability of processes and products on a more general level. These methods are fairly unknown to civil engineers but prove beneficial in analysing inspection data and expert knowledge. The widely used Failure Mode and Effect Analysis (FMEA) was adapted to make use of data already available in the maintenance management system of the BAW. The FMEA was enhanced with fuzzy logic-based evaluation methods providing comprehensive key figures for a comparative risk assessment on a large number of structures. Such qualitative risk assessment then helps in the decision process about further actions like installing a smart water level control in order to reduce the water load variation on river weirs.
- Assessing deterioration processes and damage development are crucial parts of a reliability analysis. Both they depend on strongly varying initial and boundary conditions. In this regard, the elicitation and usage of available expert knowledge is indispensable. The advantages of so-called guided expert interviews are presented using the example of the design process for a full-scale embankment model test. The interviews were conducted to analyse the long-term damage development of loose riprap embankments. Based on results of the expert interviews, the model test was designed. The model was finally erected in the wave basin of the BAW, which allows observing degradation caused by hydraulic loads after initial damage.

The presented projects demonstrate the benefits of interdisciplinary research approaches. The results achieved so far add profound and comprehensive information to the ongoing discussions about efficient investment and effective maintenance strategies. In this way, the research activities of the BAW contributes to the urgently required reduction of the maintenance backlog and, eventually, to a reliable, highly available infrastructure.

172. The Panama Canal Expansion and Its Impacts on US Ports & Inland Waterways

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The expansion of the Panama Canal is a game-changer for the global logistics industry, with far-reaching impacts on inland and maritime navigation facilities worldwide.

As one of the primary users of the Canal, the US stands to benefit the most from the expansion program. However, achieving these benefits requires a major re-think of how the US inland and maritime navigation infrastructure assets are managed.

The current model of under-investment and “fix-as-fail” will not allow the US to maximize the benefits of the Canal expansion to maintain its competitive position globally.

This paper will provide historical context on the state of US ports and inland waterways infrastructure, the opportunities and challenges presented by the Canal expansion, and the benefits and consequences of needed investment in these vital assets.

173. Dynamic Logistics Simulation: A Powerful Planning Tool

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Liquefied Natural Gas (LNG) is a commodity widely used in the power generation sector. Recently, global trade has reached volumes never seen before and this trend is expected to continue. Major suppliers located in Asia Pacific, Africa, and the Middle East are increasing their production and new projects are arising to meet the surge demand coming from Japan, South Korea, and China. LNG projects are notorious as intensive capital investments, typically located in demanding environments and required to work within tight operational limits. As demand increases, the industry faces the need to rapidly develop projects, ensuring adequate return on investment. Therefore, understanding enough detail about an entire system from the beginning is crucial for the success of the project. Dynamic logistics simulation software is a powerful tool available to provide a holistic analysis of different project alternatives and conditions in a short period of time. A team of engineers can develop a sophisticated model of an LNG supply chain system and use this model to investigate how the operation will perform – both as planned and in various “what if” scenarios. These models, which process discrete events through time, can accurately capture how random and systematic delays to any part of the supply chain cascade through the system in complex ways. Understanding these effects can help develop plans to manage risks and design a capital efficient system to maximize returns of projects. Once the model is built, a multitude of possible scenarios can rapidly be tested to allow unbiased trade-offs between various assets such as onshore infrastructure and the LNG fleet. These models can be used through design and into operational planning, HAZID and permitting applications. The power of dynamic simulation modelling in the planning of a complex LNG supply chain is demonstrated in the LNG Hawaii Express Project. This project looked at a complex and unusual supply chain network to deliver LNG from Vancouver, Canada to the Hawaiian Islands involving a variety of transport modes and several transfer points. Since the Hawaiian Islands do not have bulk LNG import or delivery infrastructure, cargoes were to be transferred into containers on infield support vessels via a ship-to-ship transfer off the coast of Oahu. Containers were to be unloaded onto shore and distributed throughout the islands via trucks and inter-island barges. Due to the complex nature of the supply chain, static analysis was limited in its ability to capture the interaction of system-wide effects. The project tested the efficiency and robustness of the proposed delivery infrastructure in different scenarios. The simulation model included the infrastructure at all transportation service locations, weather thresholds and conditions, planned and unplanned maintenance delays, and seasonal LNG demand. Along with studying the adequacy of the infrastructure and the system’s response to maintenance events, a number of sensitivity analyses were run to examine the effect of daylight restrictions, third party traffic, number of infield support vessels, number of containers, and number of trucks, among other parameters.

174. PIANC WG 173 Machinery and Controls of Rolling Gates

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Rolling gates are generally operated with a mechanical drive system that utilizes wire rope drums such as the locks in Antwerp and the new Panama Canal locks. Wire rope drive systems are the most common type of drive for rolling gates and are recommended for new construction. The most common winch drive system and generally utilized for larger gates is two drums with wire rope reeling from the top (opening) and for closing from the bottom. This system also provides the most evenly distributed forces to the gate and is the recommended drive system. The gate is opened by synchronized movement of both cable drums whereby the top cables are pulling on the connection point of the gate. A cable tension control device, which is installed on every top cable, ensures that the bottom cable remains tight. An automatic wire rope tensioning system should be included in any new design. The Panama Canal and Kaiser Lock tension systems utilize a hydraulic cylinder. Although wire rope drives are the most common, there are other means to open and close rolling gates. This includes a chain system and a rack and pinion system. Chain drives are only incidentally utilized in rolling gate projects. The maintenance requirements of a chain system are generally greater than a wire rope drive system. Rack and pinion systems are also utilized to drive rolling gates including the new rolling gates at Ijmuiden Lock. The control system for a rolling gate is very similar to a movable bridge and shares many of the same features. A programmable logic controller (PLC) system is nearly always used today and recommended for all new construction. A back-up control system is also recommended such as a hard-wired system. The speed of the gate during movement is not constant. The gate speeds up gradually to the operating speed and it slowly decreases speed towards the end. This is intended to prevent high translatory waves in the gate chamber. It also limits the size of the machinery during the initial start-up and avoids oversizing machinery. The start-up loads are always higher due to inertial loads that need to be overcome. The control system has to be capable of varying and adjusting the gate speed.

175. PIANC WG 173 Maintenance of Rolling Gates

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Maintenance of rolling gates is a major consideration since many of the components are underwater. This can be up to 70% of the components depending on the gate design. As such, rolling gates need to be designed to minimize maintenance requirements. The wear of the lower rail tracks is a major problem for many rolling gates including the Belgian locks. Therefore, like in Germany, special maintenance cofferdams were developed to provide access to these tracks and to enable the change of rails. The gate recess should also be designed as a dry dock with bulkhead provisions. Sediment and debris needs to be controlled as the gate moves across the lock chamber. The Belgian locks in Antwerp utilize mixers and a venturi system to keep sediment from settling as the gate is moved across the lock chamber. Condition monitoring of equipment is recommended for the drive machinery. Items of major and recurring maintenance include gear boxes, wire ropes, bearings (greased or greaseless), wear surfaces, lubrication, paint, anodes, and rails. Wire rope supports include both rollers and wear pads and both need to be designed to prevent damage to the wire rope. The guide roller system will reduce friction compared to a sliding system and will reduce the required power for the driving machinery. The wear on a guide roller is limited and the life time expectancy is high. Disadvantage for such a system is its reliability and required maintenance. For rack and pinion driven rolling gates, the alignment is a critical consideration and needs to be verified on a periodic basis. The lubrication of the drive system on rolling gates is a significant maintenance effort. Drive systems need to be designed with maintenance considerations in mind. The use of environmentally acceptable lubricants is recommended. The Port of Antwerp utilizes a maintenance frequency for their rolling gates. This includes moving the rolling gate with the emergency driving unit every 3 months, testing the emergency power supply (diesel generator) every 2 weeks, visual inspection of the 4 installed mixers every year, visual inspection of wire rope every 2 months plus re-tensioning as required, change the under carriage wagon every 20,000 movements, remove the accumulated debris with crane and divers every 6 months, and inspection of the ballast chambers every 6 months.

176. Study on the Filling-Emptying System of Longitudinal Culvert in the Lock Floor

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The F-E system of longitudinal culvert in the lock floor was applied in different projects with different lock dimensions in recent years in China. The main characteristics of this kind of system will be summarized. The effects of energy dissipation systems used for the longitudinal cuverts will be disccused. So the hydraulic efficiency of this kind of asymmetric system could be more balanced through improving the effciency of energy dissipation systems at outlets of culvert.

177. Panama Canal´s Bank Lighting

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Operating a recently expanded 24/7 waterway, while maintaining safety standards and addressing new traffic challenges requires the use of reliable aids to navigation systems. These aids to navigation systems include maritime buoyage system, sector lights with oscillating boundaries, ranges, and a bank lighting system. The bank lights installation is similar to lights on an airport runway, these are present on the east and west sides of the banks at the narrowest parts of the navigation channel, at Culebra Cut and at the approaches to the locks. The associated distribution power lines were scaled in order to meet the needs of the Panama Canal expansion and the construction of nearly 9 kilometers of access channels to the new locks on both the Atlantic and Pacific sides.

The first Bank Lighting system on the Panama Canal was installed between 1959 and 1961, and consisted of cool white light fluorescent fixtures. Over the years, the fluorescent fixtures were replaced with amber light low pressure sodium fixtures (LPS). For the Panama Canal expansion the new Bank Lighting project considered a technology migration to LED fixtures, keeping the performance in color and light output of the existing with a higher life expectancy, and lower maintenance costs. Over 10 km of overhead power distribution lines and 6km of underground power distribution lines were built in order to illuminate the east and west banks of the new access channels.

This paper presents the planning, design and construction of the electrical infrastructures and lighting system needed for the new Panama Canal´s bank lighting.

178. Network Consequences of Local Disruption: Measuring Shipper Supply Chain Impacts

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This work is the result of a study commissioned by the National Waterways Foundation and the U.S. Department of Transportation's Maritime Administration (MARAD). The study's goal is to improve our ability to effectively and defensibly evaluate the economic benefits associated with available inland navigation.

PROJECT CONTEXT America's inland waterway system was essential to the nation's early colonial prosperity and it has been vital to U.S. commerce ever since. As navigation more fully developed in the 20th century, the waterway network became a perennial contributor to the nation's economic success. Today, America's waterways quietly provide an irreplaceable transportation resource that is key to the nation's global success in the 21st century. Unfortunately, toward the end of the 20th century, this fundamental part of U.S. transportation infrastructure became more visible, but for all the wrong reasons. Many of the nearly 200 infrastructure projects were reaching their design life of 50 years and choke points were adversely affecting more and more commercial users. The upper Mississippi's Lock & Dam 26 and recently the Ohio River's Lock & Dam 52 and 53 have been painful examples as short outages have severely congested the system. Most of the navigation projects are today more than 75 years old and have suffered from a persistent lack of reinvestment; in addition, environmental stresses associated with extreme weather events that magnify the system's vulnerability. It is within this context that the National Waterways Foundation and MARAD commissioned this study seeks to develop and demonstrate a robust methodology to explore the expected impacts of an extended unscheduled outage at a number of important Lock and Dam projects.

LOCK AND DAM PROJECTS SCREEND AND SELECTED FOR ANALYSIS In order to assess the impact of lock availability and outages, the study team developed and used a methodology to identify a small subset of locks for closer analysis. The initial screening approach included a carefully reconciled cross-section of data describing the characteristics and performance of roughly 170 navigation locks located throughout the nation's interior navigation system. The study team prepared and presented this information to the study's sponsors who then selected four locks for further study based on their characteristics and performance metrics. The four locks selected and discussed in this paper are: Markland Locks and Dam, Calcasieu Lock, LaGrange Lock and Dam and L&D 25. Of particular note were new metrics to assess a lock's importance to the overall network. One such metric, noted on the map below for each project, describes the average number of locks on the system that an individual loaded barge traversing the subject lock passes through during a single movement (represented as System Lockages/Project Lockage). An additional measure shows the traffic in the pools above and below the lock that originates or terminate in the pool but does not transit the lock. While this study did not investigate the particular modalities of an unscheduled

outage, it is possible that the outage could be accompanied by impacts on the pool traffic as well.

ESTIMATION OF DIRECT SHIPPER SUPPLY CHAIN COST BURDENS FROM AN UNSCHEDULED CLOSURE Estimating the direct efficiency losses associated with an unplanned lock closure provided the core information on which further analysis is built. These cost estimates were derived through methods that adhere to the same Principles and Guidelines that govern U.S. Army Corps of Engineers' navigation studies. For each lock examined, the analysis compares an estimate of each shipper's current costs for waterway-inclusive movements to the cost of the next best available modal alternative. Three existing models were employed that allowed a comparison of the costs associated with the use of barge service against the cost to make such a movement by rail and/or truck. For each of the four locks analyzed, the model estimates predicted the Direct Shipper Supply Chain Cost Burden if barge service becomes unavailable and, at each location, these costs would be expected to exceed $1 billion per year, as described in the Table below:

GEOGRAPHIC DISTRIBUTION OF THE DIRECT AND REGIONAL IMPACTS Using the information about the origins and destinations of the traffic relying on each lock, it was also possible to describe the system-wide nature of the impact which each individual lock's closure is expected to have as illustrated on the four network maps below. Finally, the direct results described above were combined with a 2014 National Waterways Foundation analysis to estimate upper bounds for the regional economic impacts associated with an unplanned lock closure. The regional impact – lost incomes and lost jobs –are summarized both graphically and in tabular form.

179. Challenges in the design of port infrastructure in the Magdalena River - Colombia

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Gomez Cajiao, Colombia

The Magdalena River is the main fluvial artery of Colombia, communicating main urban centers of the country like Medellín and Bogota with the ports of Cartagena and Barranquilla in the Caribbean Sea. In recent years, Colombia has had a series of investments in port infrastructure on the Magdalena River, which join the initiative of the national government to revive the transportation of the most important waterway in Colombia. Gómez Cajiao, a leading company in Colombia in port infrastructure design, presents the current challenges and the solutions implemented in the design of ports from the hydrological and hydraulic point of view and the impact that climate change has had on port infrastructure designs. Experiences and challenges in the understanding the effect of climate change on the design of port infrastructure are presented; the impact on the environment from an Eco-hydrological point of view and the social effects considered in the design of the hydraulic solutions of the projects that are presented as case studies. The port projects on the Magdalena River present environmental challenges related to water management in wetlands, which are habitat of several species and support for families of fishermen who develop their productive activity there. The effect of climate change is analyzed as an increase in extreme flows and the possible effects of planned works in the river basin and affecting the flow regime, such as hydroelectric and reservoirs, are discussed.

180. New Contractual Model for Dredging Projects to Avoid Disputes: Case Studies of Performance Based Contracts in dredging projects around the world.

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The new application of Performance Based Contract to dredging (also known as “draft-guarantee” contract) transfers to the contractor all sedimentation risks over long periods of time and pays for all his services via monthly fixed amounts. The method is so successful that in some cases the PBC has lead to novel financing via a toll of the waterway (converting to a concession contract).

Up to now, most dredging by port and waterway authorities has been paid through, (1) surveyed volumes and fixed price or, (2) a charter contract paid directly by the agency. These methods are known to harbor the risk of disputes, primarily arising from the contract documents when encountering adverse site conditions. PBCs eliminate most of those risks, and are especially advantageous to both the Owner and Contractor when: (1) there is a stable level of policy, (2) where sedimentation can be evaluated within reasonable assumptions of risk, (3) where all other risks are covered with reasonable contractual limits (for example, extreme weather conditions), and (4) there is a sufficient large volume to be dredged that allows for competitive bidding.

This paper discusses four successful applications of the PBC in Argentina and The Netherlands involving over 20 years of continuous dredging. Additional data is presented on the technical and quality aspects that are most significant to the PBC to preserve the quality and successfully complete the projects without claims and disputes.

Keywords: Performance Based Contract, adverse site conditions, site investigation, dredging.

181. An Industry-Education-Research Cooperation for Inland Waterway Logistics

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Due to the access to mobility and to the worldwide availability of goods from each part of the world, personal life standards have radically changed within the last years. During the last decades, mobility and transport have been increasing dramatically and simultaneously, destructive effects on environment and people such as air pollution have been caused. Nevertheless, road transport – which induces the highest external costs due to accidents, noise, congestions and emissions – was used for 75.5% of freight transports in the European Union. Only 18.4% of the transports were done by train and 6.2 % by inland waterway in the European Union in 2015. It is hypnotized that the amount of transported freight will further increase and a switch to railway and inland waterways is needed to cope with this increased amount. In addition, from an economical perspective trucks operate on higher emission levels which requires a switch to sustainable transport modes such as inland waterways or railways (Eurostat 2017, European Commission, 2011). Results previous studies show that people in logistics industry lack knowledge on inland waterway logistics. Throughout Europe, only an insignificant part of study programs contains teaching units about inland navigation (Breinbauer, et al., 2012).

Due to this lack of knowledge, the competence centre REWWay (Research and Education in Inland Waterway Logistics) was built in cooperation between viadonau, Österreichische Wasserstraßen GmbH, as the responsible institution for maintaining of the Austrian Danube section and the Logistikum Steyr as research- and education institute of the Upper Austrian University of Applied Sciences in the field of logistics. REWWay aims to foster the generation of knowledge and the integration of inland waterway and eco-friendly transport into logistics education. REWWay allows an enhanced integration of inland waterway in education and training through a provision of high-quality teaching material and trainings. These teaching offers are free of charge available at the REWWay website. All those offers have been provided in order to increase people's awareness and knowledge on inland waterway transport and thus, support a modal shift towards inland waterway transport.

As a first step a literature review on inland waterway logistics and education and training was conducted. For this, schools focusing on (transport) logistics in Europe across the Rhine-Main Danube Canal were identified with desktop research. Second, an international study including expert interviews and focus groups with important stakeholders from industry and the educational sector was conducted. The aim of those workshops and interviews was to find out about the current status, needs and requirements of inland waterway logistics education. Afterwards, target group oriented key success factors with regard to logistics education and training on inland navigation and eco-friendly transport were evaluated. In total, 27 representatives from 21 institutions (vocational schools, upper schools with/without focus on logistics, universities and universities of applied sciences) participated at the market study.

Results suggest that a variety of key success factors for teaching materials and offers on logistics education and training on inland navigation have to be fulfilled to reach educational institutions best. The overall outcome of the market study was that participants from all

institutions are willing to spend more time on the topic of inland navigation and eco-friendly transport if high quality material is available and well prepared (Putz, Schauer 2014). Interviewed teachers and university lecturers show a high demand for films, PowerPoint slides, lecture notes and case studies which support students in active and self-decided learning. In fact, a high learning success can be realized through the active-involvement of students and diversified lessons or material which is claimed for logistics education (van Hoek, 2001; Gravier and Farris, 2008; Wu, 2007). Moreover, there is a need to enhanced cross-linking with the industry through field trips or external speakers. Besides, the provision of training offers for teachers to support familiarity with inland waterway was pointed out.

Based on the results of the first market study, a portfolio of learning offers had been developed since June 2013. These offers includes learning units for specific topics, a film library with questions and answers, case studies, cost and time calculations, an e-learning platform (www.ines-danube.org), a list of interesting field trips and contact points in Europe and presentations slides (from very basic level up to expert level). Trainings were held for educators on inland waterway in general and the integration of these offers in education. All those offers are available in English (and German) on the REWWay website. After the first two years of the launch of the website, google analytics show more than 43,000 downloaded learning packages or units.

In line with the results of Gravier and Farris(2008) a major requirement is the collaboration between industry and the educational sector. A recent is a workshop which was organized in Duisburg (Germany) at the largest inland port in Europe in October 2017 organized by the Logistikum. More than 60 people from industry, educational institutes and research discussed about the future of inland waterway transportation in Europe.

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182. Synchromodality and its Connection with Inland Waterway Transport

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Introduction: To shift freight transport from road to other eco-friendly transport modes is one prior goal of the European Union. Synchromodality as promising approach combines elements from different transport concepts and aims to create a flexible transport network, to sustainably use available transport resources and optimize transport processes. Since the transport sector is highly responsible for emission problems and other negative externalities, the need for promoting modal shift is evident. Synchromodality is a logistics concept, which strives to increase the share of rail and inland waterway transport. Switching between rail, inland waterway and road transport is carried out in near real-time. This is possible since shippers book their transport service “mode free”, i.e. the transport mode is not specified in advance. The transporter is therefore able to bundle the flows of goods from different customers and optimize their carriage. Close cooperation between all actors along the transport chain allows transporting goods in a flexible and resource-efficient way.

The port of Rotterdam and the European Container Terminals (ECT) started some pilot projects. The most famous one is the implementation of the synchromodality network between Rotterdam, Moerdijk and Tilburg. Even though synchromodality is a promising new concept, the applicability of this concept starting from landlocked Europe to the sea has not been investigated successfully yet. In order to prove the applicability of synchromodality in the hinterland in Central Europe, key enablers (similar to key success factors) of existing pilots of synchromodality have to be identified.

Objectives : The aim of this paper is to define the term ‘synchromodality’ and to identify the key enablers for a successful development of synchromodal transport chains in the hinterland. Moreover, to identify the current situation and projects about synchromodality in Europe and the level of integration of inland waterways in the hinterland . The main element of synchromodality is to plan transport processes based on current capacities of the different transport modes in real-time. The shipper gives the logistic service provider the possibility to choose the appropriate combination between available modes of transport. Thus a real time switch is possible and sustainable transport processes can be efficiently integrated in the transport chain. A core criterion for a working synchromodal chain is to generate a cooperation network between all stakeholders. To foster the successful implementation of synchromodal transport chains the status quo of synchromodal transport as well as potential key enablers such as the standardised exchange of data and the efficient use of ITS must be defined.

Data and Methodology:In order to define key enablers for a synchromodal transport network, the first step was to determine the term of synchromodality and to differentiate it from related transport concepts such as intermodal or co-modal transport. Thus, based on a systematic literature, using international scholarly databases, review existing definitions and explanations about these transport systems are discussed and distinguished. As a second step, we reviewed the literature to identify potential key enablers for a successful implementation based on the literature. As a third step, we conducted interviews and a focus group with companies which have been identified as best practice examples. To increase the involvement of relevant

stakeholders (i.e. politicians, logistics provider, shippers, researchers, special interest groups and IT providers), they will be invited to a discussion group. The main topic of this group is to discuss and reflect on the results of the overall project. Moreover, a desktop research is included to identify ongoing impletation projects about synchromodality and how inland waterway transport is included.

Expected results: The concept of Physical Internet, which is anchored in the long-term strategy of the European Union should be achieved by 2050. Synchromodality is a major requirement to achieve this vision. Thus, project referring to transport and the physical internet are included in the results. To communicate its benefits to the stakeholders a clear definition of synchromodality is essential. Results suggest, that key enablers will give an overview which factors must be considered (e.g. minimum amount, standardised data) based on the literature and the pioneers of synchromodality. Best practice examples and the status quo observation of the market, will help to examine existing framework conditions and to define additional required circumstances for the hinterland. By integrating potential stakeholders for the implementation of a synchromodal transport network, awareness on the topic will be raised to foster a long-term shift from unimodal to intelligent, flexible and sustainable synchromodal transport. The transport system synchromodality will help to overcome this weakness and establish more sustainable transport chains by using the eco-friendly transport modes railway and inland waterway. In addition, bottlenecks in transport chains (e.g. low water levels or congestions) can be more easily compensated. Synchromodality allows saving costs since the best and most efficient transport mode is selected. Nevertheless, before establishing such a system the main barriers and key enablers must be identified and awareness needs to be created. The implementation of synchromodality may support a modal shift towards eco-friendly railway and inland waterway.

Based on a literature review and a discussion in a team of researchers, seven main categories of potential key enablers have been determined. Those seven categories are ranked due to the number of times they have been mentioned in the papers of the literature review: Network/ Cooperation/ Trust, Sophisticated Planning/ Simulation, Information/ Data/, ICT/IT, Physical Infrastructure, Legal/Political Issues, Awareness/ Mental Shift and Cost/ Service/ Quality.

A best practice example has been identified from the port of Rotterdam, which are the founders of synchromodality. The use of inland navigation for 50% of all cargo at the new Maasvlaakte II terminal in the hinterland transport is a requirement which has to be fulfilled by 2020. An Austrian best practice example is the project ATROPINE, which simulates the effects on inland navigation of transport bundling activities of different companies.

183. Durme Valley River Restoration Plan. Maintenance dredging and reusing the sediment for nature restoration and improvement of safety against flooding.

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The Durme river is a branch of the Scheldt estuary. Nature is characterized by fresh water tidal marshes. Several controlled flood areas are located along the upstream part of the Durme. Navigation only occurs in the downstream part. The surrounding polders are drained through the Durme during low tide. Because of lack of a steady upstream discharge, since the cut off of the upstream catchment in the town of Lokeren, and a lack of regular maintenance dredging, siltation has compromised these nature, flood control, navigation and drainage functions.

The river restoration plan of the Durme aimes at revitalizing the river functions as a part of the Sigma flood protection programme devised to protect the Scheldt estuary against storm surges. The Sigma plan defines the construction of controlled flood areas, reduced tidal areas and areas subject to depoldering, giving space back to the river and restoring wetland and tidal nature.

Several of these areas (Bunt, Klein Broek, Groot Broek) are located along the downstream branch of the Durme. In order to ensure the full functioning and to prevent further sedimentation at these areas, also the upstream part of the Durme river is restored. The need for constructive sediment to realize the Sigma plan, is a major driver to dredge the silted up Durme, and to also restore the other functions. The sediment of the Durme is of sufficient quality to be used as construction material for the dikes, which are required to protect the inland areas against flooding, when the flood areas are being activated during storm. Additional sand is required to restore and bring the remaining Durme dikes to Sigma height. This height is determined to provide the required safety against flooding, taking into account the expected sea level rise by 2100.

The Durme Valley River Restoration Plan defines a cross section, aiming at restoring the gravitational drainage of the surrounding polders and revitalizing the silted up tidal marshes. The scouring function and volume to maintain the river cross section during low tide is furthermore enhanced by the depoldering and controlled tidal action, and the restoration of the gravitational drainage of the polders, but is also supported by the construction of a pumping station at the cut off in Lokeren.

European funding was found to reactivate the upstream Potpolder IV, which has become defunct because of the siltation. The project is a pilot in the USAR project (Using Sediment as A Resource, Interreg 2 Seas). The finer nature and higher degree of pollution provides a greater challenge in the upstream part to reuse the Durme sediment as a building material. A special installation will be designed and used to separate the fine polluted sediment from the coarser material used for construction of the dikes. Also in this area two pumping stations have been designed to allow the drainage of the catchment of the watercourse crossing the controlled flood area.

In the meantime dredging works have been realized in the downstream section of the river, sediment stockpiles have been created to construct the dikes of the Sigma flood control areas situated in the downstream part. The pumping station in Lokeren has been constructed. The works on the upstream part are expected to start in 2018.

Other Sigma areas along the Scheldt have been completed, monitoring proves the beneficial effect on nature restoration. Recent storm surges allowed to test the activation of the controlled flood areas, effectively proving their role in flood protection. The Durme River Valley Restoration Plan is unique in providing and effectively realizing a restoration scheme of an entire river branch of 17 km, both revitalizing nature and flood protection function.

The presentation will focus on the different elements of the project, the steps in realization, the comparison between the situation before and after construction.

184. Expert-system for automatically managing high water levels with smart infrastructures

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Expert-system for automatically managing high water levels with smart infrastructures

Voies Navigables de France began to look into the possibility of using its summit level transport network to reduce the sector's exposure to flood risks. By increasing the resilience of the hydraulic infrastructures and the forecasting and emergency systems, the network can be used to store and draw off part of the flood waters from the surrounding watercourses with a noticeable reduction of the effects of the high water levels on the network as well as on goods and people.

The so-called expert-system is made up of three complementary and indivisible segments:

- The real-time acquisition of meteorological data and water height and flow data. This data is then processed by a 1D real-time propagation model to extrapolate the results for the entire network and allow a preventive action based on the forecasts. This model will be a data assimilation model: it will evolve with each iteration according to the measurements made.

- The deployment of infrastructures to reduce the effects of the high water levels: by trapping as much water as possible upstream of the drainage basins using dams, by diverting as much water as possible from the flooded rivers to inert sectors and by preventing the watercourses from making the canals burst their banks, which could lead to a weakening of the embankments and a domino effect.

- The speed at which the infrastructures can react to events with a secure remote management system that translates the hydraulic data of the data assimilation model into operational instructions which can then be remotely and automatically applied.

In this way, the entire system works together to take instant and highly optimised actions within the sector, providing hence safety and insuring best hydraulic management.

185. Experimental investigation on submerged reef

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Coastal areas are subjected to geomorphological changes due to natural and manmade activities. Artificial reef is considered an effective way in preventing coastal erosion due to its multipurpose benefits. Artificial reefs are human made underwater structure built to promote marine life, coastal protection and recreational activities. Submerged wrecks are the most common form of artificial reef. Submerged reefs dissipate the incoming wave energy by forcing waves to break on top of the reef. Wave attenuation also occurs due to turbulence and nonlinear interaction between the reef and the incoming waves. Waves in the leeward side will be shorter and smaller and help in accumulation of sediments. These types of offshore reefs are custom-designed to trap sediment for each unique zone for different application.

In this paper the experimental investigation of a submerged reef under regular and random waves for different water levels carried out is presented. The reef is designed for conditions of south east coast of India. The reef makes an angle of 13° with respect to the shore line and envisaged to trap the sediments from the long shore sediment transport. The submerged reef has a triangular wedge shaped structure with armour stones and concrete cubes, the first of its kind in India. The model studies are carried out in 1:10 model scale in shallow wave basin (19.36 m×15 m×1 m) at IIT Madras, India. The shallow wave basin has 5 piston type paddles on one side which can generate both regular and random waves and a wave absorber on another side.The main part of the submerged reef is triangular shaped steel wedge weighing 900 t (in prototype scale) with dimensions 60 m×50 m×2.5 m with slope on either side resting on stone bed. Since the wedge is having sloping sides the waves will tend to break on either sides during the North East and South west monsoon. The studies are carried out for head sea condition with for regular and random waves with wave height 5 cm to 15 cm with wave period 6 s to 9 s. Armour stones are provided around the wedge to prevent the scour, followed by concrete cubes with holes

The wave transformation over the reef is measured using wave gauges. The waves undergo transformations and breaks on the reef compared to other waves which breaks on the beach. Since the waves break over the reef the wave energy is reduced and thus it does not cause any erosion in leeward side. In the model study the stability of the structure for 3 hour storm duration is carried out. Based on the experimental study the details of wave height transformation over the submerged reef and stability of reef are presented.

186. COFASTRANS (Container Vessel Fast Transhipment System)

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The paper will show to the audience a new port layout that will enable faster loading and unloading of containers at the quayside, particularly for the new largest container vessels. The concept is novel and yet practical, using indented berths with innovative ship-to-shore cranes. The Mega vessels are the most valuable assets in the system, so these are focused at the heart of the terminal rather than at the periphery, as is the case with conventional layouts. The efficiency of COFASTRANS is built from adaptation of the latest container handling techniques combined with large crane technology from the shipbuilding industry as well as vessel navigation in confined waters, such as seen at the Panama Canal.

This container handling solution addresses the challenge laid down a couple of years ago by Maersk Line's CEO Soren Skou on their unexpected introduction of the much larger vessels. He called for a "step-change" increase to 250 container moves per hour at each berth (up from about 150 at present). With only evolutional development over the 50+ years since the early containerisation of shipping cargoes, various ideas have been proposed but none have been close to achieving this aspiration. However COFASTRANS can exceed 300 berth moves per hour and, by using a more efficient layout, it can occupy a smaller amount of precious port land.

The author has made conference presentations on much earlier work for this concept at TOC '99 in Genoa in 1999 and TOC Asia in Hong King in 2001. Since then the vessels have become substantially larger and, crucially, this concept has now been transformed with the introduction of the new patented crane design that will substantially increase efficiency and performance. Development work has been carried out with support from the EU's Horizon 2020 SME1 programme and in association with Konecranes.

There have been no positively disruptive developments to ship-to-shore container handling since the start of containerisation in the 1960's, despite constant urging from the large international shipping lines who, in 2006, introduced new vessels of the "Emma Maersk" class that doubled the largest size to a carrying capacity of 15,500 TEU (20ft container). Then, from 2015, even larger vessels have been added to the fleet with the largest 2017 delivery "OOCL Hong Kong" 38% bigger with a capacity of 21,413 TEU. To meet their profit targets the shipping lines need reduced time in port, but this is not possible with conventional shoreside cranes that inevitably take longer to reach the extremities of these ever-wider vessels.

The next step cannot be made with normal port layouts and conventional equipment. COFASTRANS solves this problem by making the ship the central working area with direct access to the shore on both sides of the ship. The innovative new portal crane makes this possible with double the number of lifting spreaders over the ship, each with 30% less travel distance. With container transfer over both sides of the ship, there is effective use of twice the length of quayside and correspondingly less congestion on shore. This will typically result in 30-40% reduction in ship time in port and a 4-fold improvement in land utilisation, often in environmentally sensitive areas. The benefits are huge, albeit complex to quantify because every port has different geography, historic facilities and customer needs.

With more and more Mega container vessels coming into operation the time is now right for an in-depth discussion on the fundamentals of port layouts for these vessels, as shippers consider placing more orders and port operators seek to gain an advantage over their neighbouring competitors. Panama is the ideal place for these discussions. It is a global transportation hub with access to two oceans and has itself a real opportunity for even more expansion in container transhipment. Also, the Panama Canal has unrivalled experience in the navigation of large vessels into indented berth structures.

In launching the larger vessels the shipping lines have set the challenge. COFASTRANS picks this up and is targeted at the largest international container ports where one or more new berths can augment the existing operation and transform the performance and turnaround time for the largest vessels. New greenfield locations also provider a significant opportunity.

The proposed presentation will consider the market needs, review unsuccessful attempts that have previously been made to change ship-to-shore container handling and consider the challenges in making changes to the well-developed container handling industry. Explanations and technical details will be provided to show the arrangement of the berths with innovative new portal cranes and how they will align with the ship to transfer containers to and from the shore. With ports across the world having very different natural layouts, requirements and constraints, there are several ways in which COFASTRANS can be implemented. This has been distilled into three generic arrangements taking into account navigational requirements for the approach and berthing of vessels in combination with the cargo handling as well as terminal storage and traffic constraints. These various types of installation will be shown; all have the potential to substantially improve efficiency of global container transportation in terms of time, cost and environmental impact on the world’s main trading routes.

187. The Stratton Lock Expansion Project (Fox River, Illinois, USA)

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Bergmann Associates, United States

The William G. Stratton Lock, formerly known as McHenry Lock, provides lockages for recreational boating traffic on the Fox River and has been in service since 1960. The Lock serves as the passageway between the Fox Chain of Lakes in northern Illinois, and the Fox River. An average of 15,000 boats pass through the aging locks annually. The lock originally measured approximately 18x60 feet and, due to its relatively small size, users often experienced high wait times.

An engineering study was conducted in 2012 to evaluate options to increase the capacity of the lock, including an alternative to expand the length of the lock or to construct a separate lock adjacent to the existing lock. A detailed comparison of each alternative was made, considering primary factors such as cost, construction schedule, flexibility and ease of operation, ingress and egress times for boaters, and ability to facilitate potential future renovations and maintenance needs. Expansion of the existing lock chamber in the downstream direction was selected, roughly doubling the length of the lock to 18x120 feet.

Design for the lock expansion included rehabilitation of the existing lock chamber, modifications to the existing lower gate monolith, installation of a new gate monolith, reconfiguration of filling/emptying systems, extension of lock walls, safety improvements, and new lock mechanical and electrical systems. The existing horizontally framed steel miter gates were to be repaired and the lower lock gate relocated to the new lower gate monolith. The design was completed in 2013 and the lock expansion project was constructed in the winter of 2014 at a cost of nearly $4 million dollars. The rehabilitated lock has been in service now for several years and, given its increased capacity, has greatly reduced wait times and enhanced the boating experience for recreational boating users on the Fox River.

The presentation will outline the alternatives considered during the study phase, discuss features of the lock expansion design, and discuss challenges encountered during construction. Photos and video of the pre and post construction conditions will be included.

A link showing the lock construction from above:

https://www.youtube.com/watch?v=bjAQWDL2TMs

188. Landslide Control Program at the Panama Canal

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Since the beginning of its construction, the safety and reliability of the Canal excavations and dam structures have been a challenge due to the adverse geological and climate conditions of the region. The Canal has a heterogeneous and complex geological set up, added to a highly variable rainfall regime comprising average daily precipitation of 14 cm. The Panama Canal Authority has a carefully developed, periodically updated program that enables the detection of landslide activity in its early stages, to mitigate the consequences and maintain the Canal operation. This program has been named as the Landslide Control Program and was implemented since 1968. The execution of improvement projects to the navigation channel, including containment dams, widening, straightening, deepening and the recent expansion, represented new challenges in the surveillance process and the use of techniques for detection of landslides and data acquisition. To overcome the new challenges, the Panama Canal Authority has undertaken an improvement process using state-of-the-art monitoring tools such as robotic technology and real-time monitoring system. This paper presents in detail the importance and objectives of the Landslide Control Program, the Landslide Protocol Response and different types of instruments installed along the waterway, including the new instrumentation and data analyses.Since the beginning of its construction, the safety and reliability of the Canal excavations and dam structures have been a challenge due to the adverse geological and climate conditions of the region. The Canal has a heterogeneous and complex geological set up, added to a highly variable rainfall regime comprising average daily precipitation of 14 cm. The Panama Canal Authority has a carefully developed, periodically updated program that enables the detection of landslide activity in its early stages, to mitigate the consequences and maintain the Canal operation. This program has been named as the Landslide Control Program and was implemented since 1968. The execution of improvement projects to the navigation channel, including containment dams, widening, straightening, deepening and the recent expansion, represented new challenges in the surveillance process and the use of techniques for detection of landslides and data acquisition. To overcome the new challenges, the Panama Canal Authority has undertaken an improvement process using state-of-the-art monitoring tools such as robotic technology and real-time monitoring system. This paper presents in detail the importance and objectives of the Landslide Control Program, the Landslide Protocol Response and different types of instruments installed along the waterway, including the new instrumentation and data analyses.

189. Design and Construction of the Pacific Access Channel to the Third Set of Locks at the Panama Canal

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Panama Canal Authority, Panama

The Panama Canal Authority (ACP) officially began the works related to the Panama Canal Expansion in September 2007, with the excavation work for the creation of the Pacific Access Channel that would link the Third Set of Locks on the Pacific side to the Gaillard Cut, also known as the Culebra Cut. The work required the excavation of 50 million cubic meters of material, along a 6.1 kilometers, in five (5) phases and the construction of 4 dams, the longest one being a 2.3 kilometer (Dam 1E) needed to separate the water waters of Miraflores Lake from those of the new Pacific Access channel.

All the designs and the work done for the Pacific Access Channel, was founded on the geologic investigations completed by ACP. Between the years 1938 and 2001 different geologic investigations were undertaken in the area, in relation to the original Third Set of Locks Project and different other smaller projects in the vicinity. All these investigations were used as the base of the specific investigation campaign for the Pacific Access Channel that started in the year 2001 and ended in the year 2008. This investigation campaign included drill holes, test pits, geophysical investigations, in situ tests and laboratory testing, geologic mapping, elaboration of geologic section, and reports.

190. Opportunities of Building with Nature for the marine infrastructure sector

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Using the natural environment as starting point

As our climate changes, it is clear that current infrastructure solutions cannot simply be udpated to deal with the challenges ahead of us. Confronted by rising sea levels, changes in precipitation and drought patterns, changing river flows, more intense storms and a growing and proactive world population, coastal and delta areas face increased pressure to align their activities in a limited space. Project owners and initaors managers are beginning to understand that infrastructure solutions need to be integrated and resilient utilizing the values of the ecosystems rather than using more traditional infrastructure approaches.

In 2007, dredging companies, civil engineering firms, universities and NGOs united in the Ecoshape consortium and started exploring projects that reinforce existing coastal infrastructures through creation of mangroves, saltmarsh foreshores, oyster reefs and sandy beaches and dunes (Ecoshape, 2017). Commonly referred to as Building with Nature, the dynamic approach makes use of the services provided by the local ecosystem to meet the adaptation to a range of (climate) scenario's. Furthermore, the solutions have the potential to contribute to climate change mitigation by trapping carbon in marine sediments and serving as a CO2 sink (Duarte et al., 2013). The approach is similar to the PIANC Working with Nature and USACE Engineering with Nature philosophies.

Within the Building with Nature programme, various large scale pilots have been executed. The lessons learned offers major opportunities to the ports and navigation sector whereby the knowledge and experience gained from concepts tested in pilot projects can be upgraded towards project scale. This contributes to reducing business risks and operational costs, while offering substantial opportunities for operating responsibly in sensitive environments. Further, inclusive approaches that sustain ecosystems and their values could help create shared value, enabling multiple land uses to co-exist in the wider landscape. Based on concrete examples, and considered against future climate change scenarios, this session explores how the approach can help the sector to meet its development and sustainability goals and what technical, organizational and collaboration challenges are ahead of us.

Mangroves as Natural Coastal Protection

As the volume of sand is rapidly declining on a global scale, alternative solutions need to be considerd that better match the natural coastline. Many countries along the equator have or had mangroves as natural protection. In addition to attenuating the waves, controlling water levels and providing a natural habitat, they inherently protect the livelyhood of the hinterland communities both with regards to flood safety as food and wood.

Within the Building with Nature programme, a large scale pilot project is being executed along an eroding coastline in Indonesia. Numerous lessons learned have been gained along the way which are essential in understanding how to design and implement such a solution on a global scale, with regards to the natural system and the governance / social side. The experience can

also be used for marine and coastal infrastructure projects along the Panamanian Coastline and other countries in Central America.

Sand as Natural Coastal Protection

Along the Dutch coast, where sand is still at hand, a large scale coastal nourishment project (Hondsbossche Pettemer Zeewering & Port of Rotterdam Maasvlakte 2 expansion) was executed using sand as a basis rather than the existing rock revetments. For the coast protection, the design was made such that natural dunes and a lagoon were incorporated into the overall solution, providing for both nature and public space (recreation). Furthermore, a long term maintenance period was included in the design, ensuring an adaptive design that incldued potential future changes.

License to Operate

Requirements by IFC, OECD and local legislators to take measures to avoid, minimize and off-set the impacts of their interventions become increasingly strict and influence the feasibility of infrastructure projects. Consequently, the costs and duration of permitting procedures for traditional infrastructures are increasing rapidly. Meanwhile residual social and environmental impacts remain high, particularly in vulnerable coastal environments that harbor critical habitats such as mudflats, coral reefs or mangroves.

A core aspect of Building with Nature is that it embeds hydraulic infrastructure in the landscape in a way that results in minimal disturbance of the natural environment. Additionally, the integration of ecosystem-based measures in infrastructural designs does not only enhance the resilience of engineering works, but also increases their sustainability. In some cases this results in a net-positive impact: the net social and environmental benefits of a development are higher, when measured against a business as usual scenario. This offers substantial benefits for the ports and navigation sector. Beyond facilitating compliance, it contributes to ambitions of the sector to responsibly operate in sensitive environments, in line with CSR principles.

The paper and presentation will provide a short description of the Building with Nature philosophy as well as lessons learned from various pilots and projects around the world for different coastline types and marine and coastal infrastructure.

191. Advances in Methods to Repair Fatigue Cracks in Hydraulic Steel Structures using Fiber-Reinforced Polymers (Carbon and Basalt Fibers)

037

Guillermo Riveros

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Steel structures, such as hydraulic structures and ships operate in harsh wet and corrosive environments and can suffer significant deterioration. The deterioration typically manifests itself in the form of corrosion, fatigue cracking, or a combination of both. While corrosion or cracks are typically viewed as a nuisance, if left unrepair, they can threaten the integrity of the structure.

Repairing these fatigue issues using the conventional repair methods have proven to be ineffective because the traditional repair techniques were developed to work with pure tension cracks (Mode I) and not cracks that grow as a consequence of tension and shear stresses (Mix Mode). Recent studies on the use of Carbon and Glass Fibers Reinforced Polymers (CFRP and GFRP) to retrofit structures under mix mode loading have demonstrated to be a viable solution for increasing fatigue life of structures made of metals such as miter gates, lift gates, and reverse tainter valves.

With the above mentioned motivations, the studies to evaluate the viability of using CFRP to repair underwater metal structures were used to repair fatigue cracking in Old Hickory Lock and Dam miter gate at the Cumberland River and a reverse tainter valve at Pickwick Lock and Dam in the Tennessee River. The presentation will focus on the best practice to be implemented to make these repairs successful for navigation steel structures. Other composites, such as basalt, are under investigation and will also be briefly described in this talk.

192. Logistics & Infrastructure: Program Management in the Panama Canal Expansion

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In 2006, the citizens of Panama voted to approve a national referendum for the Panama Canal Expansion Program (PCEP). The goal of the program was to grow the global shipping industry infrastructure and expand the economic opportunities of Panama. This would be accomplished through an additional expanded size lane of traffic—via a new third set of locks — to double the Canal's tonnage capacity and allow the transit of much longer, wider ships through the existing canal waterway. When the expansion locks were inaugurated in June 2016 they increased ship throughput to 18,000 vessels with an increase in capacity to approximately 15,000 TEUs, a standard unit for describing a ship's cargo carrying capacity or a shipping terminal's cargo handling capacity.

During the development of the PCEP concept, it became evident that the Autoridad del Canal de Panama (ACP) could benefit from the services of a Program Management firm due to the program's risks in logistical and technical complexity; the interrelated multiple contracts; and the multi-billion dollar budget which encompassed resource needs beyond the ACP's existing engineering and procurement support managing the operations & maintenance and routine capital improvement projects. Therefore, a decision was made to partner with an experienced Program Management firm to advise and assist throughout the execution of the expansion program .

Program Management Definition

Program Management is the delivery of multiple, interrelated projects in a coordinated process for the benefit of the owning entity. The need is often associated with a spending growth for capital infrastructure programs reflecting increased risks and complexity arising from the interfaces between multiple projects as well as the effects of varying project schedules.

Program durations are longer than individual projects because programs encompass multiple projects and uncertainty is likely to be higher because of the likelihood of encountering environmental, financial, political, technical solutions and other changes.

The PCEP is defined as a Program as distinguished from a Project by the following characteristics: The scope of the program encompasses the design and construction aspects of a megaproject including contract document development and procurement, design-build construction, construction management, environmental mitigation and remediation, rainforest preservation and reforestation, wildlife and animal rescue, social impacts to residences, and site clearing for potential unexploded ordinance from previous military operations. The needs to fulfill the program role from ACP were for partnership, advice, mentorship and training within an integrated team arrangement.

ACP's Consideration of Program Management Models

The ACP evaluated the following models with a goal of selecting a working construct that aligned with its short- and long-term goals as well as its organizational and political objectives:

Owner Management Model: Owner provides project definition, hires the engineers and contractors and manages all contracts.

At Risk Model: Owner has less direct project input and control because it has assigned more risk to the Consultant and must also assign commensurate control over the Program to the Consultant.

Consultant Management Model: Consultant Manager may supplement the Owner's staff in an advisory role. The Owner hires the Program Manager, the designers and the contractors.

Owner's Agent Model: Owner hires the program manager and contractors, and may also in some cases hire the engineers, but the program manager is responsible for providing direct management of engineering services.

Integrated Program Management Model: Program Manager may be either the Owner or the Consultant, with staff from both organizations integrated at multiple levels. The Consultant staff may augment positions within the Owner's organization where expertise or experience is lacking.

ACP Selection: Integrated Program Management

The ACP selected the Integrated Program Management model. CH2M HILL would eventually phase out its staff, leaving in place an owner team trained in advanced Program Management and delivery and capable of operating and managing a world-class operation.

Program Management Services Contract Awarded to CH2M in August 2007

At its peak, CH2M reached a maximum staffing level of 40 supporting the ACP in an integrated program management team of greater than 200. With the successful implementation of the knowledge transfer strategy, that number today stands at six full-time CH2M staff. The ACP team currently has approximately 60 members assigned to the program for the remaining contract close-out period.

One Team One Mission

To meet the ACP's expectations, the CH2M team worked towards the goal of institutional and professional mentorship of ACP's staff throughout the execution. This approach was cross-cutting from the program management development of tools and processes to establish the governance of the PECP to a mirror manager approach of CH2M with ACP counterparts offering guidance, advice, and support for ACP's decisions.

PCEP's Stakeholders

Four primary stakeholders are driving the PCEP:

People of Panama: Ultimately, the people of Panama are the primary stakeholders. They are the ones who gave approval to proceed and now benefit from the success.

Autoridad del Canal de Panama (ACP): The agency of the government of Panama responsible for the operation and management of the Panama Canal.

Board of Directors: The eleven-member group responsible for establishing the Canal's policies for operation and management pursuant to the National Constitution, the Panama Canal Authority Organic Law and ACP Regulations.

Global Maritime Industry: The Canal's ultimate customers who will benefit from increased loadings, larger vessels, reduced canal transit times and lower transportation costs.

Risk Management

A key element of any Program Management model is risk allocation. Risk transfer works best when you get as close as possible to a "win-win" scenario. A risk profile with an imbalance inevitably leads to the detriment of one or more parties.

In the case of the PCEP, the integrated ACP-CH2M team identified the risks during the tendering process and the risk allocation was improved, in favor of the tenderers, as a result of open dialog. This risk approach was maintained throughout the execution.

193. Fender Systems for canal navigation: from design to operation.

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Eduardo Rodero, Dominique Polte, Anna-Lena Georg, Jan Mursch

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1-Introduction

Fender systems are a key aspect in canal navigation, as they are the safety barrier for the security of navigation, operations, structures, vessels and people. Due to the many peculiarities of inland navigation, e.g. vessel beams adjusted to the very narrow canal/lock lanes, constant lateral frictions, shear loads, locks entrances, constant traffic and many other particularities, the performance of fender solutions depends on the designers understanding of how fender systems work and how solutions can be customized to canal characteristics.

Nowadays, it is impossible to successfully operate a canal without the correctly designed fender system. A wrong fender solution can cause many problems, increase the risk of accidents, delays or even interruptions in navigation. In some cases, like the Panama Canal, traffic interruptions can have a global impact in navigation and major economic losses.

Despite the importance of customized fender solutions for canals, the available international fender standards and norms typically lack in the requirements in canal navigation. The intent of the presentation is to summarize the guidelines about Fender Systems focusing on inland/canal navigation, explain the design challenges, and show a suitable approach to all these challenges.

2- Main challenges for inland navigation projects.

Currently, designers face many challenges when selecting Fender Systems for canal navigation:

- Canal expansions and vessel sizes increase. The continuing increase in vessel dimensions (size and displacement) together with the expansion of canal capacities – e.g. the Panama Canal expansion – allowing larger vessels to navigate through these infrastructures, makes traditional solutions unsuitable. Designers need to consider the expected vessels that will use the fenders during the complete life cycle, and we can assume that those vessels will be larger than today.
- Shear forces. Fender material must be able to support shear forces, since inland navigation through canals, results in constant traffic, flowing parallel to the fender surface. Shear forces are based on the reaction force of the fender system times the friction coefficient of the low friction material. Therefore, the designer needs to have a good understanding of fender materials and properties, to find a solution with low friction coefficient.
- Wear/abrasion. The continuous flow of traffic thru canals, results in constant wear and abrasion on the fender surfaces, which are more intense compared to fender wear/abrasion on typical pier berths. The use of special materials with low friction coefficient and abrasion index, such as UHMW-PE is essential to reduce wear and friction loads as well as fender deterioration. Also, it is essential to understand testing procedures to measure and control material resistance to abrasion and other properties which have an impact on material durability.

- Life cycle/traffic interruptions. Interruption of navigation along a canal caused by fender failure, maintenance or replacements has an important economic impact and can have consequences on global navigation in some cases. For that reason, fender solutions for canal application should have extended life cycle horizons, compared to standard fender systems.

3- Guidelines for a design approach

- The importance of designs. Fender System performance and a long life cycle will be the direct result of good fender design. An incorrect design will result in fender failure over a short term. Fender design requires a good knowledge and understanding of fender types, materials, standards/norms and solutions available in the industry. It is always recommended to look for advice of a reliable fender manufacturer to select and verify fender solutions.
- Fender Type selection. The analysis of which fender type is more suitable for canal applications depends on many different factors, and as in any other fender project, each case needs a customized solution. There are certain types of fenders which have suitable features for inland navigation:
    - Arch/Square Fenders – Elastomeric rubber fenders with UHMW-PE pads. For this type of fenders, it is important to define how the UHMW-PE pads are fixed to the fender. Fixing the pads with bolts to the embedded steel plate inside the fender proves to be the much more robust solution than vulcanization, also in terms of maintenance cost
    - Wheel/Roller Fenders – specially designed for lock entrances, and corners.
    - Fender guidewall solutions for lock entrances – to provide guidance to vessels and support the correct approach into the usually narrow entrances. Guidewall solutions include the design of complete fender systems and the auxiliary structures to fix the guidewall, like pilings, etc.
- Fender material selection. Inland navigation applications need materials with special low friction coefficients and low abrasion index to reduce wear, especially these two materials should be carefully checked:
    - Rubber, used as energy absorbing device, the properties recommended in PIANC Guidelines Appendix A – 7.3 are those that help to assure acceptable resistance to the effect of aging and environmental impact.
    - UHMW-PE. Used as the contact surface between vessel and fenders, the use of polyethylene with ultra-high molecular weight not lower than 5 million g/mol and sand slurry test of approx. 15 based on ASTM 4020 (steel 0=100) is highly recommended.
- Test control. Marine fenders are an energy-absorbing device. Therefore, technical specifications for canal fender systems need to specify the procedure to determine and report performance of fenders. PIANC 2002 Guidelines, Appendix A provide a good procedure for testing fender performance under compression forces. However, for the special cases of canal fender systems which are subject to constant shear forces, it will be necessary to implement also a procedure to determine shear forces in combination with compression forces allowing only fenders tested and approved under compression-shear combination to be used for these applications.

4-Installation, operation and maintenance

Fenders are safety-critical systems which protect people, the environment, ships and structures from harm. To do this, fenders must be installed, used and maintained correctly. For the case of inland navigation canals, special attention should be put on the duration of installation and maintenance, since any of these activities will interfere daily operations and

block traffic. Our presentation will provide guidelines and recommendations should be provided to assure that fender solutions are designed to minimize those interruptions.

194. The contribution of the Panama Canal Green Route to reducing emissions from international shipping

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Alexis Rodriguez

Panama Canal, Panama

Since its opening in 1914 the Panama Canal has reduced time and distances. More than a million vessels have used the route through Panama, cutting distances, reducing costs and changing the pattern of world trade. The expansion of the Canal has enlarged the capacity for cargo transportation by this route, thereby setting new standards for maritime trade and industry.

The Green Route

The Panama Canal Green Route stepped up its strategy (https://www.pancanal.com/eng/cuenca/LaRutaVerde-English.pdf), placing emphasis on the following as factors which determine why the Panama Canal is the Green Route of maritime trade:

.1 Lower distances, fuel consumption and sailing times than other maritime routes.

.2 As the Panama Canal route is entirely on water, the carbon footprint of the goods passing through it is reduced, thus contributing to the global efforts to tackle climate change.

.3 Promotion of the Canal basin and implementation of new conservation programmes based on sustainable development.

Emissions reduction

The Panama Canal has developed a software tool which automatically calculates the CO2 emissions associated with maritime transport, incorporating different routes and cargo transport modes. Among the criteria used in developing this tool, two stand out: it should be easy to use and the calculation method should be consistent. The inputs used in calculating CO2 emissions are: type of ship, amount of cargo, mode of transport, origin and destination of cargo.

Green Connection Award

The Panama Canal has introduced a program to reward environmentally-friendly performance by clients and ships which achieve the environmental limits set by the International Maritime Organization and/or show outstanding compliance with globally recognized parameters. Five environmental parameters have been selected, as listed below:

.1 Energy Efficiency Design Index (EEDI);

.2 Environmental Ship Index (ESI);

.3 nitrogen oxide (NOX) emissions deriving from Tier-2 engine performance;

.4 ships with liquid natural gas (LNG) propulsion;

.5 tonnes of CO2 reductions achieved by using the Panama route as compared with alternatives.

Good Practices to be applied by organizations

The Panama Canal is focus in for objectives that involves the major climate change topics mitigation, adaptation, conservation and emissions reduction not only for the international shipping, also by its operations. The Panama Canal has identified lines of action and positive actions that focus on environmental management and reduction of emissions, these actions are:

To reduce and mitigate the greenhouse gas (GHG) emissions through the development of more efficient projects of generation and the execution of energy efficiency measures to reduce the emissions per unit of production.

To optimize the environmental management of the operations of the Panama Canal through the follow–up, evaluation and identification of better practices to avoid and reduce the environmental impacts.

To comply with the socio-environmental agreement for a sustainable management in the Canal Watershed through the integral management of the natural resources that allows to preserve and protect the water resources.

To contribute to world initiatives to reduce the gas emissions with greenhouse effect from the maritime industry through the acknowledgment and incentive of good practices executed by their clients.

Conclusion

The Panama Canal Green Route with the expanded Canal is assisting the efforts by nations and the maritime industry and the work done by the United Nations Framework Convention on Climate Change and the International Maritime Organization aimed at reducing greenhouse gases. It also constitutes a model of early action taken to reduce GHG emissions from the maritime industry.

The efforts of the Republic of Panama, through the actions undertaken by the Panama Canal, not only bring benefits and prosperity for the country but also have a direct effect on worldwide efforts to combat climate change.

195. Marine Accident Investigations at the Panama Canal...a success story of over 100 years

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Miguel Rodriguez

Panama Canal Authority, Panama

The Panama Canal Authority has enjoyed for more than 100 years a unique system for the investigation of marine accidents that occur within its waters, which allows for friendly settlements with its customers, avoiding long and costly litigations at the Maritime Tribunals.

Since 1909, even before the Canal opened its doors to world shipping, the Board of Local Inspectors was established and was charged with conducting formal investigations of marine accidents involving vessels navigating in Panama Canal waters under the control of Panama Canal pilots. Pilots in the Panama Canal take over control of the movement and navigation of transiting vessels, which is also unique, which could be the subject for another discussion.

Until 1999, the Board was known as the Board of Local Inspectors, since it was part of the Canal Zone system and under the jurisdiction of the Louisiana Maritime Courts. After the transition to Panama of the Canal, the name changed to Board of Inspectors, no longer “Local”.

The Organic Law of the Republic of Panama, which created the Panama Canal Authority under Panamanian jurisdiction, also established the process under which vessels would be able to present claims for damages while under the control of Panama Canal pilotage. The Law also established that in order for the Panama Canal to be able to accept any claim and process its payment, a formal investigation conducted by the Board of Inspectors, which requires a formal hearing, would have to take place prior to the vessel´s departure from Panama Canal waters.

The Board conducts a formal investigation process, with all witnesses rendering testimony during the hearing under oath, who are subject to the Penal Code of Panama. The hearings are conducted within 24 hours of the accident having taken place, so all witnesses have a good recollection of the facts.

The Board publishes its reports about a month after the hearing, which contains the findings and opinion of the Board, establishing the cause of the accident and who is or are responsible. The report also contains a complete verbatim transcript of the formal hearing. Once the report is published, the Panama Canal and the lawyers representing the vessel meet to arrive at a friendly settlement, which has been historically the case in over 95 per cent of the cases.

196. Design values for berthing velocity of large seagoing vessels

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While ships evolve constantly, berthing velocity curves developed during the 1970s are still embedded in the design of marine structures and associated safety factors have not been verified and validated by measurement campaigns. In this study, field observations of modern seagoing vessels during berthing manoeuvres in Bremerhaven, Rotterdam and Wilhelmshaven were used to evaluate safety factors for berthing energy and berthing impact loads. Berthing velocities of several types and categories of vessels at various berths and under different operational conditions were examined, resulting in an increased understanding of the factors influencing berthing energy. Navigation conditions were accounted for by differentiating factors such as vessel characteristics, environmental conditions and the berthing policy. The results show that characteristic values of berthing velocity with a return period of 50 years are in line with design recommendations in the relevant literature. Design values of berthing velocity are quite sensitive to the number of berthing operations during the service life of a marine structure. The measured berthing velocities largely depend on the general berthing policy and local experience of pilots and navigational aids. Due to newly acquired insights, some historically embedded hypotheses will need to be reconsidered. For instance, the assumption that berthing velocities are correlated to the size of large seagoing vessels could not be confirmed. The key findings of this study are useful for the design of new and assessment of existing marine structures. It is highly recommended to update the PIANC 2002 guideline titled ‘Berthing velocities and fender design’ in the upcoming years.

197. Hydraulics of the Panama Canal New Locks: from conceptual design to Cosco Shipping Panama transit

041

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On June 25, 1906 the Congress of the United States adopted the construction of a Lock canal, having a fresh water lake with a summit at 25.9 meters, as recommended by the minority report of the Board of Consulting Engineers convened by the US president one year before, the majority of the Board recommended a sea-level canal. The Panama Canal is the only infrastructure in the world that raises 27m oceangoing ships from one ocean, allows them to navigate in a freshwater lake and then lower the vessel at the other end again to sea level, using an average of 220,000m3 of freshwater for each of the about 14,000 ships that use the canal every year.

At the time of preliminary plans, excavation works within land had a leading concern than the dredging works at the sea entrances and lock structures. However, given the construction technology and machinery available most of the locks construction were performed between February, 1910 and June, 1913.

In a paper released on October 1, 1915 written by Richard H. Whitehead is very well described the process of designing the “Hydraulics of the locks of the Panama Canal”; furthermore, there are many details of after built tests that the author compares with the design data, he also sheared the alternatives considered during the design process. The performance of the US built locks in Panama is a success case study that is beyond the purpose of this paper, about 1,050,000 seagoing vessels have transited the Panama Canal in the last 103 years.

In this paper we are going to focus on the process for formulating the conceptual hydraulic designs for the new locks of the Panama Canal that started operations in June 26, 2016. These conceptual design works were performed by Consorcio Post Panamax (CPP) in cooperation with personnel from the Autoridad del Canal de Panamá (ACP) between 2002 and 2008. CPP had the experience of designing and constructing large locks in Europe whereas ACP had the experience of operating and maintaining for almost a century the US built locks.

Amongst the main criteria that ACP asked to consider were the Gatun Lake water quality, number (lifts) and size of lock chambers, type and size of lock gates, water saving, Filling and Emptying system, electromechanical systems, vessel positioning systems, earthquake loads, constructability, operations, costs and chronological estimates, etc. CPP organized visits to some large locks in Europe for gathering performance and lessons learned from these locks that had several similarities with the locks that ACP was forecasting to design as per the market studies and build given the country financial opportunities.

The conceptual hydraulic designs for the new locks Filling and Emptying (F/E) System of the US built locks designed by Whitehead was very innovative last century and also considered features from other locks built in the US and Europe, the system worked very well and it was a challenge to come up with a better one. Within the companies of CPP, Compagnie National du Rhone (CNR) was in charge of the hydraulic design. All of the parameters mentioned above, with the most important: water conveyance from Gatun Lake and/or from Water Saving Basins

(WSBs) as well as wind, Lake seasonal elevations and hourly tides, F/E times, vessels throughput and operating possibilities were taken into account.

A very important apprehension that ACP had was to break the paradigm of using locomotives atop the lock walls for vessel positioning aids; hence, it was a challenge to come up with an F/E system that would have the symmetry, evenness and swiftness to achieve a safe raising or lowering of a ship in a lock chamber.

CNR started to study the hydraulics of the US built locks and several other locks worldwide in order to gather important aspects for the final design and issued relevant design criteria for the Panama Canal New Locks since they would be the first on-sea going vessels locks equipped with WSBs in the world. A first issue raised by ACP was the possibility of having an F/E system with water entries and exits from the sides of the lock chamber, for the system with lateral culvers and F/E from the bottom of the chamber represented a maintenance concern for ACP, another issue was the fact that placing the WSBs to one side of the lock chambers (for saving space at the other side for the 4th lane of locks) created an inherent asymmetry to the system.

During a conceptual design phase, several configurations were investigated including 1 lock equipped with 6 WSBs, 2 locks equipped with 2 & 3 WSBs and 3 locks equipped with 2 & 3 WSBs.

A preliminary design of the – 3 steps locks & 3 WSBs – retained solution was then carried out including implementation of 2D/3D numerical models and the construction of a Physical Model at scale 1/30 for validating the F/E system hydraulic performances and giving ACP results with enough confidence to release Employer Requirements with respect to hydraulic issues.

After a Design & Build tender process, awarded to the consortium GUPC, CNR did carry on participating in the final hydraulic design. A hybrid modelling methodology was implemented since both 1D/2D/3D numerical models and a second physical model at scale 1/30 were run jointly during one year. These models incorporated the fews changes proposed by the contractor to the initial conceptual design. The hybrid model permitted to correct unexpected problems, to optimize the design of few components of the F/E system and to issue accurate data with respect to hydraulic performances of the system.

On-site tests were carried out in the beginning of 2016 in order to check that the expected performances were achieved. To a certain extent, these tests were the final end of a 16-years study that allows to successfully inaugurate the New Locks in June 26, 2016.

198. An integrated analysis for the Passing Ship problem on Santos Port considering Real-Time Simulations and Moored Ship Dynamics

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Felipe Ruggeri [1], Rafael Watai [1], Eduardo Tannuri [2], Kazuo Nishimoto [2]

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An analysis methodology for the passing ship problem in ports combining a potential flow model, a dynamic simulator for moored ships and a real-time simulator are presented. Traditionally, the passing ship problem is approached by defining a criteria based on safe distances and maximum velocities, neglecting manoeuvering aspects that are crucial to verify whether the ship can meet such requirements or not. In order to overcome this limitation, the proposed methodology extends the standard one by including results of pilot guided real-time simulations into the analysis process. The method is applied to evaluate the manoeuvering feasibility of a 366 m long container ship in the Port of Santos, Brazil, taking into account the hydrodynamic effects that might be caused on small capesize vessels moored at different berths of the port. Results are discussed in terms of moored ship motions and mooring loads for different manoeuvering cases, including also possible improvements on the mooring arrangements in order to increase the port operational limits.

199. The development of ReDRAFT® system in Brazilian Ports for safe underkeel clearance computation.

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Felipe Ruggeri [1], Rafael Watai [1], Guilherme Rosetti [1], Eduardo Tannuri [2], Kazuo Nishimoto [2]

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The increase of ship dimensions in the latest years combined to the requirements regarding the reduction of environmental impact during the maintenance dredging and economic constrains in the Brazilian ports require technological solutions in order to optimize the safe accessibility of large vessels. Most of these ports operate under a static draft rule regardless the environmental condition acting during the maneuver, which is theoretically a conservative approach. The bay close or restriction is usually performed based on experience, which may fail in the absence of objective parameters to define the adequate underkeel clerance, providing some unsafe situations mainly in the presence of misaligned wind and swell waves and/or negative meteorological tides. The development of computational resources, monitoring systems and communication technology in the last years provided the basis for integration of these tools into an automatic draft computation system, called as ReDRAFT, which integrates the environmental conditions collected in real-time to the hydrodynamic model of the port and ship dynamic model customized for each specific maneuver (ship properties, loading condition, inbound/outbond) in order to define the safe underkeel clearance for the maneuver. Moreover the draft windows may be predicted based on the forecast models, which is also a powerful tool for planning. The numerical models allow more accurate predictions of the estuary environmental conditions, mainly waves, current and tide, which combined to the vessel numerical model can provide the ship motions in 6DoF. The ship motions on these large vessels are reduced for short period waves, thus allowing the increase the vessel draft. On the other hand the vessel motions are significant for long waves, requiring the reduction of the vessel draft in order to mitigate the risk of bottom touch. The system is already operational in Santos and Rio de Janeiro ports, two of the most important ones in South America, for vessels considered as critical according to the nowadays port traffic. The PIANC Report n° 121 – 2014 factors are considered in the computation of the maximum safety draft. The ship related factors considered are the squat, dynamic heels due to turning and wind, wave response and net ukc. In order to simplify the utilization and avoid mistakes in the input data, a large database of vessels was created and summarized in a user-friendly interface, where the characteristics of each specific vessel is defined based on the IMO number, BZ code or vessel name. If a new vessel is operating in the port, the vessel is included in the software database using Lloyd's register information available in a standard "xml" format. The vessel hydrostatic/hydrodynamic characteristics are then interpolated using the software database if the dimensions are in the ranges of LOA, beam, depth and draft. The database contains the maximum wave motions of several points at the ship bottom considering a collection of wave periods, incidence direction, ship speed (encounter frequency correction), underkeel clearance, LOA, beam, depth, draft and ship type (tanker, bulk carrier or containership). The computations are performed in frequency domain using a higher order panel method based on spectral theory and a probabilistic approach. Since the ship geometry (stations) regarding each individual vessel is not available, some standard "design ships" are assumed and scaled to meet the desired LOA, beam, depth and draft, providing a NURBS (Non-uniform Rational Basis Spline) surface. The squat is computed based on literature regressions according to the Cb, ship speed (corrected to take into account the current effect) and channel geometry based on the the database of

hydrostatic properties, the pilots expertise regarding required ship speed to keep an adequate maneuverability and the channel bathymetry. The heel due to turning is computed according to the lateral wind, the metacentric height provided in the database and the wind measurements. The heel due to turning is computed using the ship speed and the turning radius computed from the channel alignment. The maneuvering margin (MM) is defined based on the pilots experience to guarantee the safety according to the environmental conditions, ship dimensions and available tugs. The system is already operational in Santos Port since 2015 and in Rio de Janeiro port since October 2016 for validation in order to provide reliability to the system.

200. CONSTRUCTING MODERN PORTS WITHOUT STEPPING ON WATER

016

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When the decision for the construction of a new port is taken, investors and operators look for a modern and economic engineering solution and a tight schedule for construction and starting of operations.

Engineering solutions for mostly ports structures involves the installation of piles supporting concrete or steel superstructures. In the case of Piers and Jetties an approach trestle is required to reach adequate water depths, and in some cases, pass along shallow or mangrove areas inaccessible or avoided for floating equipment.

For these situations, the strong integration between the structural design and the construction methodology is a key factor for the execution of the works. The cantitravel method which is a system that allows the work to progress regardless of the environmental conditions without stepping in water also means less impact on the environment.

The paper approaches 20 modern port installations worldwide designed and constructed with innovative construction solutions for achieving low costs, low risk, reduced construction time and reduced downtime due to adverse environmental conditions.

These 20 ports where successfully constructed in Brazil (8), Peru (6), Cuba (1), Dominican Republic (1), Equator (1), Algeria (1) and Republic of Djibouti (2).

The description and the conception of the projects, the environmental conditions, the restrictive conditions and the construction methods will be deeply approached in the paper.

201. Importance of the Suez and Panama Canals, the way they changed trade patterns, and their current and future roles.

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- Background

World trade has evlolved throughout the years for many different reasons; the presentation takes a look at the way in which the construction of the Suez and Panama Canals affected trade patterns, and their existing and future roles.

- Principal Drivers of World Trade:

The presentation explores the principal drivers of world trade: demographics, economy, technology, business cycles, globalization, containerization, maritime transport, and intermodalism.

- Construction and Expansion of Suez and Panama

Brief historical description of both Canal´s construction and expansion, with their navigational and capacity limitations.

- Canal Traffic

Evolution of canal traffic for Panama and Suez, number of transits, tonnage, type of vessels, origin/destination, and the impact of containerization.

- The Current and Future Roles of both Canals

The main topic of the presentation refers to the change that is taking place in the maritime industry, consolidation and concentration, vertical integration; and the way in which transportation networks (transshipment) is changing the role of Canals, and the value that connectivity adds to the role of Canals. Furthermore, the presentation concludes with the new governance structure of ports and Canals, and the way they interact in he logistics sector by adding value to supply chains, through value-add services, both to the Maritime as well as to the Logistics sectors.

- Conclusions

Competitiveness drivers for Suez and Panama Canals, taking a look at the hinterlands they serve, and how both Canals will increase their impact in trade patterns in the future.

202. Megatrends: The impact they could have in Logistics and Maritime Transport

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Megatrends:

- General description of the macro social and technological megatrends; population, urban development, geopolitical, social, transport (land, air, maritime), financial, environmental, and economic.

Potential impact on Logistics and Supply Chains; each topic will be analyzed with respect to the potential impact it could have on Logistics and Supply Chains:

- Changes in Geopolitics - China´s New Silk Road (OBOR)
- Changes in consumer behavior
- E-commerce
- Share Economy
- FINTECH - Blockchain/Bitcoin
- The Internet of Things
- The impact of uncertainty
- Black Swans
- Changes in the competitive landscape
- PPPs and their impact on service/cost
- The future of Transportation
- The impact of environmental protection measures in the cost of transport and logistics
- Education as a main driver of change

Conclusions

Overall discussion on the way to plan resilience in logistics to mitigate the risk of uncertainty, and new business opportunities arising from the new social and technological environment

203. Proposal of countermeasures against level 2 earthquake and tsunami for -7.5m pier on a remote island of Japan

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Masafumi SAITO, Satoshi TOKUYAMA, Terutaka HOSHIJIMA, Kenji NARIYOSHI, Yoshiaki HIGUCHI

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The coast of Japan is an area subject to frequent earthquakes and tsunamis. Since the Great East Japan Earthquake and the resulting tsunami in 2011, countermeasures against earthquake and tsunami have been implemented rapidly and extensively in Japan for facilities such as breakwaters and quay walls of commercial and fishing ports. Countermeasures are also being considered for port facilities in remote islands. Japan's Ogasawara Islands, a world heritage site, is located about 1,000 km of Japan's main island, south-southeast of Tokyo, and consists of 30 large and small islands. Among these, in inhabited Chichijima island (population approximately 2,000), Futami port functions to supply living goods to the island, move out from the island, and accept tourists. A regular service is provided by a cargo and passenger ship, Ogasawara Maru (11,035 tons, 150 meters long), from Tokyo port on a round trip a week basis. In addition, since Futami Port is the only port on Chichijima, it is also required to fulfill the function as an emergency transportation facility in the event of a disaster such as earthquake or tsunami, and the main mooring facility - 7.5 m quay must be able to withstand level 2 earthquakes and the resulting tsunamis.

In this paper, the result of seismic performance survey and tsunami wave performance survey on the quay of the pier structure will be presented, and countermeasures to satisfy the required performance are discussed. For the seismic performance, dynamic analysis was conducted on the level 2 earthquake by the effective stress analysis FLIP program. On the other hand, for anti-tsunami performance, a tsunami simulation based on nonlinear long wave theory for level 2 tsunami was conducted and stability checks for the tsunami level around the target facility were conducted. Based on these results, a structure that can withstand level 2 earthquake motions and tsunami, and is superior in economic efficiency and constructability was proposed. (Based on these results, studies and suggestions were made on structures that can withstand level 2 earthquake motions and tsunami, and that are superior in economic efficiency and constructability.) Note that the level 2 earthquake ground motion is the earthquake ground motion having the greatest strength from the past to the present and the future at the relevant design point. The level 2 tsunami indicates a tsunami occurring about once in 1000 years. Level 2 earthquake motions and tsunamis are applied to particularly important facilities among port facilities. The main conclusions are as follows.

Conclusions:

1) Level 2 tsunami to be designed for is the tsunami of the Nankai Trough massive earthquake. Based on the tsunami simulation for the level 2 tsunami by the tsunami fault model of the Nankai Trough massive earthquake, the maximum water level and minimum water level at Chichijima Futami Port were calculated. From the maximum water level and the minimum water level, the stability of the accidental condition against the level 2 tsunami was examined, and it was revealed that it possesses sufficient proof strength.

2) In addition, anti-tsunami resistance performance of the elements of the piers was examined by the two-dimensional numerical wave motion channel, and it became clear that the structure has sufficient resistance.

3) For the accidental state of the level 2 earthquake, dynamic analysis by FLIP was carried out, and the structure which ensures the stability (an allowable displacement in the horizontal direction of within 1 m) was examined. Based on the results, a ground improvement as follows was proposed as an earthquake-resistant reinforcement construction method; a ground improvement plan by the injection solidification method (medicinal fluid penetration solidification processing method) which suppresses liquefaction of the ground by consolidating the ground at the lower part of the facility with permanent chemical liquid, and reduces the stress of the steel material.

4) At present, detailed examination of the countermeasure construction method focusing on the construction plan is being carried out based on the ground improvement plan utilizing the injection solidification method (chemical infiltration solidification processing method), and hopefully the result will be presented in the main report.

204. Financing of the Panama Canal Expansion Program

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Eida Saiz

Panama Canal Authority (ACP), Panama

The Panama Canal Authority (ACP) is an autonomous legal entity, established pursuant to Title XIV of the Political Constitution of the Republic of Panama and organized by the Law No. 19 of 1997. The ACP pursuant to the Political Constitution has the exclusive charge of the operation, administration, management, preservation, maintenance, and modernization of the Panama Canal, as well as its activities and related services.

On October 22, 2006, the Expansion Program of the Panama Canal estimated at US$5,250 million was approved through National Referendum with a 78% affirmative vote. The Expansion Program included the design, construction, finance, a third set of locks to the Panama Canal comprising of the following components: (a) deepening and widening of the Pacific and Atlantic entrances, (b) deepening and widening of the navigational channels (including those of the Culebra Cut), (c) the construction of two locks complexes and water-saving basins at the Atlantic and Pacific, (d) the raising of Gatun Lake to its maximum operational level, and (e) all matters in furtherance thereof or otherwise related thereto. The financing needs for the execution of the Expansion Program was determined to be US$2,950 million through internal funds generated by the operation of the Canal, and US$2,300 million from external financing. The key objectives established for the financing of the Expansion Program were:

1. Without collateral nor guarantee from the Panamanian government
2. Long-term horizon with a grace period during construction
3. Without obligations to purchase goods and services from any particular source
4. Best possible cost subject to market conditions
5. Obligations to minimize potential interference with the operation and administration of the Canal
6. Geographical diversification
7. Increasing contributions to the National Treasury

On December 9, 2009, ACP subscribed a Common Terms Agreement with five development agencies for US$2,300 million with the set objectives. Financing consisted in a 20-year loan agreement, with 10-year grace period, which permitted disbursements based on the lenders costs, aligned to the execution of the Expansion Program. The obligations of the agreement reflected the financial strength of the ACP, as no guarantees were set. The recognition of the attributes of ACP´s contracting regulation and social and environmental system, the ACP´s corporate governance and its autonomy, permitted a continued and unhindered operations of the Panama Canal and execution the expansion program. The exhaustive due diligence highlighted the criteria matched between the agencies requirements and ACP regulatory framework. The geographical diversification was important due to the connectivity and reliability the ACP provides to global trade, thus subscribing financings with multilateral and bilateral agencies reflected worldwide participation by different member countries, which support IADB (47 members), EIB (28 members), IFC (179 members), JBIC - Asia, CAF (17 countries and 15 private banks).

Accomplishing a common ground among five multicultural policy agencies was the result of understanding each agency requirement; communicating the invested expertise and studies on engineering, social and environmental guidelines and adapting to the best-fit compromise on all parties, to reach a common understanding under one sole agreement.

Multiple lessons learned can be shared from this experience, for example: survey of all possible financing sources available in the market now. This activity helped to understand if the criteria from the sources meets the project's needs; no sole project is the same; set your organizations objectives ahead of entering into negotiations at the highest possible level thus scope of the financing is not altered. As negotiating team, be prepared to share all your institutional regulations in writing as these represent your playfield; include a multidisciplinary team to contribute their expertise and as counterparties to the lenders, experts like environmental, legal, and operational; among others. Be prepared to include in your team external legal and financial advisors who will aid in establishing the framework by which your institution would be able to adhere to international standards and practices as well as determine legal deal limitations.

205. Stockholm Norvik Port, how we build a new Baltic sea freight port for the future

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Mattias Sandell

Ports of Stockholm, Sweden

Ports of Stockholm is building a new port for container- and rorotraffic, Stockholm Norvik Port. The Stockholm Norvik Port is the Baltic Sea freight port of the future.

Stockholm Norvik Port is a new greenfield port in the city of Nynäshamn approximately 50 kilometers south of Stockholm. Ports of Stockholm operate an existing roro- and cruiseport in the middle of Nynäshamn.

The new port will, when the port is completed, cover 44 hectares. It will have a maximum water depth of 16.5 meters. This will enable calls by the largest vessels in the Baltic Sea.

It will be able to handle around 500,000 containers and a flow of 200,000 roro vehicles annually. Container operations will be run by Hutchison Ports, one of the world's biggest terminal operators. It has the Nynas AB refinery and the AGA LNG terminal as neighbours.

When Stockholm Norvik Port starts operating in 2020 the existing smaller containerport in the middle of Stockholm will be closed down and the area will be used for offices and as a residential area.

Stockholm Norvik Port is needed for several reasons:

1. Stockholm is growing

The Stockholm Norvik Port will ensure the efficient supply of goods to the Stockholm region, one of Europe’s fastest growing capital cities. With this type of growth, long-term investment in a well-functioning infrastructure is essential and the port is an important part of this development.

2. Ships are getting bigger

Container ship volumes and the volumes of ships carrying rolling goods are increasing. The shipping companies are consequently building increasingly larger vessels, which is both environmentally and economically advantageous. The Stockholm Norvik Port will meet the needs of modern ships for deeper draughts, longer quays, larger terminal areas and short and easy approach lanes from the larger fairways.

3. A modern port benefits the environment

Stockholm Norvik Port complies with the EU ambition to increase the proportion of sea transport in relation to the total amount of transported goods. A new and modern port with direct motorway and railway connections, built using state-of-the-art technologies, is an efficient and sustainable transport solution.

Environmental issues are important in the Stockholm Norvik Port project. For example, all drainage water will be collected and cleaned before it reaches the sea. All the quays will be prepared to OPS, so the ships can connect to electrical power from land.

Sewage water can be received from the ships in all quays. An electrified railway is built to the container yard.

Some geotechnical and quay design solutions that is interesting for Pianc members will also be presented.

206. The Processing and Beneficial Use of Fine-Grained Dredged Material – A Manual for Engineers

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This paper discusses the feasibility of using a novel sediment solidification/ stabilization technique, the Pneumatic Flow Tube Mixing (PFTM), which has been successfully used in Japan for the last decade in large scale reclamation projects utilizing stabilized soft sediments. The study was conducted by the Center for Advanced Infrastructure and Transportation (CAIT) at Rutgers University and its research partners to evaluate PFTM for stabilization and solidification of soft sediments dredged from the New York/ New Jersey Harbor. The study included a comprehensive laboratory investigation aimed at determining the ideal mix for PTFM stabilization, and a pilot scale demonstration of the PTFM technique in the field. Material stabilized during the demonstration was analyzed via unconfined compression tests, needle tests, laboratory vane shear tests, and flow tests in the laboratory and the cone penetration test in the field. Curing times for the samples were 3, 7, 14 and 28 days. The three cement content mixes were 4%, 8%, and 12% by weight (wet weight). Furthermore, samples of raw and stabilized dredged material were evaluated for total constituent concentrations (SVOCs, Metals, Pesticides, and PCBs) via the SPLP procedure. The results of the laboratory and field testing programs demonstrated that PFTM is an effective and efficient technique for solidification/stabilization of soft contaminated sediments from NY/NJ harbor with unconfined compressive strength values from laboratory and field samples averaging about 200 kPa and 75 kPa (8% cement content), respectively, with a uniform field mixture quality. Furthermore, the chemical analysis of the stabilized sediments indicated no detectable mass of SVOCs, PCBs, or Pesticides.

Keywords: dredged soil, pneumatic flow mixing method, unconfined compressive strength, applicability, field test

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207. Guidelines for River Information Services (RIS) edition 2018 – PIANC WG125

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1. Historical Background

PIANC recognized already in 1999 the importance of the development of River Information Services (RIS) and installed a working group on this topic with the task to develop the first edition of the Guidelines for River Information Services. These first RIS Guidelines were published in 2002. The PIANC RIS Guidelines were an important corner stone of the Directive on River Information Services of the European Commission that came into force in 2005.

Since the publication of the RIS Guidelines versions 2002 and 2004, further developments on services and standards as well as the technical and practical experience have taken place. PIANC established in 2010 the Permanent Working Group 125 with the task to keep the Guidelines for River Information Services up to date. As a first result of this Permanent Working Group, PIANC published in 2011 an update of the RIS guidelines after having analysed the world wide status of the implementation of River Information Services.

The PIANC RIS guidelines 2011 were formally accepted by the United Nations Economic Commission for Europe (UNECE) and all European River Commissions.

Since the last technical report of PIANC on RIS the development in the implementation of River Information Services has been considerably. The PIANC working group is preparing the next generation of RIS guidelines that will be published by PIANC in 2018

In the PIANC “Technical Report on the Implementation Status of River Information Services status 2010” of Working Group 125, it was stated that the development and use of RIS services in a logistics environment was still in his infancy. Since this report the following developments were recognised as relevant reasons for the update of the RIS guidelines. These developments are:

- RIS enabled corridor management
- The Maritime e-Navigation development
- The need for globalisation of the RIS guidelines

2. RIS enabled Corridor Management

Since 2010 studies have been conducted on RIS enabled Corridor Management. The concept of Corridor Management is recognised as the next step in the deployment of RIS services in Europe.

“Corridor Management is defined as information services among waterway authorities mutually and with waterway users and related logistic partners with the goal to optimise use of inland navigation corridors within a network of waterways”

Corridor Management requires sharing of information between authorities and the cooperation of public and private partners is necessary to improve both the performance of inland navigation and the use of the existing infrastructure.

Besides the necessary technical and procedural harmonisation, the basic principle of Corridor Management is the mutual agreement between the fairway authorities in a specific transport corridor on the services and functions they are planning to provide in that corridor.

Three distinctive levels of Corridor Management have been defined:

- Level 1: Corridor Management at this level provides a set of services to enable reliable route planning by supplying – dynamic and static – infrastructural information.
- Level 2: Corridor Management at this level provides a set of services to enable reliable travelling times for voyage planning and for traffic management, by providing traffic information:
    - Level 2a: considering the actual use of the waterway network (e.g. actual waiting times)
    - Level 2b: considering predictions during a voyage (e.g. predicted waiting times on the corridor) where considered reasonable
- Level 3: Corridor Management at this level provides a set of services to support transport management of the logistic partners.

Enhancing inland navigation with the concept of RIS enabled Corridor Management will lead to benefits for inland waterborne transport in the logistic chain e.g.:

- Reliable voyage planning to improve the operation of skippers, terminal and port operators;
- Improved added value of Vessel Traffic Management Services in the logistic chain;
- Simplification of the administration procedures by the usage of an intelligent information management.

The PIANC RIS guidelines are essential for the further development and implementation of RIS enabled Corridor Management being an essential corner stone towards smart multimodal transport management solutions.

3. RIS in the intermodal transport domain

The PIANC Working Group 125 on RIS analysed the above-mentioned developments but also took up the lessons that can be learned from information technologies and services in other transport domains, like there are e-Navigation in the maritime world and Intelligent Transport Systems (ITS) in the road sector.

In the RIS Guidelines 2018 special attention is given to the relation between RIS and the maritime concept of e-Navigation and the benefits of these developments for inland navigation.

The PIANC working group 156 on the relation between RIS and e-Navigation published their final report in 2017. As the harmonization between the inland and maritime world is very important, several recommendations of this working group will be of importance for the RIS guidelines 2018.

It is expected that RIS Flagship projects will take into consideration the developments in e-Navigation in order to pave the way for a coordinated implementation of RIS and e-Navigation in Inland Waterways.

4. Globalisation of the RIS guidelines

The concept of River Information Services has originated from Europe, and so does the principle of RIS enabled Corridor Management. It was soon recognized that RIS can also bring benefits to waterway users on other continents, thus waterway authorities around the world started with the implementation of RIS in their domain. In the framework of PIANC there has always been a good cooperation between Europe and the USA on the development of RIS towards a worldwide concept.

It became obvious that the RIS Guidelines need to become a tool suitable for guiding the worldwide implementation of RIS, and taking due consideration of developments in other transport domains. For this reason the new RIS Guidelines 2018 are currently transformed into guidelines for stakeholders in the inland waterborne transport domain all over the world.

208. Hydraulic measurements as support to lock commissioning: the experience of Ivoz-Ramet and Lanaye locks, Belgium

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When commissioning a newly built lock, numerous items have to be controlled and approved. This encompasses obviously all structural and electro-mechanical parts, in terms of quality of the components, assemblies and settings. Usual and exceptional operations have to be validated to comply with the safety and efficiency requirements fixed by the owner' specifications. Amongst different investigation and control method, in-situ hydraulic measurements offer a large potential and should be systematically performed.

The Hydraulic Research Laboratory of the Service Public de Wallonie was recently involved in the commissioning procedures of two new locks on the Walloon waterways network in Belgium. The lock of Ivoz-Ramet is located on River Meuse, just upstream of the city of Liège. It is an ECMT Class VIb lock, with a 225 m long and 25 m wide chamber, and a drop of 4.45 m. It was opened to the navigation in May 2015. The lock of Lanaye is located between the Albert Canal and the Meuse, downstream of Liège. It is also an ECMT Class VIb lock, with the same chamber size and a drop of 14 m. It was opened to the navigation in October 2015. Both locks are levelled through 2 longitudinal culverts with side ports.

At Ivoz-Ramet, the main purpose of the measurements was to control the lock levelling process. Temporary level sensors were installed in the lock chamber to record the levelling curve and compute the filling or emptying discharge. Water surface slope could also be computed from the level measurements and compared to the admissible mooring force criteria. Levels were recorded in the upstream and downstream reach to check the levelling wave amplitude; and in the lock culverts to control the head loss values. Additional measurements were obtained, notably for the valves position.

All measurements confirmed a good behaviour of the new lock. Levelling duration and generated forces were found almost in agreement with predictions. The emptying duration was slightly longer than expected, but this could be explained by a slower opening of the valves. Some unusual operations were also tested like levelling through only one valve (asymmetric filling), or emergency stop of the filling. Lastly, water level recording with all gates and valves closed enabled the control of the good water tightness of the new seals.

Similar investigations and controls were performed at Lanaye. Unexpected vibrations and cavitation risks required further on-site levelling optimisation. Different valve opening schedules were compared to minimize the troubles. Asymmetric filling using only one valve required particular attention due to the significant lateral forces encountered by the vessels in the lock chamber.

The hydraulic performance investigations done at Ivoz-Ramet and Lanaye covered most of the criteria usually expected in such project specifications: levelling duration, mooring forces, levelling waves propagation, cavitation risk, water tightness, in both usual and unusual operation.

The present building works were not design-and-build projects. The contractor liability in terms of hydraulic performances was limited as the design was done by the waterways administration. However, these two commissioning experiences highlighted some possible improvements for further lock building specifications. Notably, the requirements of the hydraulic tests should be better planned in terms of delays, required access, interaction with contractor staff for electro-mechanical equipment settings, etc. Procedure and criteria for water tightness testing should also be fixed at an earlier stage.

209. Gates of the 5th Brunsbüttel Lock

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The 5th lock of Brunsbüttel is located at the entry from the North Sea to the Kiel Canal. The lock system of Brunsbüttel comprises 4 locks at present, the larger of which date back to 1914. Due to their intense use and the significant demand for maintenance, it is not possible to repair the existing locks during normal operation. For this reason, another lock must be provided for the period of general refurbishment to maintain the existing capacities. This necessitates the construction of a 5th lock. This means that additional capacity will be available after the refurbishment of all existing locks.

The North Sea is characterised by intense tides, the Kiel Canal has a constant water level of approx. ±0.00 m asl. The regular tidal range of the North Sea is approx ±3.00 m. Apart from managing the tidal range, the lock is an integral part of the flood protection line on the North Sea Coast. According to a forecast, storm tides may reach a level of around 9.00 m including waves.

Consequently, the structure must meet very high requirements, regarding both protection against floods and the drainage of the Canal. The structure is largely characterised by these to contrary but also complementary requirements.

The selected gate types are rolling gates, designed so that they may also be used in the existing chambers of the large locks after their refurbishment. Therefore, the wheel-barrow system as used in the existing locks was selected. An upper carriage to which the rolling gate connects has been designed. This means that only an upper carriage with the same connection technology and a rail system as implemented for the new lock must be available in order that the gates may easily be used in the old locks. This may allow to waive spare gates, and maintenance can be standardised. The investment costs for additional gate chambers and drive technology can hence be saved.

In consideration of the required response times and the comparatively high number of locks with the same dimensions, it was possible to make the provision of a permanently operational second gate on each lock head redundant by selecting the proper response time. This reduces investment costs. Apart from a dry dock, only the space for the selected number of spare gates has to be provided. Therefore, the drive technology and the upper carriage have to meet redundancy requirements comparable to the requirements of the gates, making a failure of the lock chamber unlikely.

The manufacturing methods, safety requirements and other statutory requirements, e.g. occupational safety, have considerably changed since the manufacture of the large locks in 1914. As a result of all factors, up-to-date gates are heavier than in the past. Contrary to the old gates, the new gates have been fitted with filling and emptying gates. This allows for performing maintenance work (e.g. in a dry dock) on the filling and emptying devices irrespective of the lock operation.

A significant factor for safe filling is the structural and flow-related design of the filling channels. Damage caused by vibration and abrasion is rather likely. The structural and flow-related design of the filling gates is essential for the function of the overall lock.

Apart from the filling gates, flushing devices are accommodated in the lock gate to keep both the rails and, in particular, the gate tank ceiling free from silt sediments. In addition, a pump system is provided to fill and/or empty the ballasting tanks. This requires complex piping for this pump system on and in the gate. The control devices for these components are partially located on the gate. For this reason, it is required to fit an engine room in the gate, where all these units are accommodated.

The gate is designed as a self-floating structure, since this is the easiest and least expensive approach to transport such a structure. The floating depth must be limited so that the structures may overcome all obstacles. These are especially the lock sills. The gate must meet specific floating stability criteria so that occupational safety requirements may also be met by the gate when it is affected by waves and wind. The gate position is a parameter in this regard, since the gates are balanced in a manner so that their comparatively high dead weight has a considerable effect on floating stability. The filling gate dead weight was selected that high to ensure that they are independently closed by it. These parameters have an influence on the determination of the gate system reliability.

Safety against buoyancy is stipulated by a standard in Germany, since a floating to the surface of the gates would imply a considerable storm flood risk for the cities behind the flood protection line. The main element of the acting forces is the buoyancy of all ballasting cells and the engine room. The size and location of the ballasting cells must be selected in a manner so that the overall gate floats safely on the one hand; on the other hand, the buoyancy of the ballasting cells must be countered by the dead weight of the gate as well as of all permanently installed equipment and, in addition, by ballasting water including a buffer to ensure safety against buoyancy of the installed gates. This results in comparatively high bearing loads, which in turn necessitate a specific ratio between floating and submerging forces. This approach to safety is applied in Germany irrespective of the size and significance of a structure.

The dimensions of the rails and their anchors are of particular importance, since they are very sensitive components that are difficult to replace, especially if submerged. In this regard, all impacts have to be fully identified and their transfer has to be tracked consistently. The rail structure must especially be contemplated as regards possible structural designs.

210. Lengthen of Quesnoy-sur-Deule lock – Description of a lateral slide construction method

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The French Waterways Authority (Voies Navigables de France), manages in the North of France a particularly active territory in terms of river traffic. The Seine Nord Europe canal project, as a future link between Belgium and France, needs to improve two large-gauge waterways. One of these two itineraries, the canalized Deûle, presents a problematic lock on its route, the Quesnoy-sur-Deûle lock.

The lock is located in France, closed to the city of Lille, less than 5 km from the Belgian border. The problem stands in the fact that this lock has only one lock chamber of 110 m long, while all the others have a lock chamber of 144 m. It does not allow the navigation of the Large Rhine boats of 135 m, which are very widespread in the Nederlands, Belgium and on the Rhine River. For that reason, BRLingénierie was selected by VNF in 2013 to study the design of the extension of this lock to extend it at its new dimensions of 144.6 x 12 meters. The main difficulty for this operation is that the river traffic can only be stopped during very short closure period, which do not exceed 2 weeks per year. The second difficulty is that the lock is located in a geological context of Flandria Clay with weak and very particular characteristics.

The proposed solution consists of constructing the walls of the new lock head set back from the chamber lock, under the shelter of two cofferdams and then putting them at their final location by a lateral slide operation. This operation offers the great advantage of providing, in fine, a conventional, reinforced concrete lock, without requiring long closure. However, it induces a certain number of problems to be solved, such as the construction of modular evolutive cofferdams, the placement of tracks and slide bearings capable of bearing loads around 3 000 t, the construction of homogeneous foundations, a phasing of works allowing to work isolated from water, the connection to the existing lock.

The manner in which each of these difficulties has been solved will be developed in the article. The aim of the article is to propose an unusual solution to the problem of the extension of locks with a limited cut-off of the river traffic.

211. Experiences with Smart Shipping: results from the Netherlands

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Introduction

This paper will give a insight in the challenges and chances of Smart Shipping that lay ahead for infrastructure providers and traffic managers of inland waterways. Chances lay in more efficient waterway and traffic management due to more information, more safety and gains in sustainability.

Challenges lay ahead when Smart Shipping asks for changing rules and legislation, need for changing infrastructure and a different role for traffic management. Although there is a lot of uncertainty about the future of Smart Shipping, this paper shares the results of conducted research in the Netherlands. Also a proposition for future research questions is made.

This abstract is also addressing the need for international cooperation on the challenges that lay ahead on this topic, among others in the Pianc community. Our believe is that we can not sit back and wait for what is going to change. Infrastructure providers and traffic managers should be pro-active at what is to come.

Definition of Smart Shipping

Several definitions of Smart Shipping are available. In our view, the definition should take into account all the developments that are important for the sector and therefore Smart Shipping consists of four different topics:

1. Smart Ships: this not only takes into account automated navigation but for instance also ‘smart’ fuel solutions.

2. Smart traffic: interaction between the ships; situational awareness is one of the topics here.

3. Smart travel and transport: interaction between the ship and the logistic partner (in a corridor); solutions for lock and bridge planning, route planning and ETA at an terminal are port of this topic.

4. Smart facilitation and regulation: interaction between the ship and third (government) parties for regulation or inspection. Important topics within this pillar are corridor, asset and nautical management.

Results of recent research and projects

Developments regarding Smart Shipping are fast-moving. Rijkswaterstaat started paying attention to these developments at the end of 2016. As of then, we are keeping up with this developments by deploying several research studies and by organizing events. In recent studies, research has been conducted on the general impact of Smart Shipping, the impact on sustainability and suspected developments. Besides that, operational experience is

exchanged between entrepreneurs government agencies and educational institutions by organizing events and attending demonstrations of new technological advances.

These studies and events already produced interesting results on different topics.

Sustainability: within less than 15 years Smart Shipping can lead to a theoretical CO2 reduction of around 20% compared to 2017.

Safety: up to 80% of incidents on the Dutch waterways is the consequence of human actions. In the long term Smart Shipping should be able to reduce this number with more than 50%.

Efficiency: in the long term data sharing solutions could lead to a 25% gain in efficiency because of reductions of shipping empty containers.

The ships: the vast majority of the Dutch inland navigation fleet is quite old and does not have digital readability instruments and equipment. This may lead to new inland shipping concepts instead of upgrading the existing fleet.

Developments: the developments around Smart Shipping are quite fragmented throughout the sector and real system integrators are missing.

Community: through organizing several events a big (international) community is buildup with stakeholders from many different companies, government agencies and educational institutions. The need for international cooperation is addressed.

Ongoing research and projects

The recent research has shown that Smart Shipping has potential on amongst others, sustainability, safety and efficiency. Ongoing research conducted at the moment is concentrating on the impact of these developments on network (provider) and traffic managers. The main research question is: what impact is Smart Shipping going to have on the operations of an infrastructure provider and traffic manager?

Sub-questions raise attention to the impact Smart Shipping has on the infrastructure and legislation. It is for example expected that, staff regulations and traffic rules need to be changed. Also, further research is conducted to the possible socio-economic impact of Smart Shipping, for example on safety (cyber-security), sustainability and reliability within the logistic process.

Besides the research, new practical information is also gained the Smart Shipping Challenge: an event organized by Rijkswaterstaat on 30th November 2017. On that day dozens of demo's and presentations will be giving, demonstrating what is already possible with (semi) autonomous inland navigation of ships. An impression of the results of his event will be given.

Future research questions

Although a lot of experience is gained, there are a lot of research questions left. A brief overview of future research questions will be discussed in the presentation. Examples of these questions are:

Which requirements allow the licensing of smart ships to the physical infrastructure such as waterway, berths and locks?

What impact does smart shipping have on the use on the processes of construction and maintenance of the physical infrastructure?

Does Smart Shipping lay down specific conditions for traffic management?

Conclusion

Developments regarding Smart Shipping are fast-moving. Dozens of new technical advances are build at this moment. Recent research has shown that Smart Shipping has potential on amongst others, sustainability, safety and efficiency. The impact on the operation of infrastructure providers and traffic managers is still unclear. Current research is focusing on that topic.

The presentation

In the presentation the latest results of recent and ongoing research will be presented, the discussion will be raised which future research questions are important and the need for international cooperation will be highlighted.

212. Kentucky Lock Addition Downstream Cofferdam

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Bernard Schulte, Don Getty

U.S. Army Corps of Engineers, Nashville District, United States

Construction of the Kentucky Lock Addition project's ongoing $67 million downstream cofferdam presents safety, geologic, and construction method challenges. Approximately 500 linear feet of the cofferdam utilizes new lift-in, in-the-wet techniques to construct a concrete segmental wall - a cofferdam wall that will eventually be incorporated into the permanent wall of the new 1200 foot x 110 foot navigation lock instead of being demolished. This new navigation lock is the focal point of the U.S. Army Corps of Engineers' $1.25 billion project that is approximately 35% complete. The project site is at Kentucky Dam, the lowermost dam on the Tennessee River in western Kentucky, USA. Kentucky Dam impounds the largest reservoir east of the Mississippi River.

Kentucky Lock's cofferdam concrete wall will be constructed in ten segments with plan dimensions of approximately 45 feet by 55 feet each. Stay-in-place concrete forms, or shells, for each segment will be cast on barges in heights up to 35 feet. These 12 to 16 inch thick shells will weigh up to 1.3 million pounds. Each shell will be lifted off its casting barge and placed on a prepared foundation on the river bed using a specially designed gantry barge system. This construction method is similar to one employed by the Corps for a cofferdam wall on the Chickamauga Lock project in the 2007 timeframe. However, construction of the Kentucky Lock wall is significantly different in many respects. While Chickamauga shells were placed on previously constructed 4 foot diameter concrete drilled shafts, Kentucky shells will utilize integral and adjustable spuds on all four corners to support the shell on an irregular rock surface. This approach is a component of a Value Engineering proposal ($3 million cost savings) by the contractor to eliminate rock blasting and excavation down to a design grade. Instead of underwater blasting, the rock surface is being scarified by a hydraulically powered drum cutter to remove the weathered rock zone to expose competent rock with compressive strengths in the 20,000 to 30,000 psi range. Each shell is being designed for the resulting top of rock grade and configuration. Lifting and lowering the Chickamauga shells was accomplished by a fixed gantry, strand jack arrangement that was supported on the drilled shafts and the previously placed shell. Kentucky's method of lifting and lowering using a gantry barge eliminates the time consuming process of establishing and de-constructing the fixed gantry system for each shell.

The location of Kentucky Lock's cofferdam wall in the existing lock's immediate lower approach presents significant safety challenges and space limitations. An alternative design analysis chose this design in part to maximize the cofferdam wall's distance from the edge of the navigation channel, but the edge of the wall is still within 23 feet of the edge of the existing channel. Since the existing Kentucky Lock is one of the most heavily utilized locks in the U.S., almost continual commercial vessel traffic presents a safety and logistical challenge in this confined environment. A key to minimizing safety risks and minimizing disruptions to construction operations is a dedicated helper boat with an associated marine safety plan (MSP) owned by all parties involved. The development of this MSP commenced during preparation of the plans and specifications and involved representatives of the U.S. Coast Guard and the towing companies transiting the lock. After award of the construction contract in September 2016, the contractor, Johnson Brothers Corporation (Roanoke, Texas USA), became involved

and was responsible for drafting and maintaining this living document. Development of the MSP was enhanced through the use of a simple Table Top exercise. The Table Top employed plan views during various phases of construction in conjunction with scale two-dimensional models of all the vessel types and floating plant expected to be in use during construction. Port Captains of the towing companies could relate to this type of “modeling” and were instrumental in analyzing and selecting helper boat procedures. These procedures are now successfully being used by the helper boat and transiting vessels. In addition, the contractor has adjusted his work activities to minimize impacts to his operations because of passing vessels.

When this cofferdam’s initial design was completed in 2003, it was envisioned as a float-in structure that would require a 3 month closure of the existing lock during its construction, significantly impacting the towing industry. Based on lessons learned from the Chickamauga lift-in approach, that 3 months was reduced to 1 month. Then based on the value engineering proposal that eliminated underwater blasting and by incentives incorporated into the construction contract to minimize lock closures, the expected total lock closure is now approximately 10 days.

It is expected that other lock addition projects and projects utilizing in-the-wet construction methods in confined environments will benefit from the techniques and experience gained from the design, construction, and contracting methods employed by Kentucky Lock’s downstream cofferdam.

213. Navigation Risk Assessment in Coastal Ports using Automatic Identification System Data

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Martin Schultz

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Methods of quantitative risk assessment are needed to evaluate and compare navigation risks in coastal ports so that port managers can determine where risks are high and take actions to mitigate those risks where appropriate. This presentation describes how data contained in automatic identification system (AIS) messages can be used to assess collision and grounding risks in coastal ports. Commercial vessels and many recreational vessels are equipped with AIS transmitters, which broadcast information on that vessel's identity, location, course and speed at intervals of two to 30 seconds. In the United States (US), the US Coast Guard harvests and archives these messages for the purpose of maritime domain awareness, which is defined as the effective understanding of anything within the maritime domain that affects security, safety, economy, and environment. Collision risks are analyzed using the concept of a ship domain, which is the area around each vessel that should remain clear of other vessels. The ship domains used in this study are elliptical and have dimensions that vary with the swept path of each vessel. The metric of collision risk in navigation channels is the fraction of AIS position reports, normalized to control for differences in transmission frequency, which satisfy several criteria for a ship domain violation. The metric, which can be interpreted as the probability of a ship domain violation given that at least one vessel is present, can be calculated for individual channels, groups of channels, or entire ports and provides the basis for quantitative comparisons of collision risk across navigation channels and coastal ports. These metrics of risk provide an objective basis for relative comparisons of risk in different ports and waterways.

214. Hydrodynamic Aspects of Waterway Design and Operation

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Thomas Sellers, Wei Xu

MARIN USA, United States

The United States infrastructure system is deteriorating and in dire need of improvements in order to maintain competitive within the global economy. The 2017 infrastructure report card from the American Society of Civil Engineers (ASCE) narrowly passed the ports and inland waterways of the U.S, stating the facilities were beyond design life and inadequate for the demands of modern vessels. The U.S. Army Corps of Engineers is tasked with the challenging job of maintaining all U.S. ports and waterways with a limited budget. A large part of improving the waterways of the U.S. includes the work to deepen and widen ship channels and inland waterways. In order to efficiently utilize the limited improvement resources, efficient dredging techniques are required, therefore this paper focuses on the hydrodynamic aspects of waterway design and operation.

As a ship sails through a waterway there are many considerations that influence the path of the ship. Obvious culprits include the bathymetry of the waterway, the presence of waterborne traffic, the availability of maneuvering devices, such as tugs and thrusters, and the environment. The less obvious factors include the hydrodynamic effects of maneuvering within confined waterways. Hydrodynamic phenomena including bank suction, passing vessel and shallow water effects can be significant and are often the dominant force contribution on a vessel in a waterway. To assess all of the hydrodynamic effects, a combination of simulation tools is required. Model tests, potential flow codes, and complete Navier-Stokes CFD methods are needed to develop high fidelity models that can accurately predict the hydrodynamic effects encountered by vessels in ports and waterways. To study in detail all the hydrodynamic effects present on a single vessel or maneuver is not a cost effective option. Fortunately, software programs are available that use hydrodynamic databases to predict the motions of vessels in response to confined space hydrodynamics. A combination of software packages is required to assess the full cycle, from transit to berthing, of a vessel in a waterway. Programs such as SHIPMA utilize the combination of depth-to-draft dependent vessel maneuvering models, bank suction models, maneuvering devices (thrusters, tugs), and an autopilot to assess the accessibility of waterways designs for a variety of vessels and environments. The ROPES software can be used to predict the effect of a passing vessels on a moored vessel's motion response and programs such as aNySIM XMF can be used to study mooring systems and vessel response to environmental and mechanical loading. In addition to the hydrodynamic effects experienced in waterways, it is important to also address the operational feasibility of the maneuvers being simulated. Real-time bridge simulations combined with sophisticated maneuvering models can be used to assess the operational feasibility of maneuvers with input and feedback from operators such as pilots, captains and tug masters. This allows for operational input to be considered in the design process. The models produced at each stage of a study can be used in combination to produce a final maneuvering model that can be used in time domain simulation software in both real-time and fast-time. This complete model can be efficiently transferred between simulation platforms to allow for accurate and consistent results.

This paper will discuss the use of software to aid and improve the design of waterways and waterway infrastructure. Cases will be discussed to demonstrate the importance of modeling

the complex hydrodynamic effects experienced by vessels in confined water. A passing vessel case will be discussed for multiple speeds and passing distances. A mooring design study will be combined with the results of the passing ship simulations to assess the effect of passing vessels on the mooring system. Finally, a waterway feasibility analysis will be presented for vessels sailing with and without the effect of bank suction and depth to draft dependent maneuvering models. The use of software to improve waterway design and operation will be demonstrated by a waterway feasibility case study that focuses on vessel dependent spatial and environmental limits, tug requirements, and identification of waterway hazards.

215. Container Port Deepening in Cartagena

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Brian Shaw

Moffatt & Nichol, United States

Manga Terminal, operated by SPRC in the heart of Cartagena, Colombia, expanded at a moderate pace through the late 20th century to incorporate products ranging from cruise to Ro/Ro, and the first container handling berths were retrofit in 1995. Growth surged in recent years, precipitated by the expansion of the Panama Canal and consequent demand for nearby deep water berths and container transshipment terminals. The two terminals operated by SPRC in Cartagena, Manga and Contecar, are now one of the top five container handling entities in Latin America.

After a new berth was constructed in 2011, the terminal could not expand significantly due to land constraints, so operators turned to modernization projects to increase throughput capacity. This paper discusses port improvements which will allow docking of New Panamax vessels alongside four berth segments, totaling 700m in length, originally designed and equipped for Panamax class ships. The increase in mooring and berthing load required upgrades to fenders and localized strengthening of the mooring hardware and berth structures. Dredging at the berth face was enabled through installation of toe walls to retain the existing under berth slope – a particularly challenging design for one segment with an existing toe wall. Ship to shore operations were improved through procurement of larger gantry cranes.

Innovative engineering allowed cost-effective upgrades which maximized reuse of existing infrastructure, with the constraint of maintaining container throughput during the construction period.

This presentation will be of interest and benefit to port planners and design engineers, specifically those adapting existing infrastructure to the ever-larger needs of the shipping industry.

216. Recent large dimensions flap gate on Seine River

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Caroline Simon-Pawluk [1], Fabrice Daly [2], Xavier Bancal [3], Laurent Vidal [4]

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Recently, 3 weirs with very large flap gates have been built on the Seine River near Paris for VNF-DTBS (Voies Navigables de France- Seine Basin): Chatou, 2nd weir downstream of Paris finished in 2013, Le Coudray finished in 2012, and Vives-Eaux finished in 2017, 4th and 5th weirs upstream of Paris. The 3 old weirs had been built about 80 years ago to increase navigation depth on Seine river. They had lift gates (Chatou) or wicket « Aubert » gates. The flap gates operated each by 2 hydraulic jacks are remarkable because they are out of or just at the limit of the proven optimal scope of flap gates compared to other types, according to 2006 PIANC report (design of movables weirs and storm barriers), because of the torsional rigidity limit, or out of the range indicated by standard design guide for flap gates made by VNF-Cerema in 2009. There is no example of both larger and higher flap gate (Erbisti). The main dimensions (water height x span in meters) of these gates are: 7.8 x 32.5 (Chatou), 6 x 34 (Le Coudray) and 4.8 x 30 (Vives-Eaux), the gate height in Chatou is 9 m. However, the reasons why this kind of gates has been chosen are mainly aesthetic, liability, precise regulation and price. The main design, construction or operating constraints have been gates the structure, the energy dissipation basin, the cofferdam, the maintenance bulkhead, and fish passes. The flap gate design will be compared: use of torsion tube or traditional fish belly shape, design and installation of hinges and Cardan suspensions. The large gates have been installed in several parts assembled on place with bolts. The hydraulic jacks' rods have unusual long strokes, 9.25 m for Chatou weir. Using these 3 examples, the limit of optimal scope of flap gates will be discussed.

For Le Coudray Weir, a laboratory physical model (scale 1/12) has been made and has improved the calculations and design, for discharge, hydrodynamic forces, energy dissipation basin, hydraulic jump and downstream protection, aeration and vibrations prevention. The hydraulic winter conditions imposed to remove or to be able to remove the cofferdam every winter. In addition the soil conditions were difficult: hard limestone or chalk. So, innovative sheet-piles cofferdams have been made: cofferdam without concrete plug in Chatou, sheet-piles set on riverbed with bored piles and injections in rock in Le Coudray to insure stability and watertighting. For the 3 weirs, the maintenance upstream bulkhead will be floating ones which leads to some difficulties in design and operations, because of the large dimensions. Fish ladders with pools are made on these weirs to insure ecologic continuity. The 2 first weirs have been commissioned 4 years ago. So a first feedback can be made about operation and maintenance. Precise regulation of water level is necessary for navigation and fish passes, especially because of the Paris reach which needs stability.

217. Seismic Design and Construction of Pile-Supported Concrete Wharves for Container and Bulk Handling Terminals

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Jyotirmoy Sircar, Carlos Ospina, V.K. Kumar

BergerABAM, United States

The paper describes the seismic design and construction of two adjacent wharves in greenfield terminals off the Pacific coast of Colombia. The wharves include two quays totaling 850 m and two individual access trestles serving container handling operations and bulk and break-bulk cargo handling (coal exports/grain imports) operations, respectively.

The projects started with the intent of providing waterfront infrastructure capable of handling modern Post-Panamax ship-to-shore quay cranes, mobile harbor cranes and operations of bulk handling equipment in a remote and high-seismic area of Colombia. The design adopted a modular and repeatable open-wharf system consisting of high-capacity steel pipe piles supporting a high-capacity precast concrete deck system. Due to heavy rainfall and the remoteness of the site, a deck system consisting primarily of precast concrete elements was implemented in order to delink construction progress and quality control with site constraints. Deck elements needed to have adequate weight and sufficient reinforcement to resist the 35 kPa operational and STS Crane loads under service conditions; however, given the high seismic activity in the region, the overall design also needed to limit seismically induced lateral deflection.

State-of-the-art performance-based and capacity protection seismic design and detailing for pile-supported wharf structures per ASCE/COPRI 61-14 were adopted for the design of the quay and the access trestles. A key component of design was the development of an innovative precast concrete pile plug providing a practical connection between the steel piles and the concrete superstructure. The plugs were designed to provide significant inelastic rotation capacity without penalizing the deck design. The paper will elaborate on important serviceability and seismic design considerations and explain how these challenges were overcome in design and construction. A significant portion of success in meeting the aggressive schedule was attributed to the innovative construction methods adopted in the project. A linear top-down construction approach was adopted wherein previously installed piles were used to install future piles and deck elements. Due to this, precast element design details had to be made compatible with the top down system.

Construction of both the wharves was completed in late 2016 and they are currently in operation.

218. Sustainable Ports in Africa. A practical stakeholder-inclusive, ecosystem-based design approach

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Jill Slinger

Delft University of Technology, Netherlands

This technical session comprises four papers exploring what it means to be a sustainable port, particularly in a developing country context.

Towards a framework for integrated, ecosystem-based port development

P. Taneja, T. Vellinga, J. Slinger, H. Vreugdenhil, W.P. de Boer, A. Kangeri, B. Kothuis, M. Koetse, L. Hagedoorn, C. van Dorsser, E. Mahu, B. Amisigo, K. Appeaning Addo

This paper describes an integrated, ecosystem-based research project exploring what it means to be a sustainable port in a developing country context. Africa is one of the few areas in the world where greenfield port development is still occurring in addition to brownfield development. This means there are many challenges and opportunities to design for sustainability and to nudge existing ports towards more sustainable activities. A stepwise, case study oriented approach to tackling these issues is explicated in an effort to understand the advantages for port developers and their financiers to move in this direction.

Designing for stakeholder values in port development in Africa

J. Slinger, P. Taneja, B. Kothuis, H. Vreugdenhil, W.P. de Boer, A. Kangeri, M. Koetse, L. Hagedoorn, C. van Dorsser, E. Mahu, B. Amisigo, K. Appeaning Addo, T. Vellinga

This paper addresses the need for stakeholder-inclusive design in sustainable port development. This involves learning about the values and knowledge resources of local stakeholders at an early stage, but is a step that is often omitted in current port planning processes. However, it is essential in creating added value and in avoiding costly delays when port development is stopped or delayed by social impact findings at a later stage. A stakeholder engagement process for the Port of Tema, Ghana, is used to illustrate the types of activities required and offer insights in the outcomes. In particular, a game structuring method applied in a 50-people workshop in February 2017 demonstrated that the expertise of local stakeholders and insight into their preferences regarding potential futures for the port city and its surroundings can inform planners, port authorities and engineering scientists about what it means to be a sustainable port in a developing country context.

The contribution of nature-based concepts to sustainable port development

D. Rijks, T. Vellinga, P. Taneja, H. Vreugdenhil, W.P. de Boer, A. Kangeri, B. Kothuis, M. Koetse, L. Hagedoorn, C. van Dorsser, E. Mahu, B. Amisigo, K. Appeaning Addo, J. Slinger

The potential added value of ecosystem-based concepts in port design are explored using a series of examples from the Netherlands and Ghana. The first example relates to the sandy dunes comprising part of the protection of the Maasvlakte II extension to the Port of Rotterdam.

The second example focusses on enhancing the habitat suitability of bed protection, while the third example addresses improved connectivity and potential restoration of a brackish wetland adjacent to a recent harbor extension in Africa. The paper illustrates that the design of nature-based infrastructure requires a focus on opportunity creation and restoration of healthy ecosystems. Healthy ecosystems, in turn, help to ensure that benefits accrue to local as well as regional and global stakeholders in a port development process.

Diffusing knowledge on Sustainable Port Development

J. Slinger, H. Vreugdenhil, P. Taneja, W.P. de Boer, A. Kangeri, B. Kothuis, M. Koetse, L. Hagedoorn, C. van Dorsser, E. Mahu, B. Amisigo, K. Appeaning Addo, T. Vellinga

This paper adopts theory on pilot projects to devise a strategy for the diffusion of new knowledge and practices from case study research on an African port. Progress in disseminating knowledge and in creating awareness of new practices is reviewed. The efficacy of the strategy is also assessed.

Why this session/workshop will be interesting/ useful for the conference attendees?

It is envisaged that this technical session will provide participants with the insight in a port design process that starts from a different point (stakeholders and ecosystems) and delivers added value both in the short and long term.

219. Numerical modeling of bank erosion due to river traffic

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Hassan Smaoui [1, 2], Nicolas Huybrechts [1, 2], Sami Kaidi [1, 2], Philippe Sergent [1], Fabrice Daly [1]

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The river traffic generates wake waves depending on the speed, the size and the structure of the boats and the size of the channels, etc. They have an effect on erosion of bottom and banks of the waterways. To address these concerns, Cerema and UTC (Compiègne Technological University) have carried out several studies since 2006, improving the analysis of phenomena. The presentation will describe the progression in the results obtained at the different phases, the complementarity of the in-situ measurements and the numerical models, the limits of the results obtained according to the retained assumptions, and the future development perspectives.

- A measurement campaign on two sites (canal and river) studying the effect of boats on sediment transport and bank erosion was carried out in 2006 (Pham Van Bang et al., 2007, 2008). This campaign allowed the deployment of several sensors (ADCP, OBS, etc.) to measure the structure of vertical velocity, suspended matter and wave height. Measurements alone are not enough to quantify all flow variables due to lack of information. For example, it is very difficult, (May be impossible), to measure the in-situ turbulent fluctuations (turbulence intensity, shear stress, friction velocity ...). They must be supplemented with numerical models to quantify almost all the variables of the flow.

- A 1D vertical (1DV) hydro-sedimentary numerical model has been developed and applied to the measurement zone (Smaoui et al., 2011). It has reproduced some features of shear flow by boat speed at the surface and provided information on other parameters difficult to measure in-situ. Similarly, the 1DV model reproduced with great fidelity the successive peaks of Suspender Particles Matter (SPM) in the navigation channels due to the passage of boats (Smaoui et al., 2011). However, the 1DV model could not answer all the questions of flow and erosion of the banks generated by the wake waves due to river traffic.

- To complete the 1DV numerical model study, we realized a 2D numerical model calculating the combination of a fluvial flow and a flow generated by the boats movement (return current and the wake waves) (Ibrahim & Smaoui, 2016). The application of the developed model allowed the estimation of bank erosion induced by river traffic. It must be noted that the quality of this estimation requires a good parameterization of the bottom shear stress (BSS). For our part, to compute this BBS, we were inspired by the work on the wave-current interactions in the marine environment (Mouakkir & Smaoui, 2010).

The application of the developed 2D numerical model to the real case of the Oise river has shown that lateral erosion due to both the return current and to the wake waves is much less important than that caused by the fluvial flow. The part of the erosion due to boats passage was estimated to 8%. However, this value should be taken with caution, since in the absence of information on the critical shear stress of erosion of the bank soil, the value of 0.4 N/m² was chosen, which corresponds to a clay soil close to the soil nature of the studied bank portion. It must be noted that the results of this modeling are preliminary, and are in the beginning stage of a development process that will lead to a 3D modeling, coupling the fluvial flow, boats

movements and the flow in the water table and the bank (unsaturated medium defined by the pressures in air pores and water).

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220. Tsunami Hazard Assessment for Permanently Moored FSRU Marine Terminal in Chile

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Eric Smith, Patrick Lynett, Carlos Rodriguez

Moffatt & Nichol, United States

Introduction

Chile has a long history of great subduction zone earthquakes and the local tsunamis produced by them. Since the 1500's, there have been 14 documented earthquakes with Mw greater than 8.0, including the 1960 Mw 9.5 Valdivia earthquake, the largest recorded earthquake in recent human history. The Andes LNG project is planned to store and regassify liquefied natural gas (LNG) onboard a Floating Storage and Regasification Unit (FSRU) vessel and deliver gas via pipeline to an onshore power plant. Evaluation of tsunamis for moored vessels is not typically considered for terminal design due to the low probability of a vessel calling at a terminal simultaneously with a design-level tsunami event. However, in the case of a FSRU, the vessel is on site continuously for 20 years or more, greatly increasing the probability of the moored vessel occupying the berth during a tsunami event. In the immediate vicinity of the project site, the earthquake of 1922 generated the largest recent tsunami, with a likely amplitude of 3m near the proposed terminal. In this paper, we present a tsunami hazard assessment approach to account for the great tsunamis generated by these local earthquakes, and the potential effects of this hazard on the Andes LNG floating vessels and marine terminal.

Tsunami Stochastic Approach

To provide tsunami hazard information for the Front End Engineering and Design (FEED), a "stochastic scenario" approach is used which allows for the approximate expression of tsunami recurrence periods. With information found in the scientific literature (i.e. Dong et al., 2015), it is expected that a 1922-like earthquake (i.e Mw 8.5 with rupture immediately offshore of the site) occurs once every 100-250 years. However, the earthquake return period is a function of its magnitude only, and other parameters, such as focal depth and internal rupture angles, while controlling the initial tsunami properties, play no role in this return period. Therefore, to quantify a tsunami recurrence period, we must understand the range of potential tsunami impacts that might be caused by different configurations of a Mw 8.5 earthquake offshore of the site. We simulate a set of 16 tsunami scenarios, wherein the earthquake epicenter, focal depth, strike angle, dip angle, and rake angle are varied. The range of over which these values vary is taken from recent large earthquakes in the region. For each of these scenarios, a high-resolution tsunami simulation is performed using both a shallow water tsunami model (MOST) and a Boussinesq-type hydrodynamic model (COULWAVE). Time series of ocean surface elevation and tsunami current velocity for all 32 simulations are recorded at the project site. The current field predicted by the numerical model is characterized by the presence of large eddies spinning in the horizontal plane ("whirlpools"). The presence of these eddies was a primary motivating factor for the statistical analysis discussed here, as a single deterministic simulation might not provide a complete description of the potential variability of this complex velocity field.

From the numerical output, it is possible to generate current-based exceedance curves as a function of direction. To perform this analysis, current heading was divided into 2-degree bins,

and an exceedance curve developed for each bin. With this information, it becomes possible to express the relative likelihood of a specified current-direction pair, in terms of useful recurrence periods. For example, if the design earthquake for tsunami hazard is assumed to have a return period of 250 years, and a speed of 2 m/s (at a specific heading) is only exceeded in half of the tsunami simulations, then this information can be combined to state that a speed of 2 m/s will only be exceeded, on average, every 500 years. The speed-based exceedance curves are provided to the mooring analysis, such that a tsunami hazard level that is consistent with other considered hazards (e.g. seismic) may be used for design.

Mooring Evaluation

We evaluate the performance of the moored vessels by running a series of dynamic mooring analyses of the tsunami events. The design basis for the terminal specifies that the FSRU shall be capable of departing berth in an emergency. However, the warning time between earthquake generation event and tsunami arrival is too short to allow the vessel to be ready to depart. The dynamic mooring simulations are conducted for two scenarios: the FSRU at the berth by itself; and the FSRU and LNG carrier in ship-to-ship (STS) transfer operations. Performance results of both the LNGC and FSRU mooring are predicated on departing berth within 60 minutes and 90 minutes, respectively, of the earthquake-generated tsunami event. We selected tsunami events for the mooring analyses based on the combined return period of the earthquake event and the current exceedance threshold acceptable for the design of the berth. The FSRU-only mooring arrangement is simulated for the first 90 minutes of the 10% exceedance tsunami (return period of 1000-2500 years). The STS mooring arrangement is simulated for the first 60 minutes of the 50% exceedance tsunami (return period of 200-500 years).

The response of the vessels during the design tsunami events is modeled using a dynamic analysis program (AQWA) used for the calculation of forces and motions of multiple floating bodies. The analysis predicted forces in mooring lines and fenders, as well as vessel motions throughout the tsunami event. The tsunami currents were simulated by applying the time series of current magnitude and direction at the vessel location, assuming the current field is uniform over the length of the vessels during the early part of the tsunami event, before eddies and other chaotic behaviors develop. Additional mooring line stresses due to fluctuations of the water surface elevation are calculated and added to the mooring response for each time-step of the AQWA simulation results.

By combining the tsunami probability evaluation with generation of mooring loads, we assess the mooring performance during tsunami events and develop an approach for incorporating tsunami mooring loads into the marine structural design.

221. Experience in Waves Attenuator Structures to Protect Marinas. Functional and Structural Design.

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Javier Sopelana [1], Fernando Lopez Mera [1], Enrique Pena [2]

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1.- INTRODUCTION.

Marinas and Small craft harbors used to be located in such places as estuaries, lakes, channels, rivers and harbour areas, always in swell waves in sheltered areas. However, these areas may also be affected by other types of waves, wind waves or waves generated by vessels and boats.

The concrete floating breakwater "box or cage type" is the most used typology to protect this kind of areas, due to the simplicity of construction, easy mobilization, installation, etc. A foundation based on chains anchors and concrete blocks is commonly used for this king of structures, even though solutions with piles have been recently used in the north of Spain. Several authors have studied this kind of floating structures: Brebner and Ofuya 1968, Hales 1981, Isaacson, 1982, Miller 1984, McCartney, B. 1985, Sannasiraj et al 1998, Williams et al 1998, Gesraha 2006, Cox and Beach 2007, underscoring during the last decade the works developed by Ruol and Martinelli (2007, 2008, 2013), Michailides and Loukogeorgaki (2013, 2014) and Pena (2010, 2013, 2014).

Another kind of structures, porous permeable structures, is also commonly used in small craft harbors. The simplest porous structure may be a curtain wall breakwater (sometimes called slotted barrier or wave screen), which consists of a vertical wall extending from the water surface to some distance above the seabed. Different authors have worked on this type of structures: Wiegel 1960, Hayashi 1966, Kriebel 1992, Losada et al 1992, Kakuno and Liu 1993, Isaacson 1998, etc…until Huang et al, 2011 doing a complete review of hydraulic performance and wave loadings of slotted coastal structures. This kind of structures used to be fixed, but vertical slotted floating barrier have been studied by Sopelana et al. 2011.

In this paper, a literature review and conclusions of more than 10 years' experience in these types of structures will be presented (fixed and floating slotted barriers and box type floating breakwaters with different mooring system). The Authors have been working and developing tools and methodologies for the correct design of this structures. The experience gained combines laboratory tests, development of numerical models and experience in field instrumentation.

2.- EXPERIENCE DEVELOPED.

A partially submerged vertical floating barrier was design in a research and development project between 2006 – 2008, and patented in 2009. The first approach to achieve an optimum design of the floating structure was the study of a fixed porous barrier using theoretical method. Transmission, reflection and the wave induced force on the structure were studied. This method was validated with experimental measurements and calibrated for the case of a partially submerged slotted barrier. Furthermore, experimental tests were carried out, and the results between the fixed barrier (wave flume of A Coruña University) and the floating barrier (wave flume of Cantabria University) were compared. The final design was built in the port of

Cabo de Cruz (Galicia, Spain), and instrumented during one year in order to measure the real transmission and reflection coefficients as well as the wave induced forces on the structure.

During 2011 and 2015, several 3D laboratory tests with floating breakwater box type were performed in the wave tank at the CITEEC (R+D Centre in Building and Civil Engineering) of the University of A Coruña (Spain). Different tests were carried out (regular and irregular waves, wave direction), and the most important parameters were analyzed: breakwater geometry (depth and width), mooring forces (chain and elastomeric system) and module connector forces.

Between 2013 and 2015, a research and development project (Center for Industrial Technological Development of the Spanish Government) was performed. Laboratory test was carried out and a new numerical tool for the functional design of floating breakwater was developed.

Regarding field instrumentations, in 2015, the Xufre port floating breakwater (box type) was monitored for 6 months: 2 AWACs were installed to measured incident, reflected and transmitted waves. In addition, 2 load cells were installed in the chains in order to measure the wave induced force due to breakwater movements

Focus on mooring systems, piled moored breakwaters has a lack of studies mainly due to the complexity of analyzing the dynamics of the whole system: soil – pile – breakwater interaction. Last year, complex laboratory test was performed to analyze different aspects of piled floating breakwaters. The most innovative part of the study was the analysis of the rigidity of the system (soil-pile), the number of the rings and the clearance between pile and module. In adittion motions were registered with an IMU device.

3.- CONCLUSIONS

The purpose of this document is to present the whole experience and knowledge gained during last decade combining laboratory tests, numerical modeling and field instrumentation. This experience helped us to understand the complex processes that takes place in this type of structures and contribute to the correct functional and structural design.

222. Seizing opportunities from the Panama Canal Expansion through Adaptive Port Planning: A case study of the Caribbean Port of Barranquilla

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Background and objective of study

The third set of locks of the Panama Canal opened to traffic on June 26th, 2016 enabling the transit of Neo-Panamax **[1]** (NPX) vessels through the 100-year old maritime route. This historic milestone will impact the business cases of port- and transport infrastructure within its region of influence which includes the Caribbean ports such as Bahamas, Trinidad and Tobago, Venezuela, Colombia, Jamaica, Puerto Rico and Dominican Republic. This paper presents a study carried out to first assess the impact of the Panama Canal Expansion (PCE) on the Caribbean ports, and thereafter, to examine how the ports can adapt in order to seize new opportunities created by the expansion. An applied case of long-term planning under uncertainty by using Adaptive Port Planning (APP) framework is presented for a port in Barranquilla, Colombia.

Methodology and findings

A detailed literature study of Panama Canal Expansion (PCE) on Caribbean ports (Soto Reyes, 2017) was carried out. The study concluded that the major short-term impact for Caribbean ports would be a decrease in transhipment container volumes, lost to new direct services deploying NPX vessels calling to the newly adapted ports of the United States East Coast and the Gulf of Mexico. However, due to their privileged geographical location in the crossroad of important maritime routes their development will continue to be intrinsically linked to the Panama Canal beat. The study concludes that an expanded Panama Canal will eventually attract more Caribbean port traffic.

The PCE is expected to reach its capacity around year 2032 (Soto Reyes, 2017) and as the scrapping of old Panamax vessels take place, and the substitute fleet of NPX grows, it is likely that container transhipment business will regain traffic volumes. Thus, the new bottlenecks in the expanded Panama Canal may result in new opportunities for the Caribbean ports.

Like other ports worldwide, the Caribbean Ports are beset with many other future uncertainties related to technology, market and economy, politics and legislation as well as society and environment and yet must ensure functionality, capacity and service quality during their design life time in a sustainable manner (PIANC, 2014a, 2014b; Taneja, 2013) . We advocate an adaptive planning approach that aims at developing plans that take uncertainties explicitly into account, allowing for change, learning, and adaptation over time based on new knowledge and changing circumstances. Such flexible or adaptable plans will allow the port to be functional under new, different, or changing requirements in a cost-effective manner, and seize opportunities.

This paper presents an applied case of Adaptive Port Planning (APP) for a new port in Barranquilla, Colombia. The existing port complex is located on the West bank of the Magdalena river and the new port expansions on the East bank will consist a liquid bulk terminal with two berths, and one multi-purpose berth for the dry bulk and container terminal. The design vessel is smaller than a Panamax vessel and therefore the port will be unable to handle NPX vessels now transiting PCE.

In addition to the uncertainties related to future technology, energy transition, climate change and sea-level rise, One Belt One Road (OBOR) Chinese project (CBBC, 2016) , U.S. Protectionism policies, China's deceleration, India's surge, Latin American integration and upsurge, e.g. "Chile-con Valley" (The Economist, 2012) , the project is confronted by many other uncertain developments. These relate to traffic on Panama Canal routes, trade with neighbouring countries, future development plans of CORMAGDALENA**[2]** in the region, the demands placed on the project, and the investment in hinterland connections, i.e. developing a network of inland intermodal terminals.

Since the project is located next to an environmentally protected area, opposition from the public and stakeholders is likely. Moreover, utilities supply from the West bank to the terminal represent a logistics issue for the construction of the terminal. Decay of transhipment on Caribbean ports, scrapping of Panamax vessels due to economies of scale from NPX and other Post-Panamax categories of vessels and deepening of U.S. East Coast and Gulf ports represent some other uncertainties. A major opportunity is LNG**[3]** business as LNG becomes the "cleaner" fuel of the future.

After having identified critical uncertainties, i.e., vulnerabilities and opportunities, actions are proposed to make the existing masterplan of the port expansion robust.

The paper further suggests that a monitoring system be set up that scans the external environment for new developments and alerts planners of the need to implement the above actions.

Conclusions

We should move from risk management to uncertainty management and, from static strategic planning to dynamic adaptive planning. Accordingly, such uncertainty management and dynamic planning should be deemed as essentially interlinked and contemporaneous. Adaptive port planning is a comprehensive, coherent and integrated methodology to incorporate flexibility into port infrastructure projects.

The Panama Canal expansion will certainly bring cascading impacts on the ports and logistics platforms of the Caribbean region. Initially, the decrease of transshipment containers volumes, lost to new direct services deploying Neo-Panamax vessels. The escalated scrapping of old Panamax vessels will also have its effects. The eventual capacity saturation of the expanded Panama Canal around year 2030 may however contribute to the recovery of the container transshipment business in the Caribbean port system.

Hence, uncertainty is omnipresent as far as this point, especially when many of the estimations are based on uncertain assumptions of different alternatives for sailing patterns, mergers and alliances, innovative technologies, and global economy´s outlooks.

For the specific research case study, flexible options generally resulted in a more viable project.

Overall, the Adaptive Port Planning methodology, as applied in this research work, proved to be an innovative and yet pragmatic methodology to tackle the somehow tricky task of valuing flexibility, accomplished by means of the simple and transparent tools such as dynamic forecasting, Real Options Analysis and Monte Carlo Simulation.

Keywords: Uncertainty management, adaptive port planning, flexibility, master plan, Panama Canal Expansion, Caribbean, maritime ports, life cycle, asset management, sustainability.

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[1] NPX vessels: Vessels with the following maximum dimensions 366 meters Length over All (LOA), 49 meters beam, and 15.2 meters draught in Tropical Fresh Water (TFW).

[2] Corporación Autónoma Regional del Río Grande de la Magdalena (CORMAGDALENA)

[3] Liquefied Natural Gas (LNG)

223. The challenges of limiting the environmental impact of fairway projects

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The Norwegian Coastal Administration (NCA) has as a main objective to ensure safe and efficient navigation along the Norwegian coastline. NCA activities encompass the maritime sector of the National Transport Plan (NTP). The NTP outlines how the Norwegian government intends to prioritize resources within the transport sector. Further, the NCA exercises authority and administrative tasks related to the laws and regulations for ports, fairways and compulsory pilot service.

If someone asked what is a “typical” NCA construction project? The answer would be there is no such thing. The Norwegian mainland’s coastline is almost 29 000 km long. By including islands, the total coastline is just over 100 000 km. The coastline has its southernmost point at 57° and the northernmost at 71° north. This presents with a working environment were one must take into account a high diversity, both of biological- and geological factors, when construction projects are planned and conducted. The climate also represent seasonal challenges by e.g. extreme temperatures during winter, storms and ice.

The coast has always been a lifeline for the Norwegian society. Today, 90 % of the Norwegian export revenue origins from activity and resources connected to the sea. Increasing the quality of fairways is a well-known risk reducing measure for vessel traffic. When a new fairway is developed, existing fairways are improved or a harbor is dredged, pollution is often an issue. Industry, including i.e. fisheries, oil and gas support services and shipyards has been, and still is located to the coast and other large water bodies connected to the sea. For decades, it was common practice to use the sea as an easy way to get rid of waste. For the Norwegian ports and fairways, we like to think of this as something that is behind us. Nevertheless, our past environmental sins becomes present, also for NCA projects. Deep layers of various types and degrees of pollution creates challenges and severely increases the project cost and complexity. The removing of toxins and other type of pollution trough a fairway- or harbor project is in most cases a win-win for the environment – if conducted right. Considerations must be made to prevent the spreading of both clean and polluted sediments. This also includes e.g. runoff that contains toxins from a disposal site and in general, or damages on the environment by increased turbidity.

When preparing and executing projects, the governing authority is the County Governors environmental department. 16 out of Norway’s 20 counties (not including Svalbard) has a coastline and is a potential authority when the NCA applies for an environmental permit. The NCA as the construction client owns the burden of proof for whether or not the construction plan, mitigating measures and considerations in regard of environmental issues are satisfactory.

Due to a lack of factual knowledge in regards of some of the challenges NCA projects faces, permits and terms can to a large degree be based on what is considered overly precautionary measures. In recent years, this has in particular been the case for how shock waves from seabed-blasts affects fish, marine mammals and other wildlife. The disturbance from

construction and blasts also influences the time of the year the NCA usually are permitted to work. A common term is that construction is not to be carried out in the period 15th of May - 20th of August. This corresponds to the spring – summer breeding season for birds and other wildlife. Spawning-season for various types of fish is largely stretched between February to October. Based on local knowledge this will also be set as limitations. The NCA experiences that the safety zone set between a blast-site and a spawning area is very varying from permit to permit. This will also afflict the window given for the construction phase. Due to this the NCA now have an internal project aiming to obtain factual knowledge on the possible effects of sea floor blasting.

Another issue is plastic debris from charging tubes in the sea floor, the lack of alternatives to nonel initiation systems and the plastic waste from detonating cords. The NCA does not want to be a contributor to the already enormous plastic-waste issue in the world's oceans. Therefore, we continuously work on reducing waste from our activities.

Statement

By examples of actual projects the Norwegian Coastal Administration (NCA) aim to share experiences – and possible solutions on how to limit the negative environmental impacts in the execution phase in fairway projects. The NCA will present both what we have done well through pre-project planning and execution, when we could have performed better and ongoing internal projects on mitigating measures. Through this, we hope that others that faces similar challenges will be encouraged to contact the NCA for future collaboration and international experience exchange.

224. Optimizing Pier Structures using Dynamic Mooring Forces Modelling

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Mooring facilities in Ports are in general planned several years or even decades ago focusing on smaller ships compared to ship sizes seen today. Ship size has increased considerably in the last and recent years. We are now facing ship length >400m. Thus, formerly planned mooring facilities were often not designed for these kind of Post Panamax ship sizes. The existing international guidelines (PIANC, OCIMF) or local guidelines (EAU, Germany) did not include the latest ship sizes and therefore lead to widely overestimated mooring facilities.

To assess the real capabilities of existing or new planned mooring facilities on piers and in harbours, dynamic mooring simulation can be made. Such methods will in general lead to more realistic loads and help determining the priority for updating the infrastructure. Such analyses can further be used to expand lifetime of existing mooring facilities. DHI has developed a new software to calculate dynamic mooring forces (MIKE 21 Mooring Analysis (MA), DHI, 2017). Compared to other dynamic mooring analyses software, two-dimensional flow fields (incl. infra gravity seiching waves) can be incorporated, which can be of evidence in ports. It was already applied in several ports in Germany. 3 examples will be given to prove the savings and advances of dynamic mooring force calculations.

The existing coal pier “Niedersachsenbrücke” in Wilhelmshaven, Germany, is currently used on the sea side for Post Panmax Bulk Carriers. Additional, Feeder Bulk Carries should use the land side. The construction was build centuries ago and the design ship was clearly smaller than an actual Bulker. Re-assessments of the mooring forces (Albrecht, 2011) took static design loads (wind, current) into account. It turned out, that the static forces on both sides of the Pier can take values close to the maximum static load of the whole pier. Additional dynamic loads have even not been considered. This is particularly critical in the light of future requirements, for with two large Bulk Carriers are to be hosted simultaneously at the pier. To get a comprehensive and more realistic overview of mooring forces to expect, dynamic mooring force calculations combined with wind and currents (from measurements) and passing ships (from a hydrodynamic simulation) were carried out. It could be confirmed, that minor changes in the mooring arrangements would be sufficient to fulfil the future requirements without exceeding the structural maximum loads at the pier. No further reinforcements of the structure are needed.

Hamburg Port Authority (HPA) is planning to enforce mooring facilities along the Elbe at the port entrance to mainly host Ultra Large Container Vessels (ULCVs) while waiting for a suitable berth inside the port. The existing facilities are detached from the river bank and located near the fairway. They are designed for the former Panmax size ships. Using static standard guidelines, like the EAU (Germany), would lead to large groups of piles to host the mooring facilities. Since these berths are mainly used by Ultra Large Container Vessels (ULCVs) wind and currents play an important role. Additionally passing ships have an additional impact. The Hamburg Port Authority decided to use the dynamic mooring force tool from DHI to assess the operational limits of the existing mooring facilities in order to prevent any damage to the

existing infrastructure. Additionally dedicated piles were set to cover some critical situations identified by the dynamic mooring simulations. A general renewal based on static load assumptions could be avoided. A third and very demanding example for dynamic mooring force calculations to improve facilities can be found in Bremerhaven. To manifest its leading position as one of the main ports for the Offshore Wind industry, Bremerhaven decided to support this industry with an improved infrastructural connection. A new terminal located in the “Blexer Bogen” of the Weser river was planned for shipment of offshore components. At the “Blexer Bogen” large Bulker are passing this planned terminal in short distance. Therefore interplay of ship traffic and mooring forces of ships with special size and forms will occur. The main objective of this study was about to prove that drawdown generated by passing vessels does not endanger the applied mooring systems. DHI’s mooring assessment tool in combination with the hydrodynamic module were used to analyse the mooring forces for special offshore installation vessels. Different passing vessels were modelled using the standard 2D hydrodynamic model MIKE 21. The resulting ship waves were compared to in situ measurements to proof the reliability of the model result. As a second step these first order ship waves (draw down) and its corresponding current speeds were coupled to the mooring analysis software in the vicinity of the terminal area. The tool includes the ship geometry of special installation vessels affected by the induced drawdown and calculates the mooring forces due to the relative movements of the floating ship hull. Finally it could be shown, that in general the planned mooring can withstand the forces due to ship traffic (draw down). Only special cases need additional moorings using e.g. shore tension systems.

In all cases the dynamic mooring assessment tool showed good results and finally lead to savings in the design processes. Ship to ship interactions can be dynamically resolved and show more realistic results compared to static approaches.

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225. Driving Assistance Systems for Inland Vessels based on High Precision DGNSS (Research project LAESSI)

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Inland shipping plays an important role within the German transport system. The growth in traffic, increasing ship dimensions, reduced maneuver space etc. place high demands on the responsible skippers. It is expected that future driving assistance systems can contribute to safe navigation.

The project LAESSI (Guiding and Assistance Systems to improve Safety of Navigation on Inland Waterways) aims to develop efficient navigation assistance functions for inland waterway transport. Therefore, nautical information like position, height and heading has to be determined. One main task of the project is the development of a bridge collision warning system, which could provide a timely alert to the skipper, whenever the vessel, particularly the wheelhouse or radar mast, will not safely pass the bridge.

A feasibility study has identified Global Navigation Satellite System (GNSS) technologies as basis for the reliable height determination for such a bridge collision warning system. This approach requires information about the vertical clearance of the bridge superstructure as well as precise height information at least 300 m before the vessel will pass the bridge. The high accuracy level of less than 10 cm in the vertical position requires the use of high precision DGNSS.

The paper will present the derived requirements for inland waterway assistance functions as well as an overview about the overall system architecture. In addition the paper provides information about the high accuracy positioning system, which is based on RTK technology including integrity information. The correction and integrity data together with other waterway information will be broadcasted using the new frequency bands offered from VDES (VHF Data Exchange System). Finally the paper will describe first results gained in demonstration areas at the Rhine and Main rivers.

226. A New PIANC Standard of Practice for Managing Environmental Risks of Navigation Infrastructure Projects

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A working group formed within the PIANC Environmental Commission is developing a standard of practice to support ports and other public and commercial navigation interests in managing environmental risks associated with navigation infrastructure projects. Managing environmental risks from navigation infrastructure involves economic and environmental costs, and is complicated by the diverse range of policies, perspectives, risk attitudes and personal values that influence decision-making. The report will provide a robust yet practical approach to risk management decision-making for the broad range of environmental risks associated with navigation infrastructure. Effectively managing infrastructure project risk must consider multiple physical, chemical, biological, and socioeconomic processes that can span broad spatial and temporal scales. Understanding and clearly articulating uncertainties related to these processes is essential to developing projections regarding future performance of risk management actions and effective adaptive management strategies. An overview will be provided of the structured management process through which actions for reducing environmental risks are identified, evaluated, selected, and implemented. Uncertainty (e.g., short-term infrastructure operations), long-range risks (e.g., climate change), residual risk, resiliency of natural features and the role of sustainability and life-cycle analysis in risk management will be discussed The approach is compatible with PIANC's Working with Nature philosophy, taking into account existing approaches and current best practices worldwide.

227. Pressure Distribution Acting on Breakwater Caisson under Tsunami Overflow

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The caissons of many breakwaters either slid or overturned due to overflow pressure of the tsunami triggered by the 2011 Tohoku earthquake. For example, the offshore tsunami breakwater of Kamaishi Port, constructed to protect Kamaishi City, was destroyed by the huge tsunami overflowing the breakwater. Up until the 2011 disaster, tsunami overflow had not been considered in breakwater design; rather, it had been estimated by Tanimoto's tsunami force formula. However, Tanimoto's formula cannot express the force of tsunami overflow. Since the widespread damage engendered by the Tohoku tsunami overflow, the pressure formula under tsunami overflow has been studied using hydraulic experiments, and, in 2015, the experimental results were introduced in the Tsunami-Resistant Design Guideline for Breakwater. In the guideline, the new tsunami pressure formula is expressed by the quasi-hydrostatic pressure due to the tsunami water level. The front and the rear pressure are expressed as modified hydrostatic pressures. The modification factor is 1.05 at the front and 0.9 at the rear. Many breakwaters in Japan have been inspected and redesigned using the new design formula. However, some design problems remain. Because the new design formula is intended for simple rectangular caisson-type breakwaters, the uplift and overburden pressure are not considered; instead, only the buoyancy force acting on the caisson is considered in the guideline. In the hydrostatic condition, the buoyancy force is equivalent to the weight of the fluid that would otherwise occupy the volume of the object, i.e. the displaced fluid. The buoyancy force is equivalent to the pressure difference between the bottom and the top of the immersed object. However, under tsunami overflow, the pressure difference between the bottom and the top of the breakwater caisson, especially a caisson having a large parapet, can be extremely larger than the buoyancy force.

In order to examine this buoyancy force, a series of hydraulic experiments were conducted. The experiments were conducted in an experimental wave flume in which a large pump was installed to produce tsunami overflow. Pressure gauges, water level gauges, and velocimeters were installed at the top and bottom of the caisson model. The caisson model (32cm high, 26.4cm wide) was built on a scale of 1/36. Tsunami height in the experiment ranged from 4 to 14 cm. The experimental results clarified the following matters: 1) The uplift pressure distribution is a triangular shape whose front (rear) end pressure is almost the same as the static water pressure corresponding to the front (rear) water level. 2) The front end overburden pressure is smaller than the static water pressure corresponding to the water level. This small pressure is caused by the eddy at the front edge of the caisson. 3) The large uplift pressure and the small overburden pressure cause the upward force to be larger than the buoyancy force. This upward force degrades the stability of the caisson, especially a caisson having a large parapet.

228. Development of coral reef propagation technology through mass culture, transportation and settlement of coral larvae, in Japan

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The coral reef is an area of primary production that cultivate ecosystems with high biodiversity, and it is also an important area as tourism resources. However, many of the coral reefs around the world tend to decline because of rising seawater temperature caused by global warming.

Meanwhile, the upsizing of ships has become a global trend along with the increase in demand for logistics, so dredging of routes and construction of harbors and fish ports are increasingly important. As a result, coral reef area came to be directly changed and coral growth came to be indirectly influenced by the coastal area development.

For these reasons, in Japan, as a measure to avoid, reduce or compensate for the influence on ecosystems in the development of coral reef, we have been developing coral reef propagation technology. Here we introduce the efforts of coral propagation technology and report on the result.

Our development of coral propagation technology began with producing a large number of juvenile corals by sexual reproduction. In the period from 2006 to 2008, we succeeded in producing about 30,000 juvenile corals in aquariums on land.

In addition, we developed an artificial foundation for efficiently transplanting a large number of juvenile corals, and made it possible to efficiently transplant about 200 juvenile corals per person in a day's work. Now, since the survival rate of coral one year after transplantation is as high as 80 %, we believe that our technology has been mostly established.

However, the technology to produce juvenile corals in aquariums on land is costly, so we are currently undertaking the development of technology that can produce a large number of juvenile corals at a far lower cost. For that purpose, we developed equipment that is capable of collecting, rearing, and seeding natural coral larvae in situ. With this equipment, it is possible to produce corals at a considerably lower cost compared with the method of producing juvenile corals in aquariums on land, and to transplant a large amount of juvenile corals.

229. Towards Sustainable Port Infrastructure through Planned Adaptation

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Nowadays, long-term planning of (waterborne) infrastructure is interwoven with the concept of sustainability. International port-related organizations such as AAPA, IAPH, ESPO, OECD, PIANC, EPA, UNEP, UNCSD, USACE and WWF[i] are developing and regularly updating guidelines and codes of practice for sustainable development of ports and waterways. Literature over sustainable ports advocates common sustainability guiding principles and suggests that a more sustainable port can be realized through embracing the four perspectives of engineering, ecosystem services and governance in an integrated approach to port development. However, given the current uncertain environment, infrastructure planning also requires anticipating the long-term future under which the infrastructure must function. This future may be characterized by uncertainties leading to changing demands and new constraints. In view of this, it is apt to state that sustainable infrastructure should not only achieve economic, environmental, and social objectives, but should be robust meaning that it performs satisfactorily under a wide variety of futures and able to be adapted over time to (unforeseen) future conditions (Haasnoot, 2013). Literature over waterborne transport infrastructure make a mention of sustainability, adaptability and flexibility. Though many guidelines for developing sustainable plans exist, not much literature can be found over how to account for uncertainty in port masterplanning.

The objective of this paper is to propose some guidelines for incorporating uncertainty considerations in the process of port Masterplanning using the strategy of “planned adaptation” by synthesizing learning from four Masterplanning case studies. The paper begins by presenting a detailed literature review of current guidelines for port development to examine their handling of uncertainties. Next, it presents a comprehensive approach for sustainable port masterplanning under conditions of uncertainty; similar approaches have been applied for Water Management, Climate Change Management and Transport policies related to energy transition with success. This approach, which has its roots in Assumption based planning, is based on “planned adaptation” which is the result of deliberate decisions, based on an awareness that future might change and that action is required to return to, maintain, or achieve a desired state (Walker, 2013). The guiding principles for the design of a sustainable and adaptive port master plan are:

- explicitly define short-term goals and long-term objectives and try to connect them during the planning process;
- explore a wide variety of relevant uncertainties, varying from a global to local scale, and analyse whether the uncertainties present an opportunity or vulnerability for the plan;
- commit to short-term actions fordealing with uncertainties while keeping options open and preparing appropriate actions to meet objectives in plausible future scenarios;
- continuously monitor the external environment and take actions if an uncertainty appears ora scenario materializes.

The above approach is applied to the following (theoretical) cases, in order to create sustainable masterplans:

- Europoort, Port of Rotterdam, The Netherlands
- Port of Barranquilla, Colombia
- Port of Kuala Tanjung and Port of New Priok, Indonesia

Next, in a bottom-up approach, these case studies are analyzed to make a comparative study over the major uncertainties for port Masterplanning. On a global scale, ports are confronted with similar uncertainties related to: changing demographics, changes in global production patterns, consolidation of shipping lines, new technologies; energy transition to renewable energy sources; climate change and sea-level rise, increasing attention for sustainable growth, shift of economic influence to developing regions; USA protectionism policies, China's decline, India's surge and projects such as new panama canal, One Belt One Road (OBOR). These uncertainties can present vulnerabilities or opportunities for the port. Over short-term, local conditions, local and national regulations, port organization structure, and international standards play a role. Further, the paper present case studies illustrating how "planned" adaptation can help to deal with short- and long term vulnerabilities, and seize opportunities in order to meet the planning objectives. A monitoring system, that scans the external environment for new developments and alerts planners of the need to implement planned adaptation is essential to the proposed approach.

The paper concludes that adaptability and robustness belong under the overarching definition of sustainability. In the present uncertain environment, "monitoring and (planned) adaptation" is the preferred strategy for port planning .

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[i] AAPA: American Association of Port Authorities

EPA: US Environmental protection Agency

ESPO: European Sea Port Organization

IAPH: International Association of Ports and Harbors,

UNEP: United Nations Environment Program

UNCSD: United Nations Conference on Sustainable Development

PIANC: Member World Association for Waterborne Transport Infrastructure

USCAE: US Army Corps of Engineers

"Why the presentation will be of interest and benefit to conference attendees"

In the current uncertain environment, "sustainable" infrastructure should not only achieve economic, environmental, and social objectives, but should be robust meaning that it performs

satisfactorily under a wide variety of futures and able to be adapted over time to unforeseen future conditions. Though many guidelines for developing sustainable plans exist, uncertainty and adaptability are addressed in a sporadic manner. However, it is generally acknowledged that the most difficult challenge faced by many stakeholders in the infrastructure sectors is the incorporation of uncertainties into the decision making process.

This presentation will familiarize the attendees with major future uncertainties confronting port planners, incorporation of flexibility and adaptability considerations in port planning and key signposts that need to be monitored to detect changes in the external environment. Since case studies of masterplanning of three very different ports (Europoort in Rotterdam in the Netherlands, Caribbean Port of Barranquilla and Port of Kuala Tanjung and New Priok Port in Indonesia), are presented, it makes for a very interesting comparison.

230. Application of a Maneuvering Simulation Center and Pilots Expertise to the design of new ports and terminals and infra-structure optimization in Brazil

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In a recent initiative, the Numerical Offshore Tank Laboratory of the University of São Paulo (TPN-USP) established a research partnership with the Brazilian Maritime Pilots Association (CONAPRA) for the development and enhancement of a Maneuvering Simulation Center for port, rivers and offshore operations. The core simulator code is named SMH (Portuguese acronym for Maritime and Waterways Simulator) and it is an engineering tool used for the analysis of new operations in the Brazilian ports, in order to improve their efficiency in the context of the increasing oil and gas production and commercialization as well as the enhancement of international commercial trades. The accuracy of the mathematical model is an important requirement for a maneuvering simulator dedicated to engineering projects. The engineers, pilots and captains must rely on the dynamics of the simulator since it will be used to give answers to questions related to maneuvering analysis. The simulator can be used to evaluate new channels design, tugboats requirements, environmental window, DP system analyses, or even to define the maximum dimensions of vessels in an approach channel or basin, among others questions. Therefore, the joint work of the simulator development team and the pilots is crucial to obtain such a calibrated and reliable simulator, combining the local expertise of the pilots and their knowledge about ship handling and behavior in confined waters to the technical skills of the researchers. This paper will present the mathematical model adopted in the simulator and the calibration procedure based on results from sea-trials and pilots feedback. The tugboat operation both in vectorial and manned simulation models will also be detailed. A number of applications in Brazilian coast will be described, including ship-to-ship operations, analysis of the maneuvering of larger containerships in the existing infrastructure, evaluation of new terminals in design stage with unsheltered turning basin among others.

231. Linear Scheduling as a Data Visualization Tool for Construction Progress Analysis – A Case Study from the Panama Canal Expansion Program

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Due to an increasingly competitive environment and the thriving of more ambitious and complex projects, construction managers have been forced to enhance their project management skills to achieve successful results in terms of cost, quality and time. In order to do so, the implementation of innovative scheduling tools that allow project management teams to evaluate multiple scenarios or risks at the planning stage of a project becomes a crucial factor to foresee and mitigate conflict situations. Moreover, the quest for and use of such tools should not be limited to the planning stage, since there is also a need to identify and mitigate issues during the execution phase and maximize the efficiency of the Project Manager's decision-making process by providing a clearer panorama.

This tendency requires more focused scheduling tools that need to be chosen depending on the type of project at hand. The critical path method (CPM) is the most utilized scheduling tool in the construction industry worldwide. Nevertheless, there are types of projects in which CPM's usefulness decreases because it becomes complex and difficult to use and understand, becoming impractical and losing its core purpose. Alternative scheduling tools designed for specific types of projects can prove to be more suitable and useful than CPM solutions. Here is where linear scheduling takes importance.

Traditionally, linear scheduling is used as a visual representation of a construction schedule for projects that follow a linear production path with a large number of repetitive activities such as: highways, bridges, pipelines, dams, high-rise buildings, rail construction projects, among others. The linear schedule displays work sequence information similar to that on a CPM schedule or Gantt chart in a way that is easier and more intuitive to interpret. This paper explores the potential for broadening the applications of this tool for critical decision-making analyses by displaying and correlating information that would be less apparent otherwise.

A case study illustrating the use of forensic linear scheduling as a data visualization tool to quantify delay is offered as an example of the technique was applied in the Borinquen Dam 1E construction, a 5 million cubic meter (6.54 million cubic yards) earthfill dam constructed by the Panama Canal Authority as part of the USD 5.2 billion Panama Canal Expansion Program. The case study demonstrates how as-built information can be introduced into a linear schedule format to perform forensic claim analysis and support. Variables such as daily rain precipitation, geological conditions at the dam's foundation and unattended available areas to work are displayed and clearly identified in a single linear schedule to graphically depict the project's as-built condition based on daily reports. By using a contractually binding source of information such as the project's daily reports, an objective representation of the project facts is obtained by this method, which allows to potentially resolve disputes.

In addition, this paper also proposes an alternative method for identifying and managing the scheduling aspect of geotechnical risk using a linear-scheduling-based tool that was also implemented for the construction of the Panama Canal's Borinquen Dam 1E. The alternative

method is compared to the traditional format that involves expert interpretation of subsurface information in order to communicate the risk properly. A model was developed using linear scheduling and incorporating stochastic simulations in a way that the impact of geotechnical risk is assessed as a function of the expected underground conditions, which can be displayed directly in the linear schedule. The analysis finds that the method effectively provides a better understanding of the risk management effort and introduces a way to incorporate variables into the assessment that otherwise would not be available for quick reference, such as the interpretation of the geological profile of the project site. By doing so, a connection is made between technical aspects (such as the geotechnical interpretation) and the project management effort.

This paper's contribution to the body of knowledge is to provide innovative applications of the linear scheduling method to graphically depict data that is not readily available when using traditional means, increasing the effectiveness of decision-making and improving the way construction projects are managed.

232. Panamá and the globalization of China´s Silk Road Initiative

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Eddie Tapiero

Panama Canal, Panama

On June 12, 2017 Panama and China established diplomatic relations. This new step in the relation helps to enhance the opportunity for China´s investment in the country. But Panama is not like any other country. Panamá has a Canal and is a strategic node for the global maritime trade. Since 2013, China has been driving the Silk Road initiative as a way to improve global integration through commerce and to promote economic growth in Eurasia among other things. Still, the newly established relations create an opportunity to expand the initiative to Panama. This expansion could impact significantly global trade, especially in the Atlantic, and could further integration and globalization in the world. However, there are some key factors that need to be considered in order for it to work. The Belt and Road initiative encompasses not only the commercial dimension but other dimensions as well such as: Geopolitical, Security, Financial, Economic, and Cultural among others. Yet, if it works, the Belt and Road initiative will certainly have a big impact on trade, trade routes and on the future development of the world.

233. Planning, designing and successfully executing 4m m3 of dredging and dry excavation to expand PSA Panama's container terminal.

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Of all the obstacles in the construction of the Panama Canal over a 100 years ago, it was the complex, varied geology that possibly provided the biggest challenge, being the primary cause for the failure of the French Canal Company to construct the channel. When planning a new construction project involving removal of more than 4m m3 of material for expansion of PSA's container terminal at the Pacific Entrance of the Canal, obtaining information and how to structure the project was of prime importance.

In this paper the authors will explain the development of the project through the various stages, from concept design to successful execution, showing how knowledge and understanding of the site developed and how this changing information was used in the design, tendering and wording of the construction contract.

The solution adopted by the contractor, using a combination of dry excavation, together with back hoe, trailer and cutter-suction dredgers, was developed based on detailed experience gained from working in similar conditions nearby in Panama, and also taking into account the construction of 800m of new quay deck suitable for Post-Panamax vessels.

234. River Information Services and e-Navigation: Harmonization of Information Services and Portfolios

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The international concept of "e-Navigation" has been in development for over a decade led by IMO, IALA, and other international maritime bodies. The concept of River Information Services (RIS) has been developed and implemented on waterways around the world since the 1990s. While these concepts have developed in parallel, there has not been close coordination between the. At the same time, the technologies and concepts central to e-Navigation (such as AIS and Vessel Traffic Services) are also included in RIS. The PIANC RIS Guidelines were first published in 2002, with the latest edition published in 2011. The Guidelines are currently under revision, and as part of this effort a study was conducted to investigate the applicability of e-Navigation developments to RIS that may be appropriate for incorporation into the updated Guidelines. This paper and presentation will summarize the e-Navigation and RIS concepts, identify similarities and differences in their structure and implementation, and identify opportunities for harmonization between RIS and e-Navigation. In particular, the close parallels between the suite of RIS Services and Key Technologies, and the developing e-Navigation Maritime Service Portfolios will be addressed. It is possible that these services can be harmonized to the mutual benefit of RIS and e-Navigation, and that additional benefits can be realized for maritime and inland waterborne transport.

235. Can better turbulent mixing reduce density induced ship forces during lockage?

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For navigation locks, the forces on moored ships during the lockage are a most relevant design criterion, as they are a measure for the safety of the ships during the locking process. In most cases, these forces are controlled by the choice of the filling system and by the valve schedules. For locks at the boundary between fresh and saltwater regions, the situation differs significantly from locks with the same water density at both sides. While filling systems with distribution systems (longitudinal culverts, pressure chamber under the lock chamber etc.) are rather robust in terms of the impact of density differences, through-the-head systems show a significant impact of the density induced currents on the vessel.

In this presentation, the impact of the density induced currents on the vessels for different through-the-head filling systems will be shown on the basis of three-dimensional numerical model tests. A special focus will be put on the question whether a better mixing in the area of the upper head will be a viable solution to mitigate the density induced currents and thus the forces on the vessel. This mixing process can be induced by the shape of the filling system and is very effective for systems with freshwater only (or saltwater only). In these cases, the mixing distributes the momentum of the flow over a larger area of the chamber and thus reduces the forces on the vessel. Here, the effectivity of this process will be evaluated for situations were additionally density currents occur.

236. Bending vibrations of the Afsluitdijk gates subjected to wave impacts: a comparison of two design methods

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A vast amount of flood defence structures contribute to the safety and water regulation in coastal areas. Gates form essential parts of flood defence systems as they regulate the discharge between bodies of water (Erdbrink, 2014). During storm conditions these structures are often subjected to high water levels and waves. When breaking waves impact on a gate, this generally involves high peak pressures of short durations in the order of a few milliseconds (Bagnold, 1939; Hofland, Kaminski, & Wolters, 2011; Ramkema, 1978). Such impulsive loads lead to vibrations of the structure, potentially amplifying internal stresses compared to the static situation.

Due to the two-way interaction between the structure and fluid, detailed prediction of these dynamic interactions can become very complex. Advanced numerical methods exist, but are still too computationally costly to test a wide variation of boundary conditions. For this reason, in present engineering practice generally a simplified quasi-static approach is taken, in which an amplification factor is applied to the time-varying load to account for vibrations (Kolkman & Jongeling, 2007a, 2007b, 2007c). However, such an approach lacks far behind in accuracy compared to design standards in other fields, and gives little insight in the actual behaviour of the structure. Not knowing the exact dynamic behaviour of the gate requires conservative design assumptions leading to suboptimal design.

For this reason, a semi-analytical model using fundamental theory of dynamics of continuous systems was developed by the author that fulfils these requirements. In the present study, this model is applied to the reference design of the sluice gates in the Afsluitdijk. Results are compared to a standard, simplified quasi-static design approach, showing the benefits of more accurately predicting the dynamic behaviour of gates.

The discharge sluices of the Afsluitdijk contain double sets of gates, of which the closest to the Waddensea will act as flood gates in the future situation. During storm conditions, these gates will have to withstand the loads resulting from the water level difference and incoming waves corresponding to 1/10,000 return period conditions. Due to the presence of the overhanging monumental defence beam, breaking waves were expected to result in high impact pressures. This was confirmed in physical scale experiments performed in the Deltares Scheldegoot (Hofland, 2015), where peak pressures were measured corresponding to 32 times the significant wave height H_{m0}. Since the duration of the measured integrated peak impact force was of the same order as the first dry natural frequency of the existing gate reference design, the maximum amplification factor for impulsive impacts was applied to obtain the design load. This results in such a large required strength of the gate and the related lifting mechanism and towers, that the decision was made to remove the monumental defence beam in order to reduce the impact pressures.

The analysis based on the semi-analytic model approach is more detailed on several aspects. First of all, the interaction with the surrounding fluid is taken into account. The hydrodynamic mass and stiffness are expected to have a substantial effect on the natural frequency of the

designed gate, leading to a different response and potentially lower amplification. Secondly, the effect of the temporal and spatial distribution of the measured wave impact signal on the gate's response and required strength is studied. Finally, multiple gate vibration modes are included in the analysis. The combination of these effects is expected to result in a more efficient design than the existing one, which has benefits for the surrounding structures as well. More generally, it shows that the developed semi-analytical model approach efficiently predicts vibrations of flood gates with more accuracy than existing design methods, leading to more economic designs. (Further) validation of the model is still required, so small scale model tests are discussed to obtain this validation.

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237. Early Warning System to Support Construction & Management of Port Infrastructures: The Case of Tx-1 Açu Port Construction

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INTRODUCTION

Harbors construction and management in locations highly exposed locations (i.e. to ssevere met-ocean conditions) areis a very challenging issue. Met-ocean conditions highly affect the normal development of construction activities, seriously jeopardizing every task at the surroundings of the water-land threshold. Construction managers demand, not only the information about wave and wind conditions during construction, but also their influence and interference with daily construction activities, first, to reduce accidents, and second, to improve the management of the construction agenda along its different stages.

Once Ones the construction of the port has been completed, it is necessary to manage the exploitation and planning of port activities through a, reliable met-ocean forecasts are necessary, in order to to optimize the available resources.

This work study presents an integrated early -warning system to support construction and managemente the harbor infrastructures, providing an answer to such demands exposed at different construction stages. The system is designed to help and manage the daily schedule tasks in harbor under construction stage or the final stage, with the aim of being ais designed as a flexible tool to be relocatable in any location. The system is oriented to obtain the short and mid-term (within 180-hour prediction) characteristics of met-ocean conditions (waves, water level and wind) at the harbor surroundings in the site, as well as, the wave-structure interaction characteristics for any stage of the construction phase. The system goes beyond the classical met-ocean alert system, because integrates the use and coupling of: different numerical models,; downscaling techniques;, and met-ocean databases. ,Coupled with construction protocols related with any specific activities at any location along the harbor and under different construction stages.. One of the main objectives is to help the construction managers to improve and establish human safety threshold,s r. Related with the different tasksjobs along the harbor, exposed to the met-ocean variables, and interacting with the unfinished harbor structures.

The system allow to saveoptimize exploitation and construction costs and to achieve the individual deadlines of every task or activity. Note that some construction operations are very expensive, because use resources very specialized, and conditioned to be used only during specific met-ocean conditions along enough time-windows.

METHODOLOGY

The early warning system presented in this work contains different modules, which can be adapted according to the harbor location, the construction procedures and the met-ocean complexity.

First, deep water a met-ocean module (as the main core of the system) should be defined, covering two main tasks: a) the wind, wave and sea-level hindcast analysis, based on high-accurate and validated global datasets; and b) the 7-days hourly prediction for wind, wave and sea-level forecasting system, such as NOMADS system (provided by NOAA).

Second, the downscaling module designed to propagate the met-ocean variables from deep to coastal zone and to any location near, in front and/or inside the harbor.

Third, the met-ocean-structure interaction module that contains high-resolution analysis for one or more of the following processes: harbor agitation and resonance due infragravity waves (mild slope and Boussinesq modelling); wave run-up and overtopping (laboratory data, analytical formulations and CFD modelling); scour and silting (analytical approximations and CDF modelling); moored ship response (CFD, Boussinesq and potential theory approximation); dredging (measurements and dredge protocols); and wake waves (Boussinesq modelling), considering any construction stage for any bathymetric characteristics and any unfinished harbor structure geometries.

It is important to note that the information provided by this third module is relevant because is combined with the construction activities, recommendations and protocols along the breakwaters, basins, and berthing zones, as well as, the crucial importance in the use of CFD numerical modelling to cover the lack of semi-empirical formulations in literature for unfinished breakwater cross-sections. In particular wave overtopping information (i.e.: mean discharge, maximum volume) is considered as a crucial product to be crossed with secure thresholds related with the different construction works to determine its viability and safety.

Finally, the system can include a fourth module dedicated for the assimilation of real-time measurements provided by met-ocean data (nowcast), as a quick quality control module for each variable predicted.

The robustness of the early warning system makes it suitable for the construction stages, as well as for the optimization of the operation of these infrastructures once the works are finished.

RESULTS

All the modules are integrated in a friendly web-based interface, available 24/7 service for the managers. The web gives a quick understanding about the daily activities at the different areas of the port. Information is daily updated and if required, sent also by e-mail to the managers.

One example will be shown during the presentation for the development and adaptation of an early warning system for the construction of Açu TX-1 terminal in Brazil.

In 2013, the company FCC Citizen Services within the Joint Venture FCC Tarrio TX-1 Construção LTDA started the construction of the TX-1 terminal of Açu Superport in São João da Barra, 315 kilometers north of Rio de Janeiro (Brazil). The works include the construction of a breakwater, composed by a 600 m long rubble-mound breakwater 600 m long (Core-loc 10T) and a 2.100 m long vertical breakwater (47 reinforced concrete caissons), with a crest at +10 m elevation.

To support the construction of Açu Port, a high-resolution operational system in the port was developed, ad-hoc for the FCC constructive resources and techniques.

This operational system allows planning the operations in advance (more than a week forecast) and realistic (assimilating in-situ instrumental information), from the numerical prediction of wind, sea level, waves, long-waves, agitation and overtopping, taking into account the

geometric evolution of the works in each construction stage. The system produces daily safe working conditions (1) to transport the caissons from Río de Janeiro to the port of Açu, (2) to construct the caissons, (3) to anchor the caissons and (4) to construct the crest.

238. Piaçaguera Channel dredging case: Confined Aquatic Disposal - CAD as an alternative for the destination of sediments not available to the ocean disposal.

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The Piaçaguera Channel, located in the Santos Estuary, is an important navigation route linking the TIPLAM and USIMINAS terminals to the navigation channel of the Santos Port, considered the most important port of South America.

For years the Piaçaguera Channel could not be fully dredged due to the existence of environmental restrictions on direct oceanic disposal, related to the presence of inappropriate sediments in the channel.

During 2015 and 2016 the environmental restoration process initiated with the dredging of approximately 300,000.00 cubic meters of sediment not suitable for oceanic disposal, while TIPLAM new berth implementation dredging occurred. The initial solution for this issue was the use of geobags for sediment confinement at a CDF (Confined Disposal Facility), built at a site contiguous to the TIPLAM area.

Due to the significantly larger volume of material that needed to be dredged for maintenance and deepening of the Piaçaguera Channel, in the order of 2.3 million cubic meters, it was necessary to find an alternative solution from the one used in the TIPLAM berths implementation. In this way, several engineering and environmental studies were carried out in the search for a technical, economic and environmental solution that would allow the safe handling and disposal of the sediments not suitable for oceanic disposal from the Piaçaguera Channel. The decision matrix indicated the better alternative as an underwater Confined Aquatic Disposal - CAD cell in the interior of the Santos estuary, near the Piaçaguera Channel, in an area duly licensed and authorized by the Brazilian authorities based on rigorous and complex environmental studies carried out to obtain the permitting.

The CAD's main purpose is isolate the dredging material of lower quality inside the subaquatic cell which will be capped with better quality material. The disposal can be in natural depressions in the seafloor, in borrow pits in the seafloor from mining operations (e.g., beach nourishment), or in specifically designed and constructed cells to contain the contaminated dredged material, what is exactly the case at Piaçaguera Channel.

Thus, during the years 2016 and 2017, an underwater CAD cell was built to accomodate aproximadely 2.3 millions cubic meters using different dredging methodologies and following strict control and monitoring standards, with the opening of the cell being completed in June 2017.

Once the CAD was opened, it began to be filled with the dredged material of the Piaçaguera Channel. The first step of filling was finalized on December 2017, since then the deposited material is consolidating by its own weight for a few months until optimum density is reached so the second step of filling can be carried out and, subsequently, the CAD will be capped with suitable material to isolate the lower quality material disposed inside the CAD.

The objective of this article is to present the history, criteria and premises that support decision making for the use of an underwater CAD cell as an alternative for the dredging of the Piaçaguera Channel, as well as the constructive methodology, technical management, environmental controls and learned lessons in the distinct phases of the CAD implementation.

239. Planning, management and supervision of dredging works.

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Brazil has 34 Public Maritime Ports distributed along about 7,500 km of coastline. In each of these Ports there are different terminals, some administered by public agencies, while others leased to private companies. Access to these terminals takes place through channels of different dimensions and intricacies to navigation whose competence to dredge, whether for maintenance or even deepening, pertains to the Federal Government or the local port authorities. Exceptions to this rule occur in the Private Terminals, located outside Public Ports jurisdiction and whose competence of dredging keep up to the administration part.

Significant advances have occurred in the last decade with foreign dredging companies enter in the Brazilian market, fact that enabled the implementation and maintenance of several navigable waterways in Brazilian Terminals. But if, on the one hand, legislation and even governmental programs made it feasible to carry out dredging works of greater magnitude and complexity in Brazilian jurisdictional waters, many works did not reach the proposed objectives due to the lack of planning before the dredging execution and precarious management and supervision of such works.

This article presents good practices of dredging control and management in maritime terminals that ensure the adequate technical, financial and environmental control of the works, and helping to reduce waste of public and private resources and minimizing risks.

240. The future of River Information Services – beyond borders and transport modes

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Inland Waterway Transport (IWT) has the potential of moving significant amounts of cargo across the European continent. River Information Services (RIS) have been created to advance IWT in terms of safety and efficiency of transports by means of telematics, with the ultimate goal to improve its share in multi-modal transport chains. Since the beginning of the creation of RIS around the millennium within co-funded European projects, the EU has been actively supporting the RIS initiative, which led into a European Directive (2005/44/EC) on the implementation of RIS in the member states.

Until today EU member states have set up national RIS infrastructure based on EU RIS standards. The introduction of especially AIS and electronic charts on board has significantly contributed to safety of navigation.

However the overarching goal of increasing efficiency and the better integration of IWT into multi-modal transport chains is still not in reach. One of the main reasons is that the national RIS systems do not facilitate the necessary level of data exchange across borders and with logistics users. In 2015 the project CoRISMa (RIS-enabled Corridor Management) has developed the concept for the provision of RIS along transport corridors, based on services beyond national borders and clearly including logistics services. The concept can clearly be seen as the next evolutionary step in RIS.

The currently running project RIS COMEX (RIS Corridor Management Execution) will implement basic RIS Corridor Services along the high-priority waterway network in Europe until 2020. It will create the ability of national system to exchange data with centralised services and paves the way for future European services.

Still, waterway authorities are limited in the portfolio of services that shall be implemented and offered by the government. But RIS includes the necessary interfaces for private initiatives to create value-added services that use RIS data.

Under the umbrella of e-freight and embedded into multiple EU-funded research projects, serious attempts have been made and are still ongoing to progress with the multi-modal exchange of digital transport information for logistics purposes. In line with the Digital Single Market Strategy, the European Commission has launched the DINA (Digital Inland Waterway area) initiative which aims at fostering the digitalisation of logistics information flows in inland navigation.

The Horizon 2020 (European Research Framework Program) project “Architecture for EurOpean Logistics Information eXchange” (AEOLIX) started in September 2016 and aims at overcoming the current fragmentation of digital logistics information by creating a neutral platform which allows to connect data streams from different sources and transport modes and provide easy access to the information for logistics players. IWT and RIS will be parts of the AEOLIX “ecosystem” which shall act as communication hub between different transport modes and between governmental and private stakeholder.

The proposed paper will present the current state-of-play of RIS in Europe, highlighting several national showcases and best practices. It will further introduce the concept of RIS Corridor Management, give examples of intelligent RIS Corridor Services and present first results of the ongoing RIS COMEX project. It will then show potential application scenarios for the use of RIS in multi-modal logistics and present related concepts from the AEOLIX project.

The paper will conclude with an outlook of the future trends and development in RIS beyond the year 2020.

241. The introduction of Inalnd AIS AtoNs on the river Danube.

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Aids to Navigation (AtoN) have a major impact on safety of traffic on inland waterways. Traditional AtoNs like buoys or traffic signs are key to marking the navigable fairway and inform about dangers or relevant infrastructure (e.g. berths) in a harmonized way.

However these traditional AtoNs sometimes have issues with reliability or visibility. Strong current, floods, ice or vessel allisions may cause buoys drifting from their intended position or make them sink. Situations like strong back light, fog, snow or heavy rainfall may cause problems in detecting and correctly interpreting buoys or landmarks. Lights atop AtoNs have improved the situation but require additional efforts in verifying the correct functioning of these electrified devices in a hostile environment.

The Automatic Identification System (AIS) includes a possibility to equip and type of AtoN with an AIS AtoN station. This station called “Physical AIS AtoN” monitors its position and regularly broadcasts its name, type and position to all other AIS stations in communication range. This works well in the maritime environment since buoys tend to be very big and can carry large batteries and solar panels necessary to power such AIS devices.

In addition the so called “synthetic monitored AIS AtoNs” make use of alternative communication technologies such as GSM or satellite communication to send the status of the AtoN to an onshore system which processes the information and relays it to the AIS link using shore based AIS base stations. In both cases the AIS AtoN information will be displayed as a generic symbol in an Electronic Chart System (ECS).

On European inland waterways buoys are significantly smaller than in the maritime field and do not provide the possibility to carry huge weights. Still administrations want to introduce electronic monitoring capabilities for AtoNs in order to make the maintenance procedures more efficient and more focussed.

In addition the waterway marking on European inland waterways is done according to the European Code for Inland Waterways (CEVNI). CEVNI defines different/additional objects than IALA which doesn’t not allow for a direct usage of the AIS AtoN report (AIS message 21) as defined in the global AIS standard.

Given these circumstance the experts in Europe have been created a method to code the AtoNs as defined by CEVNI into the standard AIS AtoN report while ensuring full backwards compatibility with the maritime world. Further the European River Information Services (RIS) Expert Groups (EG) have defined a method for the display of Inland AIS AtoNs on Inland Electronic Chart Systems (IECS) in a way that reduces clutter and links the AIS AtoN object to the related static AtoN object coded into the traffic regulation layer of the Inland Electronic Navigational Chart (IENC).

The proposed paper will introduce the framework for the introduction of “intelligent” buoys on European inland waterways. It will discuss different technical solutions with their pros and cons and present guidelines for deciding on the right technical solution.

The paper will introduce the method created to code the CEVNI AtoNs into the maritime AIS AtoN message and will finally present the new and innovative solution how to present Inland AIS AtoN information in IECS.

The presentation will be supported by examples from a field trial which is scheduled to start in Austria in the first quarter 2018.

242. Fiber Reinforced Polymer (FRP) Composite Implementation in Navigation Structures

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The U.S. Army Corps of Engineers (USACE) maintains 12,000 miles of inland waterways in the United States which contain 200+ inland navigation structures such as locks and dams. Approximately 565 million tons of cargo is moved along these waterways and through these structures annually. The majority of these structures were constructed in the 1930-1950 time period with a 50 year design life. Due to national budgetary constraints, these aging structures are not being replaced, but simply maintained. However, the rate of degradation due to corrosion and wear is exceeding the rate at which they can be maintained. The risk of a prolonged failure of components to these structures, which could have a devastating effect to commerce, is becoming more likely every year. For this reason, USACE has placed a high priority on developing novel materials to repair or replace aging infrastructure in order to extend the structures' working lifetime. Emphasis has been placed on cost reductions for both first costs and long term maintenance costs, reductions in labor to implement and maintain, as well as longer durability.

In 2014, USACE researchers and engineers, researchers from West Virginia University (WVU), and a private industry manufacturer, Composites Advantage, reverse engineered a timber wicket gate in order to develop a glass fiber reinforced polymer (FRP) composite wicket gate. The timber wicket gates, which are located at Peoria Lock and Dam on the Illinois Waterway and measuring 4 ft. by 16.5 ft., were manufactured in-house out of White Oak. The timber gates are prone to rot and have a working lifetime of only 10-15 years. By reverse engineering the timber wicket gates, the team was able to manufacture a composite gate using a vacuum assisted resin transfer molding (VARTM) technique. The composite gate uses all of the same steel hardware as well as maintains the same dimensions, weight, balance, and buoyancy as the timber gates. The new composite gates were two thirds the cost to manufacture as the timber gates and are expected to have at least a 50 year working life. The composite gates were installed in August, 2015 and have shown no signs of damage or deterioration upon inspection.

Around this same time period, USACE and WVU researchers developed a glass FRP composite contact block to replace carbon steel miter blocks on miter gates. The purpose of the miter blocks is to provide a tight seal as well as transfer the hydraulic load placed on the miter gates. These blocks experience an abrasive force upon opening and closing that most coatings cannot withstand. Therefore, a microscopic layer of corrosion forms just at the surface of the miter block and is abraded away during operation. This section loss over time causes a loss in hydraulic seal which causes a redistribution of loads and stresses in the gates. The glass FRP composite block was manufactured using a thermal press technique and was shown to be lighter weight and just as strong in compression as a steel block. The composite blocks were installed at Hiram Chittenden Locks in March, 2015 and the performance is being monitored. This lock has the highest amount of lockages per year than any other lock in the USACE inventory.

In 2015, PIANC established a working group, WG 191 – Composites for Hydraulic Structures, with representatives from both WVU and USACE. This international group is tasked with identifying where composite materials provide a benefit over conventional materials for hydraulic inland navigation structures and to develop a report identifying best practices of how to use composite materials, summarizing case studies with pros and cons, and to compile guidance documents to aid engineers when using composite materials in the demanding environments of hydraulic structures. This working group has allowed researchers to collaborate and exchange information with other agencies.

Through lessons learned from previous FRP projects and technology exchange meetings, USACE intends to develop and install FRP gates and valves for inland navigation structures. USACE has a sizeable inventory of miter, vertical lift, tainter (radial), and sector gates. These gates are larger and more complex in design than wicket gates. Due to their size and intended use, they will be subjected to much greater loading conditions and stresses. The large size of these types of gates will likely require them to be manufactured in large monolithic pieces using a VARTM process. Research and development will need to be conducted to limit the amount of pieces required to construct an entire FRP composite gate.

In addition, there will be some capability gaps that will need to be filled regarding monitoring, inspection, and repair of FRP composite gates. Structural health monitoring of inland navigation structures using strain gages and accelerometers has proven to be a valuable Operations and Maintenance (O&M) tool to monitor the functionality and integrity of these large structures. The VARTM manufacturing process allows for a new and innovative way to include sensors within the structure rather than adhered to it. When FRP composite materials are damaged, it may be difficult if not impossible to visualize the damage from the surface. Non-destructive testing (NDT) techniques such as a digital tap hammer, ultrasonics, thermography, x-ray, and shearography need to be explored in an attempt to not only discover possible damage areas such as delaminations and voids, but to also quantify the damage. If a damage area can be quantified as critical, then a repair of the structure will be necessary. Research will need to be conducted into which repair techniques such as step sanding and hot bonding are most appropriate to regain structural strength and integrity. The effort will ultimately result in guidance to allow USACE to confidently design and implement FRP composites in navigation structures.

243. Design of rollergates of the lock of Amsterdam using a spectral design approach for wave forces

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Introduction

In the Dutch city of IJmuiden, a new ship lock is currently under construction. With a lock chamber of 500 m long and 70 m wide, it will be the largest lock in the world. Using this lock, the latest generation of seagoing vessels will be able to access the harbour of Amsterdam. The lock closes with rolling gates constructed in steel. Waves generate forces on the gate and push the gate onto its supports. During gate mission (opening or closing), the attenuator mechanism (equipment to close or open the gate) should overcome the wave generated friction forces in the supports. A set maximum installed force of the attenuators is chosen. A wave force that exceeds the maximum installed capacity of the attenuators results in delay. The lock is built under a DBFM (Design, Build, Finance and Maintain) contract. The construction companies have to maintain the lock for 28 years and are paid by the government based on the availability of the lock. The construction companies receive a fine when the gate mission exceeds the contractual maximum duration. Therefore, the attenuators must have sufficient power to reduce the probability and duration of a delay. On the other hand, the attenuators must be feasible, which means that the attenuator capacity is limited. This paper presents the methodology which is developed to calculate the probability and duration of delay of a gate mission. An overview is given covering the spectral design approach using linear wave theory for evaluating the required attenuator capacity and the expected gate mission delay.

Present limitations in wave force formulae

Normally the wave force is calculated using either the formula of Goda, or the linear wave theory for a single wave height and wave period. However, the wave spectrum loading the gate consists of two peaks:

- Long period waves (swell; <0,14 Hz)
- Wind waves (>0,14 Hz)

Due to the large depth of the lock of 20 meters, long waves penetrate down to the toe of the gate, generating a large force at the gate. This force cannot accurately be calculated using general wave theories:

- When using a formula based on only one wave height and one wave period, the force during gate mission is constant. To calculate the gate duration of delay for a gate mission a wave force time series must be made
- The wave spectrum is required for deriving the force spectrum and elaborating the probability density function of the wave force and to express the probability of delay.

- The method of Goda appears to overestimate the total wave force due to the linear schematization of the wave pressure between still water level and the toe of the gate. The calculated force will result in a very large required attenuator capacity, resulting in high costs
- Linear wave theory using the significant wave height and wave period gives an underestimation, resulting in a high probability of delay

Applied design methodology

To include the effect of long waves, and to be able to calculate the wave force time series and gate mission delay, a spectral design approach based on linear wave theory is applied. A response function is derived for the full gate mission (opening or closing of the gate) and for the full range of occurring wave frequencies (0Hz up to 1Hz) to calculate the wave force in each gate support. During gate mission the gate acts as a cantilever beam, this results in a combined absolute reaction force in the supports larger than the total incoming wave force. To calculate the total friction force during gate mission, the reaction force is multiplied with a friction coefficient. The cantilever effect is included in the final response function as the total friction force. The total friction force, delay and probability of exceedance of the delay duration is derived by the following steps which will be addressed in the paper:

1. The conversion of the wave spectrum to a wave force spectrum describing the transverse wave loads in each gate support (normal forces)
2. The conversion of the wave spectrum to a wave force spectrum describing the longitudinal wave loads (friction forces in the support)
3. The transformation of the longitudinal frictional wave force spectrum to a random wave force field
4. The interpretation of the longitudinal frictional wave force spectrum for the final design using:
    a. The probability of exceedance of wave forces
    b. The expected delay using a random longitudinal wave force field

Conclusion

The spectral approach gives more insight into the forces in the attenuator mechanism, compared to other theories. The main advantages of the spectral design approach are listed below.

1. The wave force is accurately calculated for low frequency waves. 1,5% of wave energy below 0,14Hz results in 17% of the total wave force. A small amount of wave energy gives a major contribution to the total wave force which would not be calculated when using only one wave height and wave period using either Goda's method or linear wave theory.
2. The required attenuator capacity and the probability and duration of delay can be calculated by transferring the wave spectrum into a longitudinal wave force spectrum. This analysis cannot be done when using a theory based on only one wave height and wave period, like is practice for the theory of Goda and linear wave theory (based on a single wave height and period).

244. Good Navigation Status in accordance with article 15(3)b of the TEN-T guidelines

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Sim Turf

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One of the objectives of the Trans-European Transport Network (TEN-T) is to ensure that European waterways are well integrated in the European transport system, promoting as much as possible inland navigation as a sustainable transport mode. The TEN-T guidelines of 2013 stipulate that, by 2030, navigable waterways of European interest have to achieve "good navigation status (GNS)". This means that these waterways have to help in reaching the full potential of inland navigation in Europe. However, the TEN-T guidelines do not provide a definition for "good navigation status". The European Commission asked a pan-European consortium to conduct a study in order to define the "Good Navigation Status" concept together with the member states, river commissions and users before the end of 2017.

The objective of the study is to substantiate the concept of GNS referred to in article 15(3)b of the TEN-T guidelines. This article stipulates that “rivers, canals and lakes are maintained so as to preserve Good Navigation Status while respecting the applicable environmental law”. More specific, the study aims to specify, in close cooperation with relevant experts, a broadly accepted concept of GNS and a common methodology that allows a sufficient level of differentiation to the various corridors and specific demand requirements and transport characteristics.

The following definition was developed during the study “Good navigation status means the state of the inland navigation transport network, which enables efficient, reliable and safe navigation for users by ensuring minimum waterway parameters values and levels of service”. Moreover, GNS is to be achieved considering the wider socio economic sustainability of waterway management transport characteristics. The key focus of GNS is on physical waterway infrastructure.

The objective of the study outcome is to come up with:

- a concept for good navigation status,

- a network assessment (identify the existing bottlenecks)

- roadmaps for critical sections of the TEN-T network

- good practise guidelines for implementation of the GNS concept (a manual that shall serve as guidance for waterway administrations on how to achieve and maintain a Good Navigation Status on the European waterway network by 2030)

- exemptions criteria (criteria for justification of exemption of the minimum requirements on draught (2.5 m) and heights under bridges (5.25 m), in accordance with article 15 of the TEN-T guidelines)

The use of the result is open: this means that the study will only serve as a technical input for the European Commission:

- input for a guidance document for member states by the EC

- input for further policies by the EC; this could involve

- link to further work in Core network Corridors

- basis for project selection criteria by INEA[1] (Connecting Europe Facility funding)

The paper will provide an overview of the main outcomes of the study.

The primary audience is waterway managers, waterway administrations, project engineers, the users of the waterways,…..

[1] The Innovation and Networks Executive Agency is the successor of the Trans-European Transport Network Executive Agency, which was created by the European Commission in 2006 to manage the technical and financial implementation of its TEN-T programme.

245. Enhancing the capacity for prediction and management of the environmental impacts of major capital dredging programs in Western Australia.

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Dredging is a critical and costly component of most major marine infrastructure developments in Western Australia's coastal waters. There are many examples of dredging programs that have been undertaken, are planned or in progress in WA that are significant by world standards. Sediments generated by dredging can have widespread impacts on marine environments and large-scale dredging proposals are therefore subject to environmental assessments, approvals and regulatory processes, which rely on predictions of impact and strategies to monitor and manage those impacts. There is, however, surprisingly little convincing information in the scientific literature that can be used to make scientifically sound predictions of the likely extent, severity and persistence of environmental impacts associated with dredging or efficiently and effectively monitor and manage impacts during dredge operations. This generates uncertainty that can cause delays through the assessment and approvals processes and lead to onerous and costly regulatory regimes.

The Western Australian Marine Science Institution (WAMSI) is a joint venture partnership comprised of the Western Australian State Government, the Australian Institute of Marine Science (AIMS), the Commonwealth Scientific and Industrial Research Organisation (CSIRO), the Bureau of Meteorology, Curtin University of Technology, Edith Cowan University, Murdoch University, and the University of Western Australia. WAMSI's Dredging Science Node has conducted world-class marine research to enhance capacity within government and the private sector to predict and manage the environmental impacts of dredging in Western Australia and in turn deliver outcomes to increase the confidence, timeliness and efficiency of the assessment, approval and regulatory processes associated with dredging projects. Eighty-one scientists from ten collaborating research organisations were supported by $19 million in funding. The program also included a unique cross-sectoral collaboration between government and industry, which provided $9.5 million invested by Woodside, Chevron and BHP as environmental offsets. In addition to the funding provided, our industry partners have generously shared hundreds of millions of dollars of environmental monitoring data. By providing access to this usually confidential data, Woodside, Rio Tinto Iron Ore and Chevron enabled WAMSI researchers to better understand the real-world impacts of major dredging projects, and therefore how they can best be managed.

The Dredging Science Node has addressed nine broad themes of inter-disciplinary research under the four broad categories to be delivered through a combination of reviews, field studies, laboratory experimentation, relationship testing and development of standardised protocols and guidance for impact prediction, monitoring and management.

Themes included:

1. Review and consolidation

    1. Review and consolidation of available environmental data collected for dredging projects
2. Pressure field prediction and characterisation
    1. Predicting and measuring the characteristics of sediments generated by dredging
    2. Characterisation and prediction of dredge-generated sediment plume dynamics and fate
3. Ecological response prediction
    1. Defining thresholds and indicators of Coral response to dredging-related pressures
    2. Defining thresholds and indicators of Primary Producer response to dredging-related pressures
    3. Defining thresholds and indicators of Filter Feeder responses to dredging-related pressures
4. Critical ecological processes and windows
    1. Effects of dredging-related pressures on critical ecological processes for Coral
    2. Effects of dredging-related pressures on critical ecological processes for Finfish
    3. Effects of dredging-related pressures on critical ecological processes for Other Organisms (including potential to facilitate the establishment of invasive species)

Information from field and laboratory based studies will be presented and the development of thresholds for corals, primary producers and filter feeders discussed in the context of dredging in the North-West of Western Australia.

The following major outcomes were achieved:

- Improved understanding of near-field and far-field source terms, their usage in environmental impact assessment and management, how they can be better estimated and expressed, and recommendations for continual improvement
- Guidance on contemporary approaches to predicting the pressure fields associated with dredging; including background conditions, deposition and resuspension
- Quantification of the temporal and spatial patterns in the intensity, duration and frequency of turbidity and suspended sediment pulses associated with actual dredging campaigns in the north-west of Western Australia and flow on effects to light availability and sediment deposition
- Quantification of changes in light quality and quantity underneath plumes and development of an in situ sediment deposition sensor
- Guidance on contemporary approaches to sediment transport modelling including; the importance of bathymetry resolution, efficacy of 2D vs 3D models, nearfield modelling and far field modelling; accounting for the effects of benthic communities on sediment deposition and resuspension; remote sensing of turbid plumes for model validation, environmental management and compliance reporting
- Corals – the relative significance of suspended sediment concentrations, light attenuation and sediment deposition on the health and survival of five coral taxa, with differing morphologies and commonly occurring in the north-west of Western Australia; critical thresholds of sediment deposition and light availability based on

laboratory experiments and analyses of industry monitoring data on coral health, survival and recovery potential;

- Seagrass – knowledge of the spatial and temporal patterns in seagrass biomass including seasonality, inter-annual variability and recruitment processes for three commonly occurring species in north-west of Western Australia; the relative significance of sediment deposition and light attenuation associated with dredging plumes on seagrass health; thresholds of sediment deposition and light-related effect and mortality;
- Sponges – characterisation of the sponge taxa present in the north-west of Western Australia through analysis of museum records and field collections, development of field guides for sponge identification; the relative significance of suspended sediment concentrations, light attenuation and sediment deposition on the health and survival of five sponge taxa, with differing morphologies, nutritional pathways and commonly occurring in the north-west of Western Australia, based on laboratory experiments, field studies and analyses of industry monitoring data on sponge health the prevalence of phototrophic sponges;
- Coral spawning – temporal environmental windows of key life cycle processes in the north-west of Western Australia; understanding the pathways by which dredging generated turbidity and sediment deposition affects coral reproduction, fertilisation, larval development and settlement; critical suspended sediment concentration thresholds of effect for impact prediction and dredging management
- Temporal environmental windows of sensitivity for macroalgae, fish and invertebrates that allow projects to be planned to avoid periods that are critical to their health and survival.

246. Relevance of the Panama Canal in the Recreational Navigation Business

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The significance of the Panama Canal in worldwide transportation business is well known and subject of numerous and on-going studies. However, the role in the recreational navigation is almost always forgotten.

This paper analyzes historical data of crossings by recreational vessels and explores the impact that the canal has on economic growth of the boating industry in Panama and the region.

Analysis of recreational traffic by type of vessel, direction, origin and destination over a period of significant changes in Panama will provide quantitative data regarding market potential of several boating industry businesses. Clear traffic patterns and seasonal migrations of sailing yachts and megayachts can be observed by analyzing the data. This type of traffic analysis has been done in the past in the context of marina market studies, but it is here expanded with more recent data.

The detailed study of recreational traffic statistic is then used to provide insight into the economic impacts at a regional level. While only a preliminary assessment of impacts is included, it is argued that major benefits have been provided to the nautical tourism sector, which has strategic interest for the tourism development of Panama, as well as to the recreational navigation industry (from marinas to yacht brokers).

This analysis illustrates yet another way in which the Panama Canal contributes to the sustainable and widespread economic growth of the country and the region.

247. A generalized cost analysis for neopanamax vessels

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ACP, Panama

The competitive position of the Panama Canal is a routing option for vessel operators across the major shipping sectors and the main trade lanes. The value of the Panama Canal routes to ship operators comes from the role of the Canal as a time and distance saver for voyages between Atlantic and Pacific regions.

All the analyses done until now have been focused on Panamax containerships and the total transportation cost from the vessel operator's viewpoint. With the opening of the Third Set of Locks in 2016, now there is an opportunity to analyze the total transportation cost for the new neopanamax, which allows up to a little more than 14,000 TEUs.

The total transportation cost for neopanamax vessels should take into account fuel, capital/charter costs, and operational costs. A comparison of neopanamax and panamax vessels should shed light on the issue of deploying the fleet in the best possible way to minimize transportation costs.

Besides the total transportation cost, there are other elements that enter into play in the definition of the routing for delivering goods from origin to destination. In this paper, we would evaluate the potential impact of factors such as inventory carrying costs (stocks), handling costs, value of frequency, reliability, etc on the routing decision. Hence, we would expand the conventional vessel operator’s point of view to a more generalized cost perspective from the shipper.

Shippers' profitability is greatly impacted by additional in-transit in- potential impact of ements he potential impact of ements that entrer into play lyze the tinventory holding costs. For example, if a route is longer, the shipper shall take into account additional inventory costs which depend crucially on the values of the cargoes shipped. Second, the reliability is an important consideration for shipper's choice of supply channels. In general, routes with less reliable "in-transit" time due to congestion will require more safety stock at destination distribution centers to avoid stock-outs. Finally, more frequent services will allow shippers to reduce replenishment times and inventory levels at their warehouses, reducing inventory and handling costs.

This paper will analyze the generalized cost in the case of neopanamax containerships with a comparison with panamax containerships. By analyzing other factors besides transportation costs, such as inventory cost, reliability and frequency, a better understanding of their effects on the competitiveness of the Panama Canal routes can be obtained.

248. Port Vision Bahia Blanca 2040, setting the course for the region

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The main deep-sea port of Argentina is situated in Bahía Blanca, a region located around 600 km South of Buenos Aires City. Within the estuary of Bahía Blanca, three clear distinct port industrial areas can be identified: Bahía Blanca, Puerto Belgrano (largest Argentine Navy port facility) and Puerto Rosales. In addition, it is important to mention that this maritime industrial complex is the first Argentine public port in terms of tonnage, with a throughput of around 27 million tons in 2016.

Recent changes in the national context and in the port governance led the Port Authority to initiate a new strategic planning process throughout an international tender. Port Consultants Rotterdam, was awarded the contract due to the innovative suggested methodology and the Dutch-Argentine expert team proposed for carrying on the project. As a direct consequence, the strategic planning process included the development of a long-term Port Vision inspired in Rotterdam´s methodology, but heavily adapted to local conditions. This process, first of its kind in the Spanish speaking world, has been performed with a strong participation of the stakeholders and following the PIANC Working with Nature Philosophy. Consequently, and due to the singularity of this project, the current paper elaborates the main outcomes of the Port Vision Bahía Blanca 2040.

The location and site conditions of Bahía Blanca are of special importance for the new challenges faced by Argentina such as the increase of efficiency in the farming areas of the country with its consequential high-rocketing on crops´ production, the potential development of one of the largest worldwide proved reserves of shale gas and oil and the progressive transformation of the energy sector towards renewable sources. Therefore, the study of main trends and developments, both globally and regionally, combined with a clear understanding of the port and the country, led to the identification of the main Strengths, Weaknesses, Opportunities and Threats for the port-industrial complex.

Thereafter, a comprehensive long-term Port Vision has been shaped around three main core visions. Firstly, and in accordance to the exploitation of the shale gas and oil with its associated attractiveness for the chemical industry, Bahía Blanca will develop into the Argentine Port-Industrial Cluster. Secondly, a favourable investment climate with the strengthening of the connections to the most productive agricultural regions in the country will enable a larger cargo flow of raw material to the port that will support the development of the agroindustry, gradually shifting the functions of port-industrial complex to a fully integrated Food Port. These two factors together with the development of new logistic centres and distriparks, not only in the nearby areas but also inland, will lead to the development of a Multimodal Logistic Hub.

Despite all the diagnosed potential developments in the years to come for Bahía Blanca, many actions need to be taken in order to partially capitalize them. Consequently, five key success factors have been identified to support the achievement of the Port Vision Bahía Blanca 2040.

These key success factors are: Investment Climate, Port Governance, Environment & Sustainability, Connections & Logistic and City and the Region. The active and strong participation of all the stakeholders to identify win-win solutions for each of the key success factors was already one of the achieved milestones during the Strategic Planning process. However, the challenge remained on how the stakeholders will stay engaged at the same, surprisingly high, rate of participation.

Therefore, for the implementation phase, throughout an Action Plan, a strong commitment was achieved with a shared and comprehensive agenda. The great success of this case study highlights the importance of creating synergies within the port community. It also stresses the relevance of consolidating stable and trustworthy port authorities like the Consorcio de Gestión del Puerto de Bahía Blanca. The existence of this long-lasting and professional governmental organization allowed to articulate all the needed pieces within the port community in order to lead the process for strategic long-term planning, not only for the port-industrial complex, but for the region as a whole.

To conclude, the Port Vision Bahía Blanca 2040 and any other long-term Port Vision, has to be shared with the business community, but, more significantly, with the people living in the region and its political institutions in order to maintain the license-to-operate and the license-to-grow climate for achieving a long-term sustainable growth to enhance the benefits of the generations to come through the derived added-value for society at the port-industrial complex. In other words, its objective is to bring confidence among the port community while improving the quality of life in the region. Consequently, and to pursue this ultimate goal, the Port Vision Bahia Blanca 2040 has to be broadly shared for common knowledge turning into a document of easy access. (**http://puertobahiablanca.com/vision_portuaria_2040/**).

249. Strategic Port Planning and its associated management, a Guide for port authorities

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Is it a utopia to prepare your port for future uncertainties? How can we design a specific methodology for developing port authorities´ strategies?

This paper aims to answer those questions by providing a practical Port Planning guideline to support ports on how to accomplish their strategies, and more importantly, on how to manage them for achieving realization.

The proposed Port Planning Guideline focuses on five steps:

1. perform a comprehensive analysis of the current situation of the port,
2. build a long-term Port Vision with the participation of every stakeholder,
3. elaborate a joint action plan with strategic stakeholders based on the Port Vision,
4. turn the Port Vision into a Commercial Plan and
5. develop a sustainable and flexible Masterplan.

The first three steps are usually known as Strategic Planning while the last two steps are usually categorized as Technical Planning.

In addition to the mentioned steps, it is important to emphasize two of the core values of this methodology. Every phase is thought in a participative basis promoting the collaboration of all the stakeholders involved in the port community who are not restricted to the port area itself. Some of the strategic stakeholders that can be listed are: the National Government, the Provincial Government, the Municipality, all the companies and industries within the port and nearby areas, NGOs, educational and research institutions, et cetera. Besides, within this process, sustainability is the other core value taken on board from the very beginning in order to anticipate the needs of future generations and the prosperity of the region served by the port. In summary, this approach adopts PIANC Working with Nature Philosophy and PIANC Sustainable Ports Approach to promote ports as one of the key drivers for reducing inequality and enhancing the quality of life within their influence areas.

The first step is the “Port Scan”, a tool developed by Port Consultants Rotterdam for the elaboration of a high-level assessment for a terminal and/or a port complex. Following this holistic approach, the performance of a terminal and/or a port complex can be understood, the bottlenecks identified, the potentials recognized and the priorities set throughout a SWOT analysis. Furthermore, this diagnosis focuses on four specific topics: layout & infrastructure, operations & logistics, organization & finances, and environmental & social aspects. By covering the aforementioned topics the current internal and external situation can be systematically addressed. This first step ensures that a terminal and/or a Port Authority is able to answer: What is our starting point?

The second step is the elaboration of a long-term Port Vision which uses as starting point all the collected and processed data for the "Port Scan". This step tries to set the future ambitions for developing a terminal and/or a port complex. Consequently, it is interlinked with a second question: Where do we want to go?.

The process for elaborating a Port Vision can become a topic on its own; however, it is important to highlight the most relevant characteristics. A Port Vision is of importance to promote investments and license-to-operate climate by giving confidence to policymakers, companies and stakeholders in the future, by allowing the alignment of strategies between the port authority and stakeholders and by facilitating the cooperation among all the involved parties. Moreover, a Port Vision sets the course for future developments, as it is a public document of easy access made with the contributions of all related stakeholders. Usually, it is composed by some core visions which are based on key success factors. The third step is the definition of an action plan for accomplishing the ambitions set in the Port Vision. This agenda also includes combined actions with some of the strategic stakeholders in order to implement the set goals and objectives. This step ends up with all the information related to the defined actions that allow the ulterior high-level control of the performance of the port through KPIs to monitor the successful progress of the Strategic Plan ("Port Scan" + "Port Vision" + "Action Plan").

The fourth and fifth steps are closely interrelated as the formulation of the Commercial Plan directly influences the elaboration of the Masterplan and, to the same extent, the other way round. This can be easily explained by the proposed approach of developing a Masterplan which is always centered around the financial feasibility of the Masterplan itself. The financial model can also be used to fine-tune and improve the Masterplan: different layouts, designs or phasing will generate different financial effects. The idea is that the financial model is used to generate the optimal choice. Thus, the Masterplan is only acceptable if it is also financially feasible, under various scenarios and following the Adaptive Port Planning Framework (Taneja, 2013) meeting many other criteria such as social, environmental and legal requirements, towards a sustainable growth.

Additionally, a strategic managerial process is also needed as the abovementioned steps require a regular cycle for reviews and updates based on the feedback obtained through the defined KPIs, the commercial trends and developments and the many associated uncertainties considered during the Port Planning process.

To conclude, and with no need to highlight the importance of sharing the knowledge gained during the implementation of this Port Planning Guideline for the Port of Bahía Blanca in Argentina, the spirit of this paper is to encourage Port Authorities to develop their own long-term Port Visions, Commercial Plans and Flexible Masterplans, based on a meaningful use of stakeholder engagement; identifying win-win options towards a continuous improvement of the ports.

250. Effects of Wave Overtopping Discharges on Property and Operation nehind the Breakwaters Crown Walls

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This research is part of the R&D&I actions being carried out in CEDEX for the public enterprise Puertos del Estado. This paper is the result of the research, which has the main objective of analize the effects of overtopping discharges over breakwaters on property, equipment, and facilities located behind the breakwater crownwall.

Two typologies of breakwaters (vertical and rubble-mound breakwater) have been analysed. The geometry of these breakwaters has been defined according to the standards used in the main Spanish harbours. The test conditions have been defined as a combination of different periods and significant wave height, introducing the variation of the sea in some of the cases. Significant wave heights have been generated from the start of overtopping to the maximum that can be produced in the installation for each period of wave considered. Likewise, the influence of the wind has been analysed.

The tests have been carried out in three different scales (1:15, 1:37.5 and 1:60) to analyse the influence of scale effects on the phenomenon. The 1:15 scale test has been used the Large Wave and Wind Flume available in CEDEX, which is 90 m long, 3.6 m wide and varies in depth between 6 m in the generation and 4.50 m in the position of the model, capable of generating waves up to 1.60 m for regular waves and wind speeds up to 25 m/s. For the remaining scales, smaller flumes, 6.5 m and 3 m wide, were used. The data are recorded by the instrumentation for further analysis and comparison according to the different scales and typologies of breakwaters. The survey determinates number of waves overtopping, mean overtopping discharges and overtopping wave volumes.

Besides, a measurement system has been implemented to measure the forces, both horizontal and vertical, produced on the platform behind the crown wall. The knowledge of these forces allows the study of the risks associated with the water discharges. Wave overtopping over a breakwater may hit the superestructure behind the crown-wall, affecting operation and causing damage to superestructure elements located behind the crown-wall (property, equipments, port facilities, etc.).

Measurements of forces produced by overtopping discharges have been made for different breakwaters cross sections and wave conditions, in order to provide information for the design of those superestucture elements.

Figure 1 shows the results of one of the test of a vertical breakwater (Hs=2 m and T=6 s). The table of the figure 1 shows the overtopping and the forces produced over the platform located behind the crown wall.

251. Design of the scour protection layer for a breakwater in an estuarine environment

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The design methodology proposed in the Recommendations for Maritime Works (ROM, Puertos del Estado, Spain) differentiates failure modes between hydraulic and geotechnical on one hand and between principal and non-principal on the other hand. In general, design of the scour protection in front of a breakwater is performed assuming a non-principal hydraulic failure mode, as it is possible to achieve negligible failure probabilities for this element under moderate costs.

The mid Río de la Plata estuary presents a combination of shallow waters, severe currents and moderate waves, together with very low bearing capacity soils. These conditions make that scour protection of a projected breakwater off the coast of Montevideo, Uruguay, should be designed assuming a principal hydraulic failure mode that in turn affects geotechnical failure modes.

This is a rare situation for which there are few references in the accumulated experience of breakwater design. Perhaps the most relevant precedent is the design and construction of Zeebrugge breakwaters (Van Damme et al. 2008). Moreover, local knowledge on the actual port of Montevideo is of little use given that current breakwaters were built more than 100 years ago (Nieto 2012).

Under these conditions the design of the scour protection layer presents several challenges, which are presented below and that will be discussed in detail in the final article.

The first challenge arises when defining the conceptual approach for design. As there is interaction between the hydraulic failure mode "loss of hydraulic stability of the scour protection layer" (which eventually leads to erosion in front of the structure) and the geotechnical failure mode “global stability of the breakwater”, both cannot be performed decoupled. The methodologies used for hydraulic and geotechnical verifications are fundamentally different, since the temporal scales in which the failures develop, the uncertainties involved in their approach and the analytical and numerical models used in each case are different. Probabilistic verification techniques are usually an appropriate tool for approaching complex problems of great economic impact and are quite well developed for the verification of hydraulic failure modes. However, they are not so well developed for the verification of geotechnical failure modes (see e.g. Phoon et al., 2016).

From the point of view of calculation and verification of the hydraulic failure modes there are at least three challenges. First, the multivariate characterization of all the random variables involved in the verification, namely: wave (incident wave height, direction, and period), currents (depth averaged intensity and direction), and sea level. Although usually assumed deterministically, two coefficients must be added to this list of random variables: the depth limited wave breaking coefficient and the breakwater reflection coefficient. The intensity of the bottom stresses in front of the structure, responsible for triggering the "loss of hydraulic stability

of the scour protection layer", will depend on all these variables. Second, the determination of an equation that relates all these variables at the initiation of damage (i.e. a verification equation). Currently there are no accepted equations for the design verification of scour protection layers subjected to the combined action of currents and waves (incident and reflected, possibly depth limited, i.e. highly non-linear). The most similar situation for which there are accepted design equations is the start of the movement of the sand under combined wave-current flow. Obviously the use of these equations in the design of the scour protection involves great uncertainties, which must necessarily be taken into account in the final design. Third, given the uncertainties inherent in the design process, it is common practice to perform reduced scale model test of the breakwater in a hydraulic laboratory prior to its construction. Physically modeling the interaction of waves, currents and a partially reflecting structure, and its effect on the scour protection layer, presents great challenges for both its implementation in the laboratory and the interpretation of the obtained results, in the latter case mainly due to scale effects.

In dealing with the above challenges the following approaches were thoroughly discussed during the preparation of the project:

To reduce the probability of failure of both failure modes independently to very low levels, in order to move them away from the failure tree of the principal modes. It was proven that for the circumstances of this project this approach was not feasible, due to: incompatibilities with construction planning, and the high costs involved in the protection. The use of higher caliber material in the scour protection easily creates construction difficulties in view of the respect of the filter rules towards the soil material. In order to accommodate construction constraints, for the design of the filters, the application of open filter layers as well as the installation of geotextiles (fixed to willow matrasses) and classical filter layers have been discussed.

To artificially separate geotechnical and hydraulic failure analysis by introducing the concept of a minimum geometry in the geotechnical calculations, based on alarm and limit lines, as was the case for the breakwater in Zeebrugge. Such approach needs to be made consistent with the inspection and maintenance strategy applicable for the project. An alarm line defines a level at which the operator can start the mobilization process of the equipment that is required to safeguard the situation before the ultimate limit line is exceeded. This limit line should correspond with the level of safety that has been required for this geotechnical failure mode. From the operation point of view it is essential that clear alarm and limit line drawings are developed to support the inspection and maintenance strategy for a project.

252. Mastering Latent Defects in Maritime and Port Engineering through Technical Risk Management

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Linear maritime engineering structures are exposed to the highest levels of risk in the construction industry, because of the serial work involved in their design and construction. Systematic design or execution errors can turn these constructions into vulnerable artefacts. At the same time, the economic drive is pushing the long linear structures towards limited levels of redundancy, where failure of individual elements can generate progressive collapse. A global approach to risk is therefore indispensable in the management of coastal engineering projects, in addition to the organization of appropriate quality control systems. Awareness has indeed grown that a second performance layer on top of the classic quality control systems is needed to cope with these challenges. Apart from the help that can be expected from working at the level of standardisation, progress is mostly expected from measures which instigate project professionalism and collaboration between the different building partners.

The intervention of an independent organization within the framework of this risk management – a well-known traditional concept in many European countries – is an added value in a global risk management of maritime structures. A typical principle that has arisen from this approach is the strife for structural redundancy, even in the most slender and economic of structures. Dealing with uncertainty in an explicit way is another. The TIS (Technical Inspection Services) play a driving role in the constant review of the risk level within the dynamic risk management environment of a construction project. This can be done in a qualitative or in a quantitative way, depending on the nature and the severity of the risk. The externalization and independency of the service can make for a practical tool to assist in managing the technical project risks and transfer to all parties around the table the necessary confidence in the design and construction process, as well as promote dispute resolution around acceptable technical solutions and innovative alternatives within projects.

Provided the company providing TIS (Technical Inspection Services) has the necessary credentials, such global approach to risk management may give access to long term insurance schemes for latent or hidden defects (LDI or IDI, Latent or Inherent Defect Insurance), covering all building actors in the project jointly in an umbrella policy.

Apart from a recap into the principles of risk management and its application to different types of port infrastructure projects, the article will focus on the introduction of this traditional European concept in the Latin American environment, through a case study of a maritime port project in the port of Montevideo, Uruguay.

The article will be propose a classification of different types of quay walls according to their level of structural redundancy and their vulnerability to lack of tightness of the joints. It is explained how these walls range between structures with excellent redistribution capacity and great possibilities to perform complete visual verification of the soil tightness of the joints on the one hand side and structures that provide none of that on the other hand. Several real projects will be run through in the article and their classification according to the proposed system will be discussed. It will be examined how it is possible to upgrade the classification of

a structure with specific interventions. It will also be shown that, in creating structural redundancy, the existence of ductility may be of the utmost importance. Elastic and plastic elongation may need to be generated to mobilize the required redistribution.

The project focused on more in detail, concerns a quay wall under construction in the port of Montevideo, Uruguay. An alternative calculation model set up independently from the black box model used by the designers, has been used as part of the technical inspection services to establish the sensitivity of the deck-on-pile structure to different sets of load combinations. It has been confirmed that the resistance to the horizontal loads for these type of structures can relatively easily be increased and tuned to the requirements, primarily by efficiently intervening in the connection node of the landward pile row (the one with the most limited free length) at marginal cost.

The alternative model has been used as part of a risk analysis, which has been able to identify and prioritize technical risks, as well as list mitigation measures for each of them, allowing for assistance in the technical management of the project.

The reanalysis of the structure, taking into account the geotechnical uncertainty of the conglomerate subsoil, also showed that a redistribution of the total projected concrete volume of the piles over the 4 pile rows, without any additional concrete consumption, could contribute to an important relief of the geotechnical risk.

Apart from a sound independent desktop analysis, a complete dynamic risk management process also necessarily includes inspection of the site construction process, a process which is currently ongoing for the reference project discussed. Experiences with it will be available and shared for the final article.

253. Intelligent Data Driven Ports and Waterways

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Modern ports and waterways do not only need to be efficient, reliable and cost effective, they also need to be safe and environmental friendly. To achieve all this, state-of-the-art technologies are needed and data is essential. From data collection by the latest sensor technology, storage in cloud based solutions, data processing and analytics by sophisticated software to intelligent predictive reports of your assets.

1. **SAFETY**

A safe environment is essential for employees and visitors. From early fire detection, public address and evacuation solutions, remote man safety, man-over-board technologies to video recording and tracking of ships. Modern video surveillance and camera analytics (unattended bags, loitering, perimeter monitoring, fence & boundary breeches, facial recognition, vehicle classification, traffic counts) can assure a safe environment during day and night operation.

Crowd flow monitoring at peak times assure a safe and efficient management of resources with predictability. External air quality monitoring guards personal health, identifies cause and show trends over time. In waterways the water level is monitored by ultrasonic sensors. These sensors monitor the exact water level in assigned areas. Flood protection and prediction software alerts stakeholders well in time.

2. **RELIABILITY**

Condition-based monitoring provides an exact overview of the current ‘health’ of machines and assets, for preventative maintenance and avoidance of unexpected and costly stoppages.

Cars can be scanned for damage by the use of camera control analytics. Sensor and car inspection scanning solutions increase efficiency, traceability and accountability of all rolling equipment on-site.

3. **EFFICIENCY**

Most car movements at ports are currently manual and are influenced by staffing limitations. Autonomous vehicle solutions are developed to support process operations, such as vehicle, AGV movements and off-road commercial equipment. Future visions also foresee autonomous shipping, including loading and unloading of ships.

Smart yard management offers an accurate visualization of the parking status, which enables easier navigation for parking, picking and maintenance activities. This

technology also provides tagging, planning, sequencing of vehicles and intelligent directing by tracking real time information. The system assists in picking and shipping the vehicle to the ultimate destination.

Traffic management controls peak times and optimizes the port user experience and predictability.

Smart retail solutions track and analyze people flow in retail environments. This enables store owners to optimize their retail floor space, sales, rental planning and crowd management, people counting, queuing alarms, blocked emergency exits, etc.

4. **INTELLIGENCE**

Container and high value asset tracking can monitor a variety of parameters such as; temperature, vibrations and GPS location of assets. Wireless sensors track moving cargo in real-time. The data is immediately sent to a central control center to help improve delivery efficiency and transparency.

Connected power tools can be tracked and controlled within the port.

A unified cross-functional sensor platform creates a dashboard of all sensor solutions within the port. It provides a digital image (digital twin) of the harbor, based on the existing or developing sensor solutions and allows overarching monitoring of all sensors at the port.

Data mining and collection analytics lead to increased knowledge and efficiencies of port and waterway operations.

If required a remote emergency call center can control the surroundings and inform staff or local authorities if needed.

5. **ENVIRONMENT**

Energy management is a top priority in many industrial applications. How to transfer industrial sites from heavy energy users to energy neutral areas?

Renewable energy solutions such as solar, wind, wave or tidal energy generation, can replace existing energy resources. Energy can be won back by sophisticated drive and control solutions to improve energy efficiency. Battery storage solutions balance demand peaks and reduce infrastructure setup expenditure. Thanks to smart electronic controllers, these storage systems can absorb excess electricity and release it again very quickly when needed. That way they help to stabilize the electricity grid. Battery storage solutions improve port and city air pollution by reduction of ship’s exhaust gases.

254. Scale model research and field measurements for two new large sea locks in the Netherlands

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In the Netherlands two large sea locks are currently being built: the new lock of IJmuiden, providing access to the port of Amsterdam and the new lock of Terneuzen, providing access to the port of Ghent. The design process for the levelling system of these navigation locks encompasses extensive hydraulic studies where both numerical and physical models are used in combination with a field measurement campaign. This paper describes part of the physical scale model research and the field measurement campaign that have been carried out, focussing on the forces on the moored vessel in the lock chamber that develop during the lock-exchange. An overview of the design process of these two new sea locks in the Netherlands is presented by Kortlever et al., 2018 and the role of numerical models in the design of the leveling system of the new lock of Terneuzen is addressed by Mahoney et al., 2018.

A physical scale model facility was built at Deltares to simulate the complete leveling cycle of both locks. Since both the new lock of IJmuiden and Terneuzen are sea locks, a density difference over the lock will be present and for both locks the density current leads to dominant forces on the moored vessel during leveling and lock-exchange. The overall objective of the scale model research was to determine the leveling times that could be achieved for the considered leveling systems and to also study the lock-exchange that occurs after the gate is opened. To that end, the physical scale model has been equipped with movable gates that open automatically after leveling. It has been shown that the forces on the vessels in the lock chamber, as a result of the density current after opening of the gate, will often exceed the forces during leveling.

In the scale model, the lock chamber, lock heads, the leveling system and also parts of the approach harbors are represented. A predetermined density difference over the lock is maintained by adjusting the density of the approach harbors between tests. The approach harbors have been equipped with movable weirs to set the water levels in the approach harbors to the desired level. Vertical density profiles have been determined at several locations in the scale model by measuring conductivity and temperature. Next to this also water levels, flow velocities, positions of valves and gates and forces on the vessel have been measured. In total more than 200 measurement channels have been logged simultaneously.

Simultaneously to the physical scale model work, a field measurement campaign was conducted in which forces on vessels in the Noordersluis of IJmuiden were measured during the lock-exchange. The Noordersluis is presently the largest lock of the IJmuiden lock complex, and with main dimensions of 400 m x 50 m it is comparable in size with the newly to be built lock in Terneuzen (427 m x 55 m), but significantly smaller than the new lock of IJmuiden (545 m x 70 m). On basis of a comparsion between results of the field measurement campaign and physical scale model results, it was comcluded that in the future situation larger forces on

vessels may be expected than currently experienced in the present locks. These results help pilots to prepare on how to handle the larger ships in the future largest locks in IJmuiden, which will be in operation in 2019, and in Terneuzen, which will be in operation in 2022.

The presented physical scale model studies and field measurements yielded new insights into the dominant processes that are important in lock-exchange processes of sea locks. The results of these studies have been used to determine requirements for lock operations for the future largest locks in the Netherlands, at IJmuiden and Terneuzen.

References:

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255. Sohar Breakwaters – Cost Based Risk Assessment

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The Port of Sohar (Oman) is protected by two breakwaters which were damaged during the 2007 tropical cyclone “Gonu”. Extensive surveys by third parties have been carried out in the past to determine the extent of the damage and studies were made for repair and upgrade designs. However, the costs for the proposed repairs showed so large that in 2016 repairs still had not been carried out.

When asked for a its opinion, Royal HaskoningDHV advised the port that in the decision making process to repair the breakwaters an important item was overlooked, i.e. that also the repaired breakwaters would have a certain risk to be damaged. Consequently, the repair should only be made in case the economic risk without repair would be (much?) larger than the repair costs + economic risk after the repair, i.e.:

If Present Risk >> Repair + Future Risk, then do the repair

The present risk looks at the probability of failure and the economic consequences of such failure. This takes into account the current (damaged) status of breakwater cross sections. The repair costs are affected by the method of repair. Hence prior to deciding to repair, one needs to have an impression of the costs of such repair. The future risk looks at the probability of failure after a repair and the economic consequences of such failure.

Following these observations, Royal HaskoningDHV was requested to quantify the above evaluation in a Cost Based Risk Assessment. An important element in this quantification was formed by finding a relationship between the damage to the concrete armour units (predominantly showing settlement) and the occurring wave conditions. Such relationship was established based on the model tests carried out in the past and relates the number of settling armour units (Nod) to the incident wave conditions (Hm0, Tp), the packing density of the armour units (ϕ) and the number of waves in a storm (Nw). Using this established relationship the present and future risk of the breakwaters could be quantified, taking into account the probability of occurring wave conditions. The approach to the cost based risk assessment, the damage function and the results of the analysis will be presented in the paper.

256. Open benchmark datasets for validating numerical wave penetration models

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Main abstract

Downtime in ports is often dominated by the nearshore wave climate and the resulting wave penetration into port basins. Geometry complexities and specific bathymetric influences, such as the effect of entrance channels, will complicate the description of wave penetration into ports and will make verifying wave conditions in relation to expected port downtime far from trivial (De Jong et al., 2016, PIANC COPEDEC).

Wave conditions inside ports can be determined during the port design process with physical scale model tests or with numerical tools. Several types of numerical wave penetration models are available, including spectral models, mild-slope models, Boussinesq-type models and (multi-layer) flow models adapted to represent also short waves. These different types of numerical wave models all have their own specific advantages and drawbacks. And although the fundamentals of such wave models have often been validated in detail, validation of the performance of these models for representing wave penetration into ports is often rather limited. One of the main reasons for this is that datasets for validation are generally quite scarce. As a result, downtime estimates based on the outcomes of these numerical models may be inaccurate and unreliable.

Field measurement datasets for model validation are often limited in duration and may include only a few observation locations. Furthermore, these may lack relevant extreme conditions. As an alternative, Deltares has performed throughout the years several physical scale model tests on wave penetration under a wide range of controlled conditions and including several output locations in each scale model setup. These test series ranged from full realistic port layouts to more schematic situations. The former were aimed at verifying the performance of port extension plans, whereas the latter were intended to highlight and record specific aspects of wave penetration processes, some particularly created to serve as validation material. This has allowed Deltares to validate its numerical wave penetration models in detail and it has given us detailed insights into the capabilities and limitations of the different types of numerical wave penetration models (see e.g. De Jong et al., 2016, PIANC COPEDEC).

In line with its ‘Dare-to-share’ policy, Deltares now wants to make the most relevant of these datasets available to interested parties, to be applied in research initiatives on numerical model validation together with Deltares. The available datasets will at least include one full port layout, a schematic port layout with a captive ship and a series of schematic port layouts increasing stepwise in complexity. We believe that by sharing these data and by jointly working on the validation and development of numerical models we can get most out of the available laboratory measurement data and arrive at the most interesting and relevant results.

The paper and presentation will give an overview of the different datasets on wave penetration available at Deltares. It will also include an overview of analyses based on these data sets made so far, which can serve as starting point for further cooperations with interested parties.

Added value to conference attendees

Attendees will hear about validation possibilities for tools describing the dominant factors influencing port downtime. Engineers and researchers will hear about data availability on these topics and they will be updated on the cooperation opportunities that Deltares proposes. This will allow port designers and model developers to validate their models with suitable and systematic datasets, contributing to the development of such tools. The proposed collaboration encourages model comparison as well as publishing of results, which will benefit port designers, engineers and users of port infrastructure.

257. Methods to assess the performance of bubble screens applied to mitigate salt intrusion through shipping locks

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Bubble screens are applied at shipping locks between salt and fresh water bodies, in order to reduce the amount of salt intrusion as a result of the locking process. The importance of limiting this salt intrusion is found in the required quality of the fresh water, which is given by ecological reasons or due to its use for agriculture and/or drinking water.

Recent shipping traffic developments contribute negatively to salt intrusion unless proper mitigating measures are taken. Increasing shipping intensity demands more frequent lockages, with every lockage adding to the amount of salt intrusion through the lock. Furthermore, the enormous size of modern locks means they contain a large amount of salt water that potentially flows towards the inland water bodies. These developments have called for a renewed assessment of the potential of bubble screens to mitigate salt intrusion. Compared to the application of a freshwater flushing discharge through the lock, the primary alternative, bubble screens are obviously more expensive as the required flow rate and pressure demand a significant compressor size. An important question therefore is to optimize the design or use of the bubble screen such that the required salt intrusion reduction is met at a minimum use of energy. An additional question is how the bubble screen technology scales up towards the larger depths of modern locks. Various measurements have been performed in the past decades to address the application of bubble screens in shipping locks. Recent work has focused on the application of various research methods to contribute to the further understanding of the bubble screen technology.

Examples of in situ measurements are found in Uittenbogaard et al. (2015), who present the application an innovative combination of bubble and water screens at the Stevin Lock (The Netherlands). A similar design of bubble screen was tested subsequently at the Krammer recreational lock (The Netherlands) by Weiler et al. (2015). This study also evaluated the expected costs of operation of a bubble screen in the larger commercial locks of the Krammer lock complex.

Scale model research regarding bubble screens considers various application areas and approaches. Van der Ven and Wieleman (2016) present small scale experiments of a bubble screen in a flume of 1 m depth and 1 m width. They make use of practically unscaled bubbles. Another important simplification is that the performance of the bubble screen is evaluated only on the induced water motion, as use is made of homogeneous water. The measurements are compared to available in-situ measurements from Bulson (1961) and scale model measurements of comparable scale by Riess and Fanneløp (1998).

Recently scale model measurements have been performed at Deltares that provide data of high accuracy and at a high spatial resolution. These comprise PIV measurements of the flow and the quantitative recording of the mixing induced by the bubble screen by applying a dye to the salt water compartment. The quantitatively high quality data help to accurately establish the performance of bubble screens as salt intrusion mitigating measures and may show room to improve the bubble screen operation or design.

A third research method with great potential is the application of computational fluid dynamics (CFD). An example is found in Meerkerk et al (2015). More recent computational studies show a promising increase of numerical stability which helps in the application of these methods in advisory or research projects.

The various research methods have their specific drawbacks and benefits. This presentation gives an overview of these methods and their applicability and accuracy when assessing the performance of bubble screens as a means to mitigate salt intrusion through locks. The presentation includes results from ongoing research currently being conducted at Deltares.

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Interest to conference attendees

Salt intrusion is difficult to measure, to predict and to mitigate. This presentation gives an overview of the available methods to provide such a prediction when a bubble screen is appleid and the applicability and accuracy of these methods. This is interesting in particular to lock operators and lock designers. The presentation provides recent and state-of-the art methods. Further, the subject relates to the conference topic Environment (e.g. Fresh water availability, Multiple purpose water reource systems) and as such is interesting for various parties at the conference.

258. Future proofing port infrastructure within the Port of Rotterdam How to create more value for the Port Tenants

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Egbert Van der Wal

Port of Rotterdam Smart Port, Netherlands

Together with the Smart-Port research institute, Port of Rotterdam uses all means from scientific research to pilots within infrastructure projects to enhance the capabilities of the Port Instructure.

The abstract will give an insight in which techniques we have used to future proof our port infrastructure.

There will be no scientific paper but an well documented presentation about the challenges and proven techniques we used in the last 2 years. The results from these techniques will be shared the presentation. Most of the techniques can be used by other ports to improve the capabilities of their port infrastructure.

The Ports in Holland, of which the Port of Rotterdam is by far the biggest and most advanced port, have according to the World Economic Forum the best port infrastructure in the world. This is for us not a call to sit back and relax but instead to face our challenges head on and see how we can overcome our challenges by using our infrastructure network to the fullest.

The biggest challenge we are facing are the following:

1. Increasing ship sizes in different parts of the port
2. Autonomous shipping
3. Changing cargo flows and a more circular economy
4. A large dependency on oil based products which will not last for another 30 years
5. Port infrastructure which has surpassed the design life time but needs to cope with higher demands, changing functionality and customer needs.
6. The integration of infrastructure and logistics so both aspects can exel together.

But building infrastructure is no more than a means to an end.We are focussing on infrastructure and the network because we believe that everything we do should contribute to the fact that our tenants can do their business by using our infrastructure network. We are achieving this by creating more time for the customers to use the infrastructure and using the (hidden) capacity of the quay walls.

This requires Digitisation of infrastructure, insight into the actual use, insight into the actual load limitations.

By 2035 the port infrastructure will be so smart and adaptive that it can be adapted to changing customer needs and will be optimally tailored to new logistics concepts

We are looking at this from two perspectives:

1. Life cycle performance and life cycle extension
2. Smartening the infrastructure by using remote sensing, Structure health monitoring and digitisation.

Ad 1. Life cycle performance and lice cycle extension of maritime port infrastructure:

Challenges:

- How do we extend the lifetime of 50% of all quay walls in the port area
- How do we overcome the uncertainties in a quay wall structure and turn them in to strengths?
- How do we cope with changing Customers requirements, functionalities and demand for more capacity on the existing quay walls
- How do we shorten the realisation time for quay walls and limit time for maintenance
- How do we bring conservative theory in line with the actual use of the infrastructure
- How do we cope with the fact that there are nog appropriate design guide lines.

We are aiming for the following results in the upcoming years:

- Substantially lower construction and maintenance costs (> 20%),
- Substantially shorter lead time for the realisation of the infrastructure
- Enhancement functionality existing quay walls for customers (higher site loads and deeper vessels)

Ad 2. Smartening the infrastructure by using remote sensing, Structure health monitoring and digitisation.

Challenges:

- adopting the latest technologies in maritime infrastructure, such as remote sensing and robotics to enhance the capacity of the infrastructure and reduce downtime.
- Smart use of large amounts of available port data, such as hydrometeorology, sensor data quay walls and AIS
- Smart, real-time measurement of actual use vs capacity
- Extending the service life of existing quay walls by combining owner and user data.

What are we aiming for in the upcoming years

- Optimisation of usage by customers based on real-time data
- Maximum Uptime through smart quay walls that inform timely about parts to be replaced soon
- Bringing theory in line with practice by introducing data of the current use into the design process
- Creating a digital twin of the port.

For both of these perspectives the presentation will have examples and suggestions what can be done to overcome the challenges and enhance the capabilities of the infrastructure to suit the needs of our customers. The Maritime Port infrastructure will be used as an example in these cases. Insight will be given in the techniques that are being used successfully by the Port of Rotterdam.

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259. A New Sea Lock in Terneuzen, with the same size lock chamber as the Panama Canal Expansion Project

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Terneuzen, a city in the Netherlands with a little over 55.000 inhabitants, is housing a lock complex with three sea locks connecting the Scheldt River to the Ghent-Terneuzen Canal. This canal is the main waterway to the inland Port of Ghent (Belgium) and is a part of the Rotterdam-Paris inland waterway route, one of Europe's busiest navigated canals.

The current lock complex is showing long waiting times for inland navigation and is since a certain time at its maximum capacity. To improve the access to the ports of Terneuzen (NL) and Ghent (BE), and to facilitate a fluent passage for navigation, the governments of Flanders (the Northern Community in Belgium) and the Netherlands decided in 2012 to build a new and bigger sea lock in Terneuzen. With a lock chamber of 427m by 55m, the New Lock in Terneuzen will have the same size lock chamber as the Panama Canal Expansion Project that became operational in June 2016.

Today, there are 3 locks on the complex: an Eastern (since 1960s), a middle (since 1910) and a Western lock (since 1960s). The New Lock will replace the oldest, but still functional, middle lock, and will be operational by mid-2022 after a building time of 4 years. The lock complex will remain operational throughout the works.

For the construction of this project, a Design and Construct (D&C) tender was put on the market by the Flemish-Dutch Scheldt Commission (Vlaams-Nederlandse Scheldecommissie, VNSC, a partnership between the Netherlands and Flanders for jointly managing the Scheldt estuary). After one year of tendering, the Joint Venture SASSEVAART was elected in September 2017 as the contractor for the New Sea Lock in Terneuzen. The contract value is € 753 million incl. VAT. The Joint Venture Sassevaart consists of the Belgian marine contractor group DEME (with its companies DIMCO B.V. and Dredging International N.V.), the Dutch group BAM (with its Dutch company BAM Infra and the Belgian BAM contractors) and the Belgian Contractor Algemene Aannemingen Van Laere N.V.. Also the company Engie and the consultants Arcadis and IV-infra will work on this contract as subcontractors for Sassevaart.

In the full paper more details will be given on the tender procedure, the construction phases and how they are designed to have minimal disturbance on the navigation. Also the first works in the field will be discussed. In this abstract, only a few of the design considerations to reduce navigation disturbance are given, along with some numbers to emphasize the magnitude of this spectacular sea lock project in the Southwest of the Netherlands.

Minimal navigation and construction disturbance

To have minimal spatial impact, it was chosen to build the lock from water and only work within the final contour of the sea lock and its quays. An optimal cost versus space versus navigation disturbance ratio was found by Sassevaart.

The contract requires that the Eastern and Western Lock should be fully operational at all times, where the middle lock – the one to be replaced – can be taken out of service during the construction period. One of the reasons this tender was won by Sassevaart was to keep the middle lock operational for ship classes up to CEMT IVa (or vessels equal in size) for most of the construction period by building a temporary waterway around the construction zone. (Conservative) tender studies proved this will reduce the lost hours of navigation by 50.000 to 75.000, and passing time for ships will be reduced by minimally 25%. This measure has an economical value of minimally € 22 to € 34 million.

Besides this temporary waterway, Sassevaart has chosen to transport only +/- 10% of the soil to be removed from the construction site (net dredging works, about 9 million m³. brut dredging works about 13.5 million m³) by using the locks. Most of the soil is transported towards the side of the lock where it will be dredged; a large part is transported via pumping lines (both floating and shore lines) over the lock complex. The remaining percentage of soil that is being transported by barges using the lock is shifted as much as possible to the lee hours of the locks. The use of the lock complex by the contractor Sassevaart is kept to a minimum.

Sassevaart will also install extra mooring and berthing facilities to improve the waiting quality for the ships.

Facts and figures

The New Lock has a lock chamber of 427m by 55m and has a concrete floor at -16.80m above NAP (with NAP the Dutch reference level). The Ghent-Terneuzen Canal has its still water level at +2.13m NAP, whereas the Scheldt River fluctuates between -1.89m NAP and 2.29m NAP in daily situation.

This New Lock will allow passage for large seaworthy vessels of 366m long, 49m wide and a draught of 14,5m.

The expected amounts of concrete are 300.000m³, 32.000 tons reinforcement steel, 10.000 tons construction steel for building the lock gates and bridges and another 50.000 tons of construction steel for piling and steel sheet walls.

This New Lock, just as the Western and Eastern locks in the Terneuzen's lock complex that just have been renovated for this purpose, will be operable from a distance.

260. No standard lock gates for the new sea lock in IJmuiden in the Netherlands, the largest lock in the world

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Largest sea lock in the world

The new sea lock in IJmuiden will be in terms of length (500 metres) and width (70 metres) the largest sea lock in the world. With these dimensions, it allows passage to the world's largest ships, who will be able to pass through the lock (regardless of the tide) which will strengthen the international competitiveness of the port of Amsterdam. At the same time the new sea lock is built ‘future-proof’. At an altitude of 8.85 meters above sea level, the Netherlands are protected from the rising sea water for the next two centuries.

A unique design

The functionality of a navigational lock is particularly determined by the lock gates and drive mechanism. Because the set of requirements and the spatial boundary conditions vary per lock, each lock requires a specific gate design and a standard solution is not available. This also applies to the new IJmuiden sea lock, where the design of the rolling gates, measuring 72 meters in length and 11 meters in width, is governed by the required robustness and RAMS performance, the environmental conditions, and the limited construction space. The new sea lock is built between the existing locks, which will largely remain open to shipping and road traffic during construction.

The limited width for the new lock heads and the rolling gates proved to be a difficult design challenge. A sufficiently reliable concept had to be developed, requiring minimal maintenance effort. The three rolling gates are designed according to the 'wheelbarrow principle'. The gate rests on a lower roller carriage on the lock chamber side and on an upper roller carriage on the gate recess side. The upper roller carriage also serves as a road surface by means of which onshore traffic can drive on and off, across the gate.

Gate structure

The lock gates hold water on both sides and comprises two retaining shell sheets, with horizontal sheeting sections in between, which requires minimal use of steel. In fact, the gate structure could be described as a girder resting on two supporting points and bending around the vertical axis. The gate will only start to bear down upon the concrete sill in the event of extremely high water levels.

At the location of the roller carriages, the gate will be positioned centrically on rubber bearings. These allow the gate to move horizontally causing the gate to be pressed against its buffers in the event of a differential head load without exerting a horizontal load on the roller carriages and rails. During opening and closing, the gate will be guided horizontally by means of polyethylene guide strips fitted at different elevations on both long sides of the gate and also in the rail beam structure at sill level of the gate bay.

Buoyancy system

To limit the load on the roller carriages and rail structures, the gate will be equipped with a large rectangular buoyancy system with air chambers over the entire length and width of the gate. There are special ballast tanks to compensate for marine growth and sedimentation. All ballast tanks can be emptied in the event of a gate change, which causes the gate to float upwards and allowing transportation.

Levelling system

Below the flotation system there are sixteen levelling openings that can be closed by means of hydraulically powered steel gate valves. The decision to incorporate levelling through the gate instead of through short culverts was again the result of limited space in combination with the vulnerability of the existing adjacent lock structure.

Robustness

The gates were designed to be more collision-resistant than required by the client. In the event of ship collisions up to a determined impact energy, the gate structures will undergo plastic deformation in a way that cracking does not occur in the shell sheeting. Computational analyses that simulated various collision scenarios demonstrated that the lock gate is sufficiently robust.

All hydraulic and electrical installations in the gates have been placed outside the collision-sensitive zone. For the same reason, the 16 levelling valves, each with their own hydraulic cylinder, have been placed at the center of the gates to prevent the slide guides from sustaining deformation in the event of a collision. The air chambers have been compartmentalized to limit loss of buoyancy in the event of a leak. In such a situation, the lock gate will still be able to fulfil its operational function, and allow navigation through the lock.

Environmental conditions

The presence of floating debris, marine growth and sedimentation can lead to accelerated wearing of the rail tracks, thus impairing the availability of the lock. To prevent this as much as possible, special facilities have been incorporated in the lock gate. At the front of the lower roller carriage a bull bar and dirt scraper have been fitted to the gate structure so as to push any obstacles encountered on the rail structure and on the guide beam into a collector well as the gate moves forwards. Additionally, a jet pipe will blow sand and sedimentation from the rail track.

To avoid that the lower roller carriage becomes overloaded due to accelerated marine growth or sedimentation as time passes, it is provided with a load sensor that will be continuously monitored. If there is an increase in the serviceable weight, it is possible to respond rapidly and compensate weight by pressing water out of the ballast tanks.

Drive mechanism

The upper roller carriage houses the machine room for the transmission drive. The gate will be moved by six hydraulically powered pinions and two pin tracks on each side of the gate recess. Due to the major differences in navigable levels, the recess walls can undergo horizontal deformation by several centimeters. The drive trains are pressed against the pin tracks by a central pressure bar with spring buffers. The hydraulic drive system behaves like a differential with six output axles, three on both sides.

261. Container ships moored at the port of Antwerp: modelling response to passing vessels

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Statement

Safety of port operations is a key aspect in creating a positive environment for a port to expand in an increasingly demanding society. An important aspect here is the safe mooring of (large) vessels, currently being addressed in the PIANC WG 186. In order to improve the conditions for moored vessels, accurate modelling software is indispensable. The Maritime Technology Division of Ghent University has conducted many studies over the last years, focussing on the effect of passing vessels on moored ships.

Accurate modelling of the behaviour of moored vessels due to passing vessels is required for several reasons. At existing terminals, the safety of berthed vessels is maximized by optimising the mooring configuration of said vessels. When a new design vessel is expected at the berth, simulations are used to decide whether the vessel can moor safely given the existing boundary conditions, which are dominated by the passing ship traffic. As ports value their dynamic presence in the world market, quays are often reoriented, welcoming other design vessels. Mooring studies can help in pre-emptively assessing the new situation, in order to ensure safe conditions for the design vessel of interest, without the need to set speed limits for the passing vessels. Mooring simulations are also useful when designing new quays or even new harbour parts. This allows the designs to be optimised for a range of moored design vessels.

Abstract :

The safety of the moored vessel is affected by port and location specific factors. Some ports suffer from incoming swell, some from harsh wind conditions, others from the effect of passing vessels. In this paper, we focus on the effect of passing vessels on moored container vessels. Where the passing distances are rather small, e.g. due to the geometrical layout of the port, a passing vessel may cause the moored vessel to move along the quay during the ship passage. Large motions will eventually cause safety issues, both for vessel, quay infrastructure but most importantly for the crew members and workers. Reducing passing speeds in order to limit ship motions is a theoretical solution, however from point of view of safe navigation and/or efficient traffic management, this is not always a desired option.

In order to accurately model the behaviour of moored vessels, the software tool which is used for scenario analysis needs to be validated using model tests and/or full scale measurements. The Maritime Technology Division of Ghent University uses a two-step approach to model the effect of passing vessels. The forces acting on the moored vessel are calculated using the potential code ROPES [1] [2], which has been validated by model tests executed in the Towing Tank for Manoeuvres in Shallow Water (co-operation Flanders Hydraulics Research – Ghent University) in Antwerp, Belgium [3]. The motions of the moored vessels and the forces in lines and fenders are evaluated using the in-house software Vlugmoor, which solves second order motion equations in the time-domain. In order to validate the results, the modelled motions of the vessel are compared with GPS readings from full-scale measurements performed in the port of Antwerp. This has been done for various moored container vessels, monitoring their

movements during the entire stay at the berth. Several critical passing events are extracted from the data time series.

Subsequently, the software is used to study the mooring configuration of the observed vessels in detail. In a first stage, the position of the lines is optimised to minimise the longitudinal motions of the vessel along the quay, which is being observed as the dominating motion. All lines need to be positioned to maximize the longitudinal force component of the line, minimising the steepness and the angle with the quay wall in the horizontal plane. Secondly, the importance of having sufficient pretension in all lines is shown. The absence of pretension is most pronounced when nylon lines are used, as they show a non-linear stress-strain behaviour. If slack is present in the lines, there is a postponed reaction to the external force, causing heavier loading of the other lines. This leads to breaking of lines at lower external loads than expected based on conditions with optimal pretension. In a last part, the effect of important parameters, such as water depth, ship speed, passing distance, … on the behaviour of the moored vessel is shown.

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262. Case study: Engineering of a EPC 3km jetty fast track project

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Keywords: Jetty, EPC, In-house engineering, tight schedule, remote location.

Introduction

In the Red Sea, the BESIX-Orascom Joint Venture has constructed the Ain Sokhna Product Hub, a 3 km F-shaped jetty. The project consists of three berths, including berthing furniture and M&E works (firefighting systems, CCTV and control building). The construction time was less than one year.

The paper will focus on the engineering aspects related to this EPC contract. The mains challenges of the project where:

Extremely tight construction schedule

Absence of trustable geotechnical investigation at start of the works

Top side equipment and layout not fully defined at the start of the detailed design

The paper will consist in a case study about the fast track engineering study in the framework of a challenging EPC contract with limited information at start of the detailed design.

The project includes:

- 3km of Trestle
- 3 Loading Platforms
- 3 Service Platforms
- 18 Mooring Dolphins
- 12 Berthing Dolphins
- 530 piles driven in 9 months
- 16,000 m³ offshore concrete poured in 9 months

Engineering Schedule

The schedule of engineering woks presented in this section. The sequence on work in relation with the available input data and the strategy to allow early procurement will be detailed. A basic design stage with some tangible targets has been undertaken immediately after kick-off. Its results with the associated limitations was provided to the procurement tem to enable market enquiries while the detailed design was progressing

Geotechnical investigation and consequences on design

The 7 CPT logs for the 3 km jetty provided during tender where not sufficiently detailed to undertake a detailed design for permanent works. Hence, a dedicated soil investigation campaign was specified. The mobilization of state of the art floating equipment in a remote

area was challenging. Hence a sub-campaign, land based and requiring the construction of a temporary bund was undertaken.

The land-based campaign has allowed the early identification of a liquefiable layer in the first 300meters of the jetty where a causeway was originally planned in tender. An additional engineering team has been mobilized to design a mitigation measure for this issue. The stability of a traditional rubble mounted causeway was jeopardized by the presence of this layer. Hence, it has been proposed to cast vertical concrete piles through a temporary bund with land based equipment. This solution was to be provided up to a depth where the steel piles of the remaining part of the jetty could be driven through this layer with marine equipment. Both concrete and steel piles reduce drastically the sensitivity to the weak layer.

The CPT preformed by the JV indicated an soil profile constituted of alternating weak sand and soft clay layers. The interpretations of the results of the soil investigation lead to very long steel piles to be installed for the jetty (up to 75m). The design has been confirmed by two static load pile test at two different locations. At each location, 4 piles where installed: two reaction piles, 1 compression test pile and 1 tension test pile. Pile test have demonstrated that the design was adequate.

Structural design

Pile design was mainly governed by geotechnical bearing capacity and by the combination of axial force and bending moment. The installation of the piles with jack-up barges was also carefully designed. The very long piles where having an long stick up portion of their length above the driving gates before start of driving. Finite 3D models where undertaken to check the risk of local buckling inside the gate supports under the combined effects of: self-weight of the pile; weight of the driving equipment and compression wave during driving.

The crosshead beams joining the piles have been designed to work properly in absence of piperack, with 1 or with 2 piperacks. As the jetty has a particular F shape, piperacks are crossing the roadway at some locations. Particular crossheads have been designed to support the piperack bridges at these locations.

The roadway spanning from Crossheads to crossheads has been designed as simply supported on a 36m span. It is made of a composite deck. On top ow welded steel beams, precast planks are installed which are connected to the main beams via in-situ concrete and pockets of shear studs. This choice of structural solution has allowed procurement near the site, ensuring guarantee on the delivery.

The services platforms are supported on vertical piles. The deck is composed of precast slabs connected through in-situ stiches. This structural solution has allowed very quick installation with all the concrete prefabricated on site. This has allowed optimized usage of the marine fleet. The loading platform are supporting berthing fenders. For these 3 platforms, an engineered pile layout has been proposed, match with the two main requirements: distribute efficiently vertical and horizontal loads within the pile group while offering regular supporting mesh to precast pieces. These platforms are split in two zones: the front part where heavy elements are to be embedded are deep in-situ sections while the rear part, supporting lighter equipment, is composed of precast planks connected with in-situ stiches.

M&E requirements

In order to allow early exploitation of the terminal, requirement has been raised during design to support water piping and gas piping along the jetty. It has been proposed to extend the

bracing of the roadway steel beams outside of the footprint of the roadway in order to use them as support for the piping.

Conclusion

This case study will demonstrate how the detailed design by an in-house engineering department of an EPC contractor has allowed to build the jetty in the required time frame with the selected equipment. Focus will be set on the constructability of the different parts of the project, showing the interconnections between: design; procurement and construction, resulting in a safe and efficient project.

263. Use of Model Simulation at the Panama Canal for Resource Estimation

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Use of Model Simulation at the Panama Canal for Resource Estimation

The transit of vessels through the Panama Canal is a complex process that requires a plural and diverse number of resources working in a synchronized manner throughout all the geographic areas and phases that the transit involves. These resources are distributed accordingly and their assigned radius of activity depends on the planned logistic corresponding to every one of the 365 days of the year. Some of them remains within a confined zone, others move within one of the two major defined geographic sectors: Pacific and Atlantic, and a few fallow the vessel al the way.

Equal to the complexity of the transit is the estimation of resources needed per day, considering that the sequence and the mix of vessels (by size, market segment and direction) varies every time. In the year 2006 the Panama Canal consequent to this reality, began the development of simulation models that could estimate with better precision and confident level some of these resources. Model simulation would replace then the manual estimates utilized at that moment.

The models mentioned above include the resources of tugs, launches and on deck Line handlers and they are described as follows:

Two models were developed corresponding to the two major geographical sectors: Pacific and Atlantic.This division was made since the majority of the resources are assigned within this two specific sectors.

The software utilized is ARENA by Rockwell Automation which permits the development of process simulation models for a wide range of business or public environments.The main developing mechanism consist of incorporating modules, provided with the software, and construct logics, from scratch, via flow charts and the help of visual basics for very complex events and interactive windows

The models simulate the vessels transit process, and as the vessels go through all the navigation channels and locks they are assisted, on one hand, by launches in a way of embarking and disembarking personnel (such as Pilots and On deck-Linehandlers).And, on the other hand, by tugs which assist in the maneuverability and safety in specific navigational channels, on the approach to the Lock walls and within the new locks.

The models were developed with a very high graphical visual approach with the purpose for the developer or user to see clearly the events taking place. This characteristic is very helpful during the developing and debugging stages. Also, the dynamic graphics helps the presenter to transmit his message and results and very importantly: for the audience to help assimilate the issues being discussed.

The main input that feed the models are the vessel schedules corresponding to either a few days or an entire year and can come from three different sources: 1-real historical data, 2-

manual schedules and 3-from the new Capacity Model that can generate, automatically, schedules for a desired period of time. The schedules received are then processed into another Excel file designed specifically with data and formulas which are linked to the logic structure of the models. The Capacity Model is the most used source and it is normally ran for an entire fiscal year into the future.

As the models ran, they register the number of the different resources in use, at ten minute intervals, corresponding to the established geographic sectors or operational dock. At the end of each day the data is exported to an Excel file.This Excel file automatically generates demand curves which allows the establishing of the number of tugs and launches required and the corresponding operating structure (watches during the day).For the tugs, it relates to each of the two major geographical sectors and for launches it relates to each operational dock.

The models also generates demand curves for the On deck-Linehandlers which helps optimize the structure of the shift schedules of these personnel (most appropriate reporting times and quantities) as they permit to visualize the match or gaps between the supply and demand curves during the day.

With these two models the Panama Canal throughout the years has been able to experiment with diverse number of scenarios and to generate all kind of information and provide answers to several specific administrative questions and opportunities to improve efficiencies.

Besides these two models many others, representing other processes, have been developed at different times for process optimization and resource estimation.

264. Operational Capacity Model for the Panama Canal

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The Panama Canal Authority (ACP) employs a sophisticated simulation model that combines a scheduling algorithm together with simulation software to perform operational capacity analyses. The Panama Capacity Model (PCCM) allows the ACP to model the canal under different demand and configuration scenarios. Scenarios where the configuration of the Panama Canal is modified, typically examine the effects on capacity of navigational rule changes, infrastructure projects, and the optimization of operational processes.

Dredging Division in the Panama Canal has been benefiting from the use of the PCCM, as the model is being used to gauge the effect on capacity of dredging projects, and thus, estimate their economic feasibility. This information has been useful to prioritize projects, and program Dredging Division's work schedule.

265. Simple but accurate calculation method for vessel speed in a minimum capacity lock

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Introduction

The increase of vessel size puts an upward pressure on the maximum allowed vessel dimensions in various inland waterways. Clearance between lock and vessel is decreasing to marginal values. This is especially the case with existing locks designed to provide sufficient locking capacity for large number of small vessels. However, with growing vessel sizes, these original “capacity” locks turn into “minimum” locks for the new modern vessels. As such, waterway authorities are increasingly challenged to allow vessels with dimensions that exceed the maximum allowed. Besides the risk of collision of the sill or the lock head, there is also the aspect of the time required to sail in and to sail out of the lock. This paper is a contribution to understanding the consequences of larger vessel size in the existing lock infrastructure focussing on the vessel speed during sailing in and sailing out of the lock and the subsequent increase of the lock-cycle time.

Background

For a specific canal in the eastern part of The Netherlands (Twentekanaal) the government decided to upgrade the canal to Class Va vessels. The canal was originally constructed for Class IV vessels with a draft of 2,6 m. In the existing locks (L= 133 m, W= 12,0 m, D: 3,45 m) the margins with a Class Va (D=2,8 m) vessel decrease to below the minimum values recommended in the Dutch Waterway Guidelines (WG,2011).

- Margin in width 2* 0,3 m =0,6 m where recommended: 2*0,55 m =1,1 m;
- Gross underkeel clearance 0,65 m, where recommended 0,70 m.

The questions that arise are:

- Is the UKC still positive and safe? Or does the vessel touch (or even damage) the lock sill?
- Is the vessel able sail in and out of the lock with acceptable speed?
- Is the increase of the locking cycle time acceptable?

Desk study

Where sailing in a canal can be characterised as sailing in confined water, sailing in a lock should be characterised as sailing in extremely confined water. The sailing speed in confined water can be calculated with the method described by Schijf (1949) and Jansen & Schijf (1953). Schijf’s method has been applied for the calculation of the sailing speed and the squat of the vessel in the very confined water of the lock. The objective is to compare the critical sailing speed and squat for vessels from all CEMT-classes and at a number of drafts. The result of

the calculations indicated that the existing navigation lock would be able to lock the larger ships safely, but that the locking cycle time would increase.

However, Schijf's method does not account for the important aspect of energy dissipation in the return flow and the increased water level in front of the bow in the dead end of the lock chamber. Therefore, it was decided to verify the results of the computations with prototype measurements.

Prototype measurements

Prototype measurements have been executed with a loaded CEMT Class Va container vessel. The vessel sailed up and down the canal twice and thus through the lock four times. During the sailing down and up, the following data was collected (frequency 1 Hz):

- Manoeuvring of the vessel (use of main engine, ruder and bow thruster);
- Position (x, y and z) of bow and stern of the vessel (RTK receiver); and
- Water pressure in the lock heads at (both sides of the gates).

A total of 4 sailing trips through the lock have been executed:

1. Sailing and locking down with a draft of 2.6 m
2. Sailing and locking up with a draft of 2.6 m
3. Sailing and locking down with a draft of 2.8 m
4. Sailing and locking up with a draft of 2.8 m

Characteristic values and verification of Schijf's method

From each measurement a number of characteristic values have been derived:

- Dimensions of the lock and the water level;
- Use of main engine (propeller) during lock entry and lock departure manoeuvre;
- sailing speed in the lock during sailing in and during sailing out;
- maximum squat of bow and stern in lock head;
- drop in water pressure inlock head during passing of vessel.
- lock entering time (from bow in lock head to stern in lock head);
- lock departure time (from bow out of lock head to stern out of lock head);

Verification calculations with Schijf's method

The verification calculations have been executed for the exactly the conditions and water depth that occurred during the measurements. The measured and calculated sailing speed and the time for sailing in and sailing out of the lock appeared to deviate significantly. The deviation appeared to be explained from the hydraulic processes that are not accounted for in Schijf's method:

- Dead end waterway (resulting in increased water level in the lock in front of the bow);
- Hydraulic resistance between vessel hull and lock chamber that results in a water level inclination along the vessel.

The above two effects have been added to Schijf's original method. This resulted in a very good agreement between the measured and calculated values.

Conclusions

A simple method has been developed to evaluate the sailing speed and time required for the entering and departing of the lock chamber. The basis of the calculation method is Schijf's well-known method that describes the hydraulics around a vessel sailing at constant speed in a uniform canal. The paper presents the calculation method, the measurements, the verification and the adaption of Schijf's method. In addition the paper will compare the calculation method with measurements of one vessel sailing through 5 locks in Belgium.

266. Physical model research on breaking logs for through the gate filling of new Sint-Baafs-Vijve lock

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The lift height of most inland navigation locks in the Flemish region of Belgium is limited to 2-3 m. For these locks openings integrated in the lock gate sealed by vertical lift valves or butterfly valves are commonly used as lock levelling system. To improve the spreading and energy dissipation of the filling jets and hence reduce the hydrodynamic forces on the moored ships, breaking logs (also referred to as energy dissipation bars) might be mounted at the downstream side of the gate openings. Beem et al. (2000) provide some Dutch design guidelines. Since the shaping of a gate opening across the thickness of a steel gate and the integration of the valves are somewhat country-specific, it was decided to set up a generic physical model at Flanders Hydraulics Research (Antwerp, Belgium) aiming at determining the effect of breaking logs on the flow inside the lock chamber and optimization of the breaking log configurations adopted in Flanders (Verelst et al., 2016).

In this contribution, an account will be given of the specific research carried out in this model during the design of the levelling system of the new lock of Sint-Baafs-Vijve (river Lys, Belgium). During the physical model research, 4 different configurations were tested. For reference purposes, the first configuration did not have any breaking logs. Next, three configurations with respectively 7, 5 and 3 breaking logs were tested. At first the discharge coefficients of the configurations were determined, for valve openings ranging between 20 % and 100 % of the total valve lift height. It turned out that the influence of the breaking logs on the discharge coefficient was negligible for valve openings below 50 % and limited for higher valve openings. Secondly, the effect of breaking logs on the energy dissipation was studied. When adding breaking logs, the spreading of the filling jet increased and the maximum velocity reduced to approximately 60 % of the velocity measured in the core of the jet compared to the configuration without breaking logs.

The research revealed that the exact positioning of the breaking logs with respect to the gate opening at the upstream skin plate is more important for the spreading of the filling jets than the amount of blockage of the gate opening at the downstream skin plate. The lowest velocities were achieved with the configuration with 3 breaking logs, which is the configuration with the least blockage of the gate opening at the downstream skin plate.

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267. Towards a Complete Design of the Manoeuvring Areas Additional Factors Involved in the Detailed Design

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Abstract

In order to establish the dimensions of approach channels and manoeuvring areas, PIANC guidelines consider two phases: Concept Design and Detailed Design.

The Concept Design Stage includes preliminary design of channel width, depth and alignment using empirical formulae, together with limited data related to ships and environmental conditions. Only rough estimates of the dimensions of the proposed channel (width, depth and alignment) are determined. The results sometimes are conservative, because general guidelines cannot assess all case-specific features and conditions.

The Detailed Design Stage is a more rigorous process intended to validate, develop and refine the Concept Design. The operational aspects are checked, referred to weather conditions, ship size and manoeuvring capacity, tug assistance, piloting, etc. If the conditions are relatively simple and all the design criteria are easily fulfilled, there may be no need to make significant adjustments to the Concept Design. But in most cases additional analyses are necessary to determine a more accurate design that will definitely be safe and usable without unnecessary expense. In this case, much more detailed information is needed regarding fairway geometry, weather and current conditions, ship characteristics, manoeuvring strategies, etc.

Real-time Manoeuvring Simulation is the most advanced tool to be used in this process. A realistic, detailed, complete representation of the port and its particular physical conditions is built. Ship behavior in shallow waters and restricted channels can be accurately reproduced, together with the assistance of specific tugs. Moreover, Pilots and Captains can take part in the analysis, so their expertise and the perception and decision making factors are incorporated to the design.

Real-time simulation, if properly defined and executed, can absolutely help to define a more accurate design and operation conditions of a port area. A detailed approach based on specific local conditions (geometrical and environmental), specific ships (dimensions, propulsion and steering capacity), AtoN and tug assistance will provide complete, accurate and detailed indications on the execution of manoeuvres, both in normal and emergency conditions. Therefore, precise operation limits, manoeuvring strategies and contingency plans can be elaborated also involving human factor.

In some cases, the analysis of new scenarios is outstanding, such as the access of new larger ship classes to existing ports (container vessels, LNG carriers, cruise vessels,…). The limitation in space and therefore the reduction of the manoeuvring areas becomes a critical factor. The final design will depend not only on the dimensions obtained from the statistical analysis of the simulation results but also on many other factors involved. These concern mainly Change Management (adaptation to key factors of the project in their new configuration) as well as the creation of a Confidence Building Process.

For this purpose, a technical committee representing the main experts in the project (Port Authority, Operators, Designers, Maritime Authority, Shipowners, Pilots, Tug Companies, ...) is recommended to be created to participate in common workshops during the design process, in order to check input data and assumptions, survey the simulations, contribute to the discussions and finally validate the simulation results and include their opinions.

This process is considered decisive in relevant projects involving such new scenarios, where important changes are proposed (increase in the size of vessels or significant changes in the geometry of the manoeuvring areas, especially if additional dredging is required).

In this way, the management of the change of all relevant factors by seafarers in charge of the manoeuvre (detailed knowledge of the behaviour of the new vessels, modified operational limits, training process of the new manoeuvring strategy, detailed knowledge of the modified manoeuvring areas and new AtoN, definition of communication procedures between Pilots and Tug operators, definition of operation procedures, ...) is totally connected with the proposed design. This process will finally conclude with the definition of a detailed procedure describing all relevant factors to take into account so as to operate the design vessel in the port.

Consequently, in most cases, the final manoeuvring areas (geometry and dimensions) are directly related to the manoeuvring skills and confidence level that Local Pilots are able to transmit to the main stakeholders of the project.

Interest and Benefit:

During years of port design studies related to navigable areas, the experience is that it is quite often necessary to explain why the manoeuvring areas obtained are sometimes so optimized in dimensions. From the point of view of the nautical advisor and port designer, it is important to highlight that the final design does not only consist of a set of dimensions to be defined, but also a detailed procedure to be fulfilled. This allows to, step by step, reach the final goal, which consists of operating the Design Vessel in the Port under the limiting conditions using the optimum required navigable areas. So, this complete design concept includes not only a geometrical description of the manoeuvring areas but also the consideration of a relevant set of nautical factors and human behaviour.

268. Full-scale measurements to assess squat and vertical motions in exposed shallow water

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The shipping traffic to the Belgian and Dutch ports located at the Western Scheldt estuary and the river Scheldt follows an access channel of restricted depth. As a result, deep-drafted vessels cannot always sail 24 hours a day on the River Scheldt. The period in which these vessels may proceed inbound or outbound is called the tidal window. The Common Nautical Authority (CNA) calculates these tidal windows and gives permission for the vessels to proceed. For the calculation of tidal windows, the CNA is in the process of adopting a probabilistic access policy to determine the tidal windows.

In a probabilistic approach the expected vertical ship motions are estimated based on ship particulars and environmental conditions, in order to define a safe criterion for the under keel clearance [1]. In this respect an accurate prediction of ship squat and dynamic vertical ship motions is of utmost importance. In order to validate the squat and seakeeping calculations applied in the probabilistic calculation, full-scale measurements are being executed.

A first series of full-scale measurements focused on seven inbound cape-size bulk carriers (with approximately 16.5 m draft) to the port of Flushing (the Netherlands). These voyages involved small under keel clearances (to a minimal value of 16%) and exposed wave conditions (with a wave height up to 2.6 m).

Seven full scale measurements were provided by the Dutch Pilotage by means of positioning data from three RTK-GPS antennas that where mounted on both bridge wings and at the bow. These data were processed to determine the motions of the vessel in 6 degrees of freedom at 5 Hz. By referring the ship motions to a static measurement (at near-zero speed), the height of the antennas could be referred to the water level. With these reference heights the vertical ship motions at sailing conditions could be referred to the water level. Special attention was paid to an accurate reproduction of the tide along the trajectory in order to obtain an accurate measurement of the dynamic draft. The vertical ship motions were divided into steady motions (related to squat) and dynamic motions by means of a digital filter.

In addition to the squat, the ship speed through water was determined based on position measurements and hindcast calculations of the current carried out by Rijkswaterstaat. The under keel clearance and the blockage were also determined using the most recent survey data at the time of the measurements. Furthermore ship meetings were obtained from an AIS analysis.

In order to evaluate the relationship between dynamic ship motions and wave conditions, the ship motions were compared to directional wave spectra available at the Belgian coast (source: Meetnet Vlaamse Banken).

Processing of the above-mentioned data clearly revealed the influence of ship speed and under keel clearance on squat and the influence of swell on dynamic ship motions. Furthermore, in order to validate the safety margins corresponding to a probabilistic

accessibility approach, the full-scale data could be applied for direct comparison to the calculation of the dynamic draft performed by CNA.

First, the paper will give a detailed introduction, presenting the aim and scope of the project. Secondly, the post-processing methods applied to obtain ship motions, tide, current, AIS, bottom depth and waves will be described and illustrated. Then the results of environmental parameters and vertical ship motions will be presented and discussed after which the vertical ship motions will be compared to the actual under keel clearance and to the deterministic criteria applied at present. The paper will conclude with a summary of the most important observations and propositions for future research.

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269. River Information Services in a multimodal Intelligent Transport domain

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Since the first initiatives of the European Commission on River Information Services, this concept on information exchange to support traffic and transport management in inland navigation, has found its way throughout the world. In recent years River Information Services (RIS) the development and especially the implementation of RIS has been considerable. Multi-end Synchromodal transport and logistics will put new requirements on the RIS related services, systems, technology and standards. For RIS this brings new opportunities for improving the quality and efficiency of inland Waterway transport. In the transport and logistics domain the focus is more and more on multimodal transport with information services in intermodal context. In this context important requirements are:

- A paper-free, electronic flow of information associating the physical flow of goods with a paperless trail built by ICT includes the ability to track and trace freight along its journey across transport modes
- The simplification of freight and transport information exchange to reduce the cost of transport.
- Freight should be identifiable and locatable regardless of the mode it is transported on.
- It is essential to create a single transport document for the carriage of goods in any mode.

It becomes more and more clean that digitisation of transport and logistics is an essential prerequisite to guarantee in the coming decade an efficient and sustainable transport. Digitisation has the objective to move from paper to electronic documents, through simplified procedures and integrated information exchanges across different sources. A necessary condition is that standard (information) interfaces within the various transport modes are put in place and their interoperability across modes is assured. RIS can contribute to above mentioned ambition and challenges if attention will be given to changing requirements on River Information Services in a multimodal environment and above all the focus will be on the seamless interfaces with information services in other transport modalities. A key issue in this is to consider analyzing the interaction between RIS services with other concepts for the information services in other transport modes. In addition it can be of great benefit for the further development of RIS to consider using services, information, technologies, architecture, etc. that consists in the Intelligent Transport Systems (ITS) of these transport modes. A pro-active attitude towards this development of multi modal transport information services is essential. Development of multi modal information standards is demanded, Assessment of these future requirements should be put on the agenda of the RIS community. A transition strategy for RIS towards harmonised multi modal transport and logistics information services environment is to be developed.

Comparing RIS and ITS

The PIANC working group on River Information Services did a restricted study on the ITS concept for roads and for railways (The ITS concept for railways is called in Europe ERMTS -

European Railway Traffic Management System). The aim of this study and consequently the presentation during the PIANC World Congress is to offer, firstly, an overview of the main features of the principal key objectives of ITS in comparison with RIS. Secondly a comparison focused on the services as provided by RIS and those of ITS for roads and ERTMS for railways. The presentation will give detailed information on the comparison between ITS road-services as defined in US, EU, Japan and ISO standards as well as a comparison of ERTMS Services for railways according several standards. Based on the study, recommendations are given regarding future interfaces with ITS development, or the extension of RIS services to other areas. In order to obtain a reliable comparison according this standard purpose the features of ITS for roads and railways have been classified according the criteria considered for RIS and adapting, as much as possible, the concepts and definitions of roads and railways' ITS to them. Taking into account this classification criterion, a comparison considering the three levels of RIS definition: [1] Functional, [2] Services and [3] Technologies, will be made. A classification will be given based on the Functions and Services established for RIS, and matching with them those concepts (both systems, functions, etc.) that best fit with their definitions.

Differences and Synergies

Although, from a general point of view, all Intelligent Transport Systems (considering RIS included in this category), should have, at the end, same or quite similar high-level functional requirements, it could be easily stated that actual features of the transport mode could made the stakeholders to prioritize some of them above the rest. This fact can be stated when comparing the Key functional requirements for RIS with the ones required to the Roads and Railways' ITS. When comparing these systems, one could state that although most of indicated key functionalities are required to both of them, there are some differences in regards to the focus that is put in some areas.

Possible benefits for the RIS domain in the relation to ITS

Finally, as a conclusion of the report, a brief note on the possible benefits for the RIS domain will be provided, mainly focused in those developments in ITS domain that could best fit with inland navigation features.

270. Integrated Asset Management: predictive, future responsive and use orientated decision making.

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In the recent years Port of Rotterdam worked on a higher level in Asset Management of its maritime infrastructure, which is confirmed by achieving the ISO 55000 certification. The currently running program Integrated Asset Management adds to this basis to look at the assets as part of the logistics chain and/or nautical process and ensure the availability of (asset related) information for all in the chain involved parties, not only within the Port of Rotterdam organization but beyond, such as customers and other stakeholders.

The customers and stakeholders want to know more about the assets, but we want to know more about how customers use and need the assets with the aim of increasing efficiency in all parties. In society and the world around us we see increasingly challenges that result in threats and opportunities, not just for individuals and the environment, but also for organizations such as the Port of Rotterdam. This includes issues such as climate change, world population growth and more specific issues for the port authority like energy transition, autonomous sailing, alliances in the container transport and the demand for mobility. At the same time, there is exponentially increase in digitization.

Everything is measured or can be measured and is available digitally. POR will have to prepare for major changes in the field of digitization and robotization in the port, which is already recognized in the ports digitization strategy: PoR's aim is not only to have the best port infrastructure, but also the smartest. Same goes for the assets of PoR in the future. Where the assets are "dumb" now, they will be in the future equipped with smart sensors. These sensors monitor continuously the assets of PoR. Integrated, anywhere in the Port, all at the same time, all together and on every second of the day, assets will cooperate with each other.

Hence: "the Inspector of the future is a sensor." No longer doing things right, but doing the right things in asset management Using smart and integrated analyses (Analytics) that make it possible to understand and anticipate better and that now are still unknown and unforeseen. Analytics within Asset Management is seen as one of the critical success factors to assets and modalities to make timely measures and developments in the port. Analytics allow us to make future-oriented decisions based on facts, so called ' what-if ' scenarios and to develop aging models based on actual use. This allows us to optimize the performance of assets and modalities based on real time and future use (like predictive maintenance and future-responsive).

Analytics will also tell us on which areas still insufficient information is available to support adequate decision-making. Also analytics will trigger for the tuning of appropriate information based on, among other things, sensors, external data sets, and big data. The availability of (real time) data will also provide benefits in the design of new assets. Integrated asset management does not start when a new asset is built and delivered, but gives added value in the design process, by making clear what the longer term effects are of choices in the design, based on data from actual use. In the end it delivers a saving of deployment of hours and money.

On several areas there is now talk about scaling up, so also in asset management. Eventually, the shared information, lead to systems that are associated with each other and communicate with each other independently, a complex of systems, where plans, information and so on is shared between organizations and leads to more cooperation and decision making based on the interests of the entire chain of systems. What eventually leads to an even more efficient port management. The benifits are evident.

271. World's largest FRP Composite Mitre Gate

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Rijkswaterstaat stimulates innovation by use of Fiber Reinforced Polymer (FRP) Composites in civil waterway works in cases where there is a material property advantage.

As FRP Composite is strong, durable, lightweight, low-maintenance, and easily fitted; the use of FRP Composite instead of classic steel or wood was chosen for new large Mitre Gates in the Wilhelmina Canal, The Netherlands.

Each leaf of the bottom gates has a dimensions of 6.3 x 12.3 meters and are designed to resist a hydraulic head of 7.8 meters.

Because of the less intensive maintenance regime also low hindrance for water traffic during the 100 years of the intended design life is expected. Also the use of tropical wood will be avoided, which contributes to one of the Rijkswaterstaat general environmental objectives.

This paper describes aspects of designing, building, installing and the performance after more than one year of service of the largest FRP Composite Mitre Gates in the world today in the Wilhelmina Canal, The Netherlands.

The design approach for this hydraulic FRP Composite structure is discussed, based on the functional requirements in conjunction with the hinges, the quoin blocks, gate paddles and the sealing requirements.

Extra specific requirements and testing of the FRP Composite material ensure the structural safety and durable performance. This creates consensus among designers, operators and users to accept the use of FRP composite as an innovative and reliable material for this relatively large hydraulic structure.

Note:

Presentation of this paper will be given as part of the SHORT COURSE: Miter Gates, Rolling Gates and Operational Machinery Process Design. This presentation helps the world wide discussion to make the use of FRP in hydraulic structures acceptable among designers, operators and waterway users. In general, by using FRP Composites in hydraulic structures all stakeholders can benefit because of the reduction in maintenance costs and hindrance.

272. Revisit the Economic Impacts of the Cruise Ports in the United States Considering Responsible Cruising

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Using port operation information, REgional ECONomic System (RECONS) developed by the Institute for Water Resources (IWR) US Army Corps of Engineers (USACE) provides estimates of regional and national jobs and other economic measures such as income and sales associated with port activities. Economic impact tool not only reflect regional growth and the importance of port activities, but also serves as an assessment to redistribute maritime resources back to the port communities.

Understanding such, the USACE is also responsible for construction, operations, and maintenance for more than 50 federally authorized cruise ports in the U.S. However, the federal budgetary funds are often linked to total tonnage a port handled rather than the number of passenger served or the regional economic benefits from cruise ships and the passengers. There is a need for the USACE to extend the scope of RECONS to incorporate cruise ports so a standardized and objective assessment can be provided to have a comprehensive view of the benefits of these ports.

Often time, greater economic impacts in terms of job creation, economic growth, and direct/indirect impacts to the local economies are used for marketing and planning purposes to showcase the importance of a port as the economic driver. However, the results from the economic impact study alone may not well serve the local stakeholders and the public who care more about the social awareness of environmental issues, conflicts of interest alongside the value-added chain, and responsible cruise tourism in the local community. Externality and implicit economic costs are often neglected in the calculation of economic impact to truly reflect the reality.

Therefore, this research aims to rethink the concept of how cruise activities is measured in the impact analysis in a way to incorporate key qualitative information such as corporate social responsibility (CSR) in general and environment management and planning in particular. For instance, governance structure of the organization of a cruise port, employees' education and training practices of a major cruise line, green policy implementation regarding air emission, energy consumption, and waste management for all parties involved in the cruise value-added chain, etc. will be taken into consideration while assessing the economic impact.

The contributions of this study are twofold. First, we offer a theoretical framework to tailor cruise economic impact platform, which will capture the uniqueness of a cruise operation in the value-added chain, the contribution of cruise ports, cruise lines, and cruise service providers and suppliers in a cruise maritime cluster can be quantified respectively as input factors and then come up with an aggregate measure of direct, indirect, and induced impacts as output. Second, we provide a quantitative metric to measure for all relevant environmental responsibility and social awareness to pursue responsible tourism and sustainable cruising. This kind of application will also contribute to a bigger picture of climate change mitigation in the maritime industry, and provide a concrete measure of what kind of adaption plan could be implemented.

273. Theoretical study and engineering application of the structure design of deep plug-in large diameter steel cylinder

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To meet the sustainable development of shipping industry and the need for large-scale shipbuilding, effective development and rational utilization of marine deep water space is the top priority of the future shipping industry. However, deep-water marine environment is extremely complex. Traditional structures are unfavor able for deep water structure neither economically nor technically. Therefore, in order to meet the development trends towards deep water, there is an urgent need to develop a new port structure that adapts deep water environment, deep soft foundation and is of good stability and rapid construction.

Plug-in large diameter steel cylinder structure is a space shell structure with no cover, no bottom and no partition. It works as a whole together with the backfill sand inside the cylinder. From the point of mechanics characteristics and work mechanism, the work mechanism of shallow plug-in steel cylinder structure is close to gravity structure. However, when the soft soil layer is thick, the buried depth of cylinder is deep and the soil layer under the bottom of structure is not hard, there is no definite bearing point at the front toe of steel cylinder. The center of gravity is unable to achieve a stable torque. The stability is mainly maintained by lateral friction of soil inside and outside the cylinder wall and embedding action of soil before and behind structure, i.e., the cylinder must be inserted to a certain depth in order to achieve stability. In this case, the plug-in cylinder structure takes into account the force characteristics of both gravity structure and pile foundation structure. From the point of foundation adaptability, deep plug-in steel cylinder structure is very adaptable to deep soft soil foundation environment. The cylinder can be directly sank into soft soil to reach the bearing stratum. It also can be inserted to a certain depth of soft soil with the foundation before and after cylinder being properly dealt with according to demand. From the point of construction process, using plug-in steel cylinder structure in the deep sea area may not form the foundation bed, which speeds up the construction progress and saves costs. To sum up, compared to traditional structure, deep plug-in steel cylinder structure has advantages such as simple form, good mechanical condition, short construction period, economic material usage, strong foundation adaptability, small wave reflectivity and so on. Hence, it is more suitable for harsh sea conditions especially on the silt soft soil foundation. Such a structure will have broad prospects of application and should be further studied and promoted.

Whereas, as a new structure in harbor engineering, deep plug-in steel cylinder structure is still in its infancy with limited design experience and imperfect calculation theory in the world. So far, there is no unified recognition of calculation theory and method for structure stability and displacement in the industry, nor relevant standards and norms. At present, insiders have limited knowledge about the mechanical condition, the failure form, the complex interaction between cylinder and soil, the selection of the calculation parameters and the simplification of the model of deep plug-in steel cylinder structure. Deep researches on mechanism and design method of deep plug-in steel cylinder structure need to be did to solve the important issues of principle dimensions, stability and instability criteria which is related to project technical feasibility.

In this paper, by using three-dimensional finite element numerical simulation method, working mechanism of deep plug-in steel cylinder structure has been studied through sensitivity analysis on core parameters. Plane equivalent calculation method that simplify the spatial structure into a planar model of deep plug-in steel cylinder structure is proposed. Interaction model of soil and steel cylinder is identified. Distribution rule and calculation method of soil pressure are presented. Referring to field data measured from east and west artificial island project of Hong Kong-Zhuhai-Macao Bridge in which deep plug-in steel cylinder structure were used to build islands, model selection, border setting and choosing principles for parameters of spatial finite element numerical simulation for stability calculation are studied as well as the structural stability criteria. Plane equivalent calculation method for stability of plug-in steel cylinder structure is also verified and perfected.

274. A modern cyclone harbour for escort class tugs in north-west Australia

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ABSTRACT

This paper describes the design and layout of the marine facilities associated with the recently constructed Hunt Point Tug Harbour in Port Hedland. Port Hedland is located 1,322km north of Perth in Western Australia. The DMS latitude:longitude coordinates for the harbour are 20°18'14"S, 118°34'11"E. It is Australia's highest tonnage port and one of the largest iron ore loading ports in the world. Port Hedland is situated on one of the most cyclone affected stretches of coastline of the southern hemisphere with a tidal range of 7.5m.

The key design challenges addressed in the design were:

1. A requirement for post-cyclone operability up to and including a 500 years ARI cyclone event.
2. Safe egress from the tugs following completion of the cyclone mooring procedure in up to gale force winds (35 knots).
3. A design storm tide (including an allowance for 0.4m sea level rise) of 9.2m above LAT.
4. Cyclone berths catering for *RAstar 85* Escort Tugs with maximum displacement 1175t.
5. Minimise the environmental footprint and any regret capital expenditure associated with the potential future expansion of the harbour.

The resulting harbour design has met with approval from all stakeholders including the operations personnel.

1. INTRODUCTION

BHP identified a requirement to increase their towage services in Port Hedland. The strategic aims achieved through the recently completed harbour include:

- Mitigate the significant risk associated with the potential grounding of a vessel blocking the shipping channel which is 42km in length, tidally constrained and uni-directional.
- Provide new state-of-the-art tug berths to support the increased towage requirements associated with the planned future expansion of the iron-ore export operations at the port.
- Reduce the cyclone related disruption to port operations.

The new facility at Hunt Point has been designed to accommodate eight (8) new escort class tugs. Located behind an existing seawall, the environmental footprint, impact on recreation at the adjacent public beach and the requirement for marine based construction plant have been minimised. Four (4) berthing pontoons are located within the harbour catering for two (2) tugs at each berth. To provide for improved operability of the berths, the following features have been included on each pontoon:

- Fixed rotating access brows at two locations to allow bow-in and bow-out operational mooring of the tugs.
- Cyclone mooring line reels.
- Mooring line hangers.
- 1.8m wide gangways (of maximum 1:4 slope at LAT) providing a zero-step access to each pontoon through the full 7.49m tide range.
- Along-side cyclone mooring arrangement capable of surviving cyclones up to 500 years ARI (compared with a four-point cyclone mooring arrangement used elsewhere within Port Hedland).
- Mooring line snap-back guards for safe egress after mooring the tugs in pre-cyclonic conditions.
- Shore power, compressed air, drinking water and fire-water provided via the gangway.

In addition to the eight (8) tug berths, a pontoon for small boats is provided in the south-west corner of the harbour, as are navigation aids (including day-night lead marks designed in accordance with IALA specifications), revetments and other associated shoreside facilities.

2. TUG HARBOUR LOCATION AND LAYOUT

The Hunt Point Tug Harbour location was selected as the preferred location as it provides a number of benefits including:

- No increase in environmental footprint.
- Least energetic conditions within the lease boundary enabling a safer, less complex cyclone mooring design.
- Located within an existing seawall allows for shelter to be achieved with minimum effort.

Part of an existing sea wall was removed to create the 50m wide (at the toe of the entrance channel) entrance to the facility. Two 45m long piled sea-walls are located either side of the entrance to the harbour to protect the heads of the revetments in severe weather conditions and minimise wave penetration into the harbour.

2.1 Operational and cyclone berthing arrangement

A cyclone mooring arrangement alongside a pontoon has been adopted in lieu of the four-point arrangement used elsewhere in the port. This provides the following benefits:

- Reduced per-berth footprint.
- Safe for access to shore following completion of cyclone mooring procedure.
- Reduced cyclone mooring procedural complexity.
- Simpler tide-following mooring point details integrated into the pontoons.

The facilities provided within the Hunt Point Tug Harbour satisfy the requirements of operational and cyclone berths for eight (8) escort tugs. This is provided via four (4) 52m long, 5.85m wide pontoons. The pontoons are arranged so that two are parallel to the adjacent coastline (NNE-SSW) behind the causeway to the south of the entrance and two lie WNW-ESE on the far side of the harbour. Each of the four pontoons has been designed to be capable of berthing two (2) of the escort tugs. The operational mooring berths for four (4) crew transfer vessels are provided by a 21.6m long by 4.5m wide pontoon running E-W.

Each tug pontoon has been designed to allow the tugs to moor either bow-in or bow-out during non-cyclonic periods. For cyclone mooring, the tugs are required to moor bow-out. The crew

transfer pontoon is for operational use only and is not required to moor boats during cyclonic conditions.

The mooring of the vessels alongside the pontoon prior to the onset of gale force winds (pre-cyclonic conditions) enables landside access via the pontoon and access gangways for the crew to go ashore after completing the cyclone mooring procedure.

The fendering system comprises two twin air-block fenders per tug (four per pontoon). Low friction facing is used on a 2.4m wide fender panel to increase the contact width on the tug sponson. The air-block fenders provide a low reaction at small deflections making them ideal for use on the pontoons and with the tug hull geometry. The size of the air-block fenders is governed by the design cyclonic conditions. The energy absorption requirements during normal and abnormal berthing are significantly lower than those for peak cyclone events.

275. Physical Modeling Supporting Design and Construction of Low Crested Breakwaters for the Ayia Napa Marina, Cyprus

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A new marina and land development at Ayia Napa, Cyprus, was designed by SmithGroupJJR. The marina features a 600-slip harbour framed by a large shoreline protection scheme comprised of wave absorbing block wall, revetments, breakwaters and pocket beaches, as well as significant upland development including two towers and residential villas, some of which are in close proximity of the sheltering breakwater. A one kilometer long low crested breakwater with tetrapod armour was selected as the most technically, economically and environmentally feasible solution. A key design feature was maintaining a crest height low enough to provide the villa owners and marina users with un-obstructed views of the ocean. Therefore, a key element in the design was limiting the amount of wave overtopping that could pass over the low crested structure and threaten the villas, yachts, cars and people on the lee side of the breakwater. In particular the maximum overtopping flowrate rather than the mean time-averaged flowrate was identified as a critical design criteria, since it is more closely linked to the risk to people and property.

The original design of the breakwater was verified and optimized through an extensive physical model testing program. Flume physical model tests at scale 1:45.1 were carried out in March 2015 to define the breakwater cross section, were a 20 ton tetrapod armor unit was selected on a cross section with a 4 Tetrapod berm width of 10.2m and crown wall up to an elevation of 7.8 meters was designed to obtain a desired overtopping rate. However, as the site plan evolved, it became apparent that the height of the crown wall, at 7.8 meters above the low water tide level, created an obstruction to the view shed from inside the Marina basin and the Villa which prompted SmithgroupJJR to consider alternative designs.

Therefore, a redesign of the breakwater cross section to lower the breakwater height for the purpose of improving the views from the residential villas and the Marina basin was done. Several schemes to reduce the crown height were considered, and a wide low crested breakwater concept was selected. A second physical model study was commissioned in order to verify the performance of alternative design and guide their optimization with respect to wave overtopping, stability and constructability. The tested cross section was designed using the Neural Network Overtopping tool from TU Delft to develop the structure geometry and the guidance of Van Gent (2013) to determine the size of the berm stones. The proposed section consisted of two layers of tetrapod armour units placed on a structured grid, set to a front slope of 1:1.33 to a crest elevation of +4.6m above the waterline, and a 20 meter berm width backed by a crown wall at the same elevation (Figure 1). Also, the feasibility of removing the need for an excavated trench, on the shallow water portion of the breakwater, to secure the toe of the structure required verification in the physical model.

The efficient physical model study of the revised design was carried out at the National Research Council of Canada (NRC). A two-dimensional physical model of an idealized foreshore at the project site was constructed at a geometric scale of 1:42.2 in a 63m long by

1.22m wide wave flume. Scaled models of two breakwater cross-sections (one in shallow water, the other in deeper water) were constructed and exposed to scaled reproductions of the design wave conditions forecast for the site. The physical model provided a good simulation of the important hydrodynamic processes influencing the tetrapod armour layer stability and overtopping, including nearshore wave transformation, wave breaking, wave run-up, and interstitial flows through the armour and filter layers.

The performance of the two cross-sections was assessed by observing the stability of the armour units and amount of overtopping during exposure to a series of irregular wave conditions and elevated water levels representing design storms. The effects of different widths of the top “berm” on the stability and overtopping rates was explored using a double berm width-tray system to optimize the laboratory time use. Each test series generated much information with respect to the interaction of the extreme design waves with the foreshore and the breakwater (wave breaking, run-up, and overtopping), and the response of the breakwater to this forcing (stability of the armour and the resulting overtopping discharges). The physical model was crucial to refining and confirming the design refinements developed to accommodate the site conditions encountered during the construction, and the efficiency of the model study led to reduced downtime in the field while these design sections were verified and optimized.

The Ayia Napa Breakwater is currently under construction, where 50% completion has been achieved and is expected to be completed in April 2019. The construction of the breakwater has been closely supervised, assuring that the breakwater meets the design conditions as observed in the physical model. Even though difficulties have been encountered the different parts of the breakwater have been successfully achieved, including the toe trench to secure the Tetrapods from sliding, the Tetrapod innovative placement pattern, and the top berm width.

During construction several large storms have been encountered, which have allowed for checking the design parameters as observed in the physical model tests. For this purposes a wave gauge has been installed at the location of the wave paddle of the test flume section. Overtopping rates have been measured, the behaviour of the trenched Tetrapods documented and thus far the observed performance of the portions of the breakwater built are in agreement with the physical model results and design expectations. The innovative design and design approach of the Ayia Napa Marina Breakwater provides a good example on how to achieve a harmonic breakwater with the landscape and environment, as well as highlighting the value of integrating a physical model to deal with potential design changes that arise during construction.

276. Designing Ocean Reef Harbor Entrance for Swell Conditions

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The construction of Santa Maria and La Pinta islands are nearing completion just offshore of Panama City, Panama which will result in waterfront developable land close to the city core. The islands are situated south of Punta Pacifica in front of Panama City. Wave activity in the Bay of Panama is dominated by swell waves generated by far-off storm events in the Southern Hemisphere. Typical wave periods range from 14 to 21 seconds. The area also suffers from extended durations of 20 seconds swell waves. A multidisciplinary design team led by coastal engineers was tasked with designing a recreational mega-yacht harbor, to be situated between the islands. The harbor design had to achieve satisfactory tranquility in the berths, provide safe navigation though the entrance for vessels up to 61 meters (200 feet) in length, maintain water quality circulation, minimize siltation, and offer aesthetic and recreational amenities.

Unlike shorter period wind waves, swells refract and diffract much more severely, propagate much deeper into embayments due to their longer wavelengths, reflect more strongly, and are more difficult to absorb. Furthermore, in shallow waters these swells become highly grouped and exhibit complex non-linear characteristics. Designing a harbor entrance to minimize the propagation of this swell action to the berths is therefore much more challenging and requires innovative engineering to overcome the problem. This presentation provides an overview of the state-of-the-art modeling techniques, physical model testing, and unique engineering approaches applied to create a successful harbor entrance design in a complex swell-wave climate.

The design evolved by modeling various combinations of breakwater lengths and configurations and by incorporating an absorptive beach into the construction of the island containment breakwater. A rigorous numerical analysis was performed using a Non Linear Wave Transformation Model based on the Boussinesq equations to realistically simulate the swell wave behavior and diffraction patterns. Animations of the wave action were created to explore wave behavior patterns not readily apparent in the simple reporting of wave heights. Physical modeling explored various wave absorbing rubble beach profiles to further mitigate swell wave energy at the base of the harbor entrance and dissipate reflective resonance within the channel. The subsequent basin design and test results demonstrate a clear and successful indication of the performance to be expected from the constructed harbor design.

277. Low head hydropower generation. A new opportunity for old structures. A UK perspective

072

Ian White

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This presentation will look at the new opportunities for generating hydroelectricity at low head hydro sites alongside existing navigation structures. It will present details of the latest developments in the UK using Archimedean Screws, turbines and embedded grid generation.

The relationship between hydro developers and navigation authorities will be considered especially the need to maintain navigational levels being a priority as against maximising energy output.

The issues associated with the economic sustainability of hydro plants utilising environmental subsidies will be examined and compared with other sources of green energy such as wind power and photo voltaic.

The very positive impact on, and the improvements in bio-diversity in rivers previously blocked to fish migration, will be discussed giving examples of fish pass developments in the UK. The obvious benefits in the reduction of CO2 emissions and the financial benefits of being fully sustainable in terms of producing electricity will be discussed. Reference will be made to the types of environmental control imposed upon proposed developments including water abstraction /impoundment licensing, planning and heritage protection by the UK regulatory authorities.

The challenges faced over the last five years of hydro development will be reviewed as well as the lessons learned in the process. Reference will be made to a number of completed sites and examine the additional benefits that have arisen from allowing the development and operation of low head hydro electricity generation.

The current need to deal with cyber security will also be examined.

278. Concrete mattresses for lining and erosion protection of flowing water bodies

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Concrete mattresses have been commonly used since more than 50 years. Installations at navigable waterways have been documented at the Canal de Jonage (France) in 1993 or by the Federal Waterways and Research Institute (BAW) in the early eighties in Germany. After their application has become very unpopular during the last years the concrete mattress system is currently experiencing a comeback. Recently executed research projects (such as ice load testing at the Samara State University of Architecture and Civil Engineering, Samara, Russia or the hydraulic roughness investigations at the RWTH Aachen University, Aachen, Germany) have gained new insights in the concrete mattress technology which accelerate this development.

The objective of the study at the RWTH Aachen University in 2016 was to determine the hydraulic roughness of geosynthetic concrete mattresses as a basis for the design in practice-oriented applications such as canal linings. For this purpose, a hybrid model approach was used, that combined physical model tests and numerical modelling. The skin and form roughness of full-scale uniform mattresses were investigated in the laboratory flume of the Institute of Hydraulic Engineering and Water Resource Management at RWTH Aachen University. As the tests were performed in real scale, model effects could be eliminated and neglected. The experimental tests provided a data base to calibrate and validate a numerical model for analyzing the influence of the geosynthetic mattress shape on the hydraulic roughness. As a result, the hydraulic roughness of geotextile mattresses was quantified. In order to describe and analyze the ice load resistance of the concrete mattress system large scale field trials were conducted at the shore of the Saratov Reservoir, which is an impoundment of the river Wolga. The field work was scientifically supervised by the Samara State University of Architecture and Civil Engineering (SSUACE), Samara, Russia. During the winter period of 2014/2015 the climate conditions and the ice thickness were continuously monitored. In addition to the field trials laboratory tests were carried out. Based on the insights of these two investigations in consideration of the existing gost standards a new design method for the ice load resistance of geoysynthetic concrete mattresses was derived.

The scope of the paper is to present a summary of the findings of the two different research projects. Furthermore the paper will illustrate the applicability and practicability of the system by showing some recently executed projects like the repair works at a German waterway. Due to the leakage of the existing asphalt revetment maintenance at the Main-Donau-Canal was required. Water reed rhizomes had perforated the lining layer. The mattress system was selected because of the potential installation under water while the ship traffic could continue. Another large scale example with the installation of approximately 150,000 m² mattress is the rehabilitation of a hydro-electric power plant canal close to Munich.

In summary the scientific research in combination with the long term experience and the recently executed projects will demonstrate the reliability of the rediscovered system.

279. Estimating turbidity near a dredging operation using a weather balloon-mounted camera

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Dredging and placement of dredged material results in resuspension of sediment creating a plume in the water column. Monitoring the plume's extent with appropriate temporal and spatial resolution is important when complying with regulations at the dredging and placement sites. In this study, a weather balloon-mounted RGB camera was used to acquire high resolution images near a dredge. Measurements of turbidity near the water surface and aerial images were concurrently acquired. Spectral calibration targets were positioned separately as part of each turbidity measurement and were in each images field of view. A post-processing script was developed and tested for the capability to automatically identify spectral calibration targets in each image, parse the spectral signatures, and correlate spectral data to turbidity data to create a monitoring application. This approach will help produce evidence-based information about a dredge plume on a larger scale and help engage the process of leveraging better-informed dredging strategies.

280. Benefits for Economy, Ecology and Society: River Engineering Measures in the Elbe Estuary

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The port of Hamburg, located at the Elbe estuary in Northern Germany, is challenged by a high maintenance effort due to sediment which is transported by a powerful flood current from the North Sea into the upper estuary and port area. This leads to high costs for the port, but also to unfavorable environmental conditions for protected nature areas in the estuary.

The shape of the estuary has been modified continuously over the past centuries due to land reclamation, deepening of the shipping channel and cut-off of tributaries for flood protection – resulting in the current effects of sedimentation for economy and ecology. As an answer to these unfavorable conditions an adapted sediment management strategy supported by river engineering measures to create space for the estuary are considered to be suited to contribute to the reduction of tidal energy and the upstream sediment transport. In 2012 Hamburg Port Authority (HPA) started the construction works for the pilot project “Kreetsand/Spadenlander Busch”. This river engineering measure has three objectives. (1) It will contribute to reducing the tidal energy by creating approximately 1.1 mill. m3 of additional tidal volume. (2) Valuable natural habitats like shallow water area, mudflats, reed and floodplain forests will be created. (3) Parts of the area will function as recreational area for residents where they will get the opportunity to experience a tidal influenced landscape.

Local residents and stakeholders, including environmental organizations and local administration, were involved right from the beginning in the planning process in 2008. During the construction process the complexity of the tidal dynamics and estuarine functioning as well as the construction of the area itself are explained by informative posters in a publically accessible information shed located at the site on the dyke.

After the works will be finished in 2020, natural processes are allowed to form the embankments inside the area by erosion and sedimentation and thus create naturally changing habitats.

However, the effect of the pilot “Kreetsand/Spadenlander Busch” on decreasing tidal energy is only marginal due to its size and its location within the estuary. More river engineering measures consisting of larger areas have to be planned and carried out. But finding a suited location for further measures within the 140 kilometers long estuarine stretch seems to be rather complicated due to the individual interests of different federal states and various stakeholder groups. Therefore an estuary partnership, the so-called ´Forum Tideelbe´, was found in 2016. All affected stakeholders of the estuary are involved, e.g. representatives of the administrations of the three responsible federal states, HPA and the German Federal Waterways and Shipping Administration (WSV), municipalities, environmental organizations, trade and industry representatives, fishermen, farmers, water boards, leisure organizations, etc. It is their task to choose and propose suited locations to the responsible administrations for conducting further measures, e.g. reconnecting anabranches to the main estuary channel or setting back dykes to create more space for the estuary. Main criteria are the contribution of the measure to (1) reduce tidal energy and related upstream sediment transport, (2) create

ecological valuable habitats, and (3) feasibility. Furthermore the whole process should lead to a better understanding of natural estuarine processes and improve the communication and cooperation between different stakeholder groups and administrations. Based on the recommendations responsible administrative bodies will make their decision. So far, this kind of process, i.e. involving various societal groups in estuarine management, is rather unique in Germany.

The presentation will give an overview on the development of the process, lessons learned and on the current state.

Conference attendees will benefit from the experiences made and lessons learned on how economic, ecological and societal interests will be combined in river engineering measures being a part of integrated management of estuaries - one of the most dynamic and complex natural environments.

281. PIANC WG 173 Design and Fabrication of Rolling Gates

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The aim and purpose of the WG 173 report is to determine technological guidelines for design, fabrication, construction, operation and maintenance of both rolling gates and movable bridges. Currently, rolling gates are a nearly unanimous choice in navigation locks with chambers wider than about 40 m. Rolling gates are ideal for applications that require handling a differential head from both upstream and downstream directions. For this reason, rolling gates are commonly used for locks subject to tidal changes and storm surges such as sea locks. Rolling gates utilizing the wheelbarrow design are the largest in world. In a wheelbarrow gate, one carriage is placed under and one at the top level of the gate on the operating machinery side. In the classical support system, there are two undercarriage assemblies arranged near the gate ends and both carriages are under the gate. The disadvantages of the wheel barrow type gate are advantages of a classically supported gate with two under carriages and vice-versa. Rolling gates are generally designed as buoyant to help reduce operating loads and support the gate load. Buoyancy tanks also allow the gate to be raised off the carriages by flotation to allow maintenance. Many components of the rolling gate are subjected to fatigue and wear in particular the carriages and rail tracks. A typical operating speed of a rolling gate is 0.3 meters per second but this can vary depending on the size of the gate. A rolling gate carries hydraulic lateral loads not only in the closed position, but also when moving or when in recess. These loads include loads by residual water heads at the end of filling and emptying, loads by wind waves, loads by currents and tidal forces in an open chamber, and loads by currents as result of salt and fresh water exchange. The skin plate of a rolling gate is sized to serve as the effective flange of the main supporting structural framing and as the plate that retains the water pressure acting upon the panels.

282. PIANC WG 173 Panama Canal Rolling Gates

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Johnny Wong

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The Third Lane locks of the Panama Canal become operational in 2016. A total of 16 rolling gates are included in the project using double gates at each lock head. At a length of 57.6 meters and height varying between 22.3 and 33 meters, width of 8 meters and 10 meters and a structural weight varying between 2500 and 4200 metric tons a piece, the new Panama Canal lock gates are the largest in the world. The gates are 22 meters high at the lake level and up to 33 meters high at the ocean side. The rolling gates average speed is 11 meters per minute, so it takes a maximum of 5 minutes to open and close the gate across the 55 meters of chamber width. The Panama Canal Third Set of Locks has strict requirements for time and service to better serve its customers who demand high reliability and lane availability. The design requirements of the new locks requires a minimum of 99.6% of lane availability time. A major design issue to consider for these gates was very high seismic loading. The new rolling gates are a wheelbarrow type design but a unique feature is the removable lower carriage pulled out through the top of the gate. In order to do this, the load of the gate had to be transferred to the lower wheel carriage via a tall slender compression column and a load limiting device to prevent overloading the wheels. The load limiting device and compression column also have advantages from a seismic point of view. The seismic parameters for the gate design includes the compression column, running from the lower wagon to the top of the gate structure, with guides and clearances to provide lateral gate displacement under hydraulic load. After an earthquake event, the load limiting device will return to its original position to allow the gate to return to normal operation. This arrangement not only prevents the carriage overloading in case of an earthquake, it also adds more elasticity to that support and directs the eventual damage to the column, sparing the main structure of the gate, the carriage and its rails. One issue with the Panama removable carriage design is that to remove it requires a fairly compact lower carriage with small rail distances (track gauge). The carriage and the wheels cannot be any wider than the gate and in this case the spacing of the lower wheels is only 1600 mm which is fairly narrow for how tall and wide these gates are. This is possible thanks to the “assumed” absence of lateral loads on rails and is in fact the major advantage of the chosen system.

283. Disaster Prevention Facilities and Marine Environment Improvement Effect

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ABSTRACT

Concrete structures are indispensable for disaster prevention. At the same time, its inorganic characteristics sometimes are pointed out as a symbol of environmental destruction. In Japan, concepts of ecological consideration were incorporated into River Act and Seacoast Act in the 1990s, and shapes of concrete structures have been modified. However, most of these are mitigation of environmental impacts due to development activities such as reclamation, and they were born from the conflict of “development” versus “environment”. Under these circumstances, the authors have developed SUBPLEO FRAME [1)] (SPF) which can increase sliding resistance of a breakwater, and Environmentally Active Concrete [2)] (EAC) using amino acids. They can achieve both “disaster prevention” and “environmental conservation”.

In this paper, examples realized improvement of the surrounding marine environment while firmly demonstrating the disaster prevention function are introduced.

Example 1

In the restoration of the north breakwater of Hachinohe port, which suffered tremendous damage due to the Great East Japan Earthquake Tsunami, SPF was adopted as a resilient structure. SPF is a structure that charges filling stones into a concrete frame block, and is installed behind a breakwater caisson. It can increase sliding resistance of the caisson embankment by interlocking of the filling stones restrained by the frame block and the rubble mound stones. The size of the inner frame is 1.8m x 1.8m (depth 1.5m), and the mass of the single filling stone is around 30kg. Since the filling stone has many voids and roughness on the surface, suspended materials such as silt settled down are hard to accumulate, and a variety of benthos habitats are created. In the breakwater at Hachinohe port, SPF and foot protection block are installed adjacently and are in the same environment. After 2 years of installation, many algae and marine organisms are inhabited in SPF. On the other hand, since the surface of the foot protection block is flat, the suspended materials are accumulated, and there are almost no algae and marine organisms. Normally, stones of about 30 kg are scattered by relatively-small overtopping waves and flows. However, because the filling stones of SPF are inside the frame block, they can stay there by shielding effect. Moreover, each height is 1.5m, and it can be piled with 2 steps, 3 steps, and used even in deep water places. Thus, SPF has a disaster prevention function (physical resiliency) and an environmental improvement function (creation of growth and habitat environment of living things).

Example 2

In the breakwater at Wajima port in Ishikawa Prefecture and the revetment of Shimonoseki coast on Yamaguchi prefecture, the EAC panels are attached to the concrete armor units which play an important role to protect main revetment body. EAC is a concrete mixed with Arginine which is one of amino acids, and it is confirmed that the growth rate of microalgae on the block

surface is 5 to 10 times that of ordinary concrete. After 2 years of installation, not only are there many algae growing on the EAC panel, but the gaps created by the panels become a hiding place for shellfish. Moreover, after one year of installation in Shimonoseki port, the EAC panels have a lot of algae flourish than the ordinary concrete panel. In this way, the concrete blocks for disaster prevention, attached with the EAC panels as an environment-conscious product, can contribute environment conservation and further improvement of the fishing ground productivity.

As described above, by utilizing the stone materials and the EAC, it is possible to contribute to realization of Agenda 2030: the Sustainable Development Goals (Goal 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development). In this paper, the details of the above examples and the example of shellfish gathering effects are also introduced.

Reference

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2) K. Sato et al., 2011. Characteristic of Periphytic Algae on Concrete Contained Amino Acid, 9th International Conference on The Environmental Management of Enclosed Coastal Seas.

284. Improving traffic flow analysis: the integration of trajectory analysis in capacity modelling. A case study applied to the Nord-Pas-de-Calais ECMT-Va-canals

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In order to investigate the need and to define priorities of investments in the improvement of the traffic flow in Northern France a trajectory study and a traffic flow study are being executed for the ECMT class Va network of Nord-Pas-the-Calais. The named Canal à Grand Gabarit links the Port of Dunkerque with the Scheldt River and its connections with the navigable waterways of Wallonia (Belgium) in a west east direction. In a south-north direction it will link the future Canal Seine Nord Europe with the Deûle-Lys river connection, and will as such provide a high performing inland waterway connection between the Seine basin (France) and the ports of the Western Scheldt and further on Rotterdam (Belgium-Netherlands). To accommodate the expected increase in traffic, potential bottlenecks will have to be identified, and improvements investigated and proposed.

The trajectory analysis allows to study the geometrical constraints to navigation, and their impact on safety, ease and fluency of the traffic on a case by case evaluation, in which the interaction between ships, or between ships and the waterway infrastructure is investigated. The required space between ships, and between ships and infrastructure can be defined for different ease, safety or fluency categories of the waterway. Such analysis will however not allow to define the viability of the waterway network to accommodate the traffic. For this purpose a traffic model is used, the latter will however be fed with the nautical intelligence of the trajectory analysis.

A desk top analysis is used to test the existing and design canals, and their ease and safety level. Sections with the lowest ease levels can as such be identified, as well as critical sections for overtaking and encountering other ships. These are the prime objectives for real time navigation simulations that are used to define the functional constraints of the different waterway sections. Viability and conditions of ship-ship and ship-infrastructure encounters can be defined through these simulation: speed, required space (length and width), possible ship (class) combination, for different equipment, flow conditions, … This information is used to both propose and investigate measures for improvement of the infrastructures or canal, or to either accept a lower functionality and impose restrictions to the navigation (e.g. reduced speed, alternating traffic …). To understand the effect of traffic fluency of such a decision, however, a traffic model is used.

A traffic model allows to build up an image of the traffic flow for a given traffic density in a given network with its given geometric characteristics. With increasing density the flow will at first increase linearly, but will reach a maximum for a specific density, after which flow decreases again, and finally comes to a standstill.

The traffic model will be used as an instrument to identify bottlenecks for the traffic flow for expected traffic after the construction of the Canal Seine Nord Europe, and to support well balanced decisions for both structural and soft measures to accommodate the expected traffic flow. It is worth to investigate whether investments in enlargement of the waterway are useful,

if lock capacity remains unchanged, and whether the effort should be put in the upgrading of the lock complexes or in the bottle necks of the canal proper.

The existing traffic model IMDC Waterways (Adams et al., 2014), has been improved to include berthing times at intermediate destinations such as quays, and to take into account temporary constrictions of the fairway due to ships being (un)loaded. Speed or alternating traffic is either imposed (regulations) or calculated on the basis of ship characteristics.

The model is a so called hybrid traffic model combining theory from both microscopic as macroscopic traffic models, to allow a reduction of calculation time compared to pure microscopic models. The handling of ships is on an individual level (microscopic), checking the ship by ship. It is macroscopic in the sense that stretches with similar geometric characteristic are defined as single links characterized by the most constraining cross section. Links are defined to handle the traffic in a realistic way, without compromising calculation time. Traffic is generated based on an Erlang distribution law, which may vary in function of the traffic density at any given time (variation during the day, during the week – largely due to operating times of the locks). After a warming up period an image of the traffic is built. Allowing to evaluate the traffic capacity of the waterway network including locks, quays, ports and waterway sections. Calibration is based on known traffic flows.

Knowledge from the real time simulations of the trajectory analysis is used in the traffic model: to limit ship speed in critical sections during encounters or overtaking manoeuvres, to define required space for the manoeuvers by specific ship classes, and to check whether the manoeuvers are possible or whether traffic must alternate. The insights from the traffic model flow back to the definition of measures to be investigated by the real time simulations.

The presentation will focus on the interaction between the trajectory study and the traffic study, and the proven benefits for both of the studies.

285. Development and Expansion of PSA's Panama Hub Port at the Former Rodman Naval Base

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The opening of the new, third lane of the Panama Canal, and the expanded use of larger container vessels provided PSA an opportunity to expand their single berth facility at the former Rodman Naval Base into a modern transshipment terminal. The terminal location is advantageous since it is 'across the bridge' from Panama City and hence does not present the same restrictions and roadway traffic conflicts experienced at the other port facilities; more importantly, it provides easy access to the hinterlands in the rapidly growing western provinces of Panama. The expansion includes construction of two new, deep draft berths (-18.5m MLWS), built to accommodate the largest future container vessels and ship-to-shore cranes. In addition, a new high capacity/high volume container yard for transshipment will employ rail-mounted gantry crane (RMG) operations making it one of the first terminals in Latin America to do so. PSA will have at their disposal twelve container blocks (4200 TEU ground slots) fitted with semi-automatic RMGs. In addition, the terminal will provide six container blocks (990 TEU ground slots) fitted with rubber-tired gantry cranes (RTGs) to service reefers and import/export container cargo. Terminal improvements include adopting an efficient electrical design, advanced information technology (IT) services and multiple redundancies to allow the facility to operate seamlessly and continuously. The terminal was developed rapidly on a site with difficult and diverse geology. Marine construction was challenged by its close proximity to the Panama Canal and the coordination required to manage the marine fleet. Land construction had to adapt to geotechnical variabilities, topography and interfaces with an existing operating terminal. The PSA Rodman Terminal will set new standards for modern container terminals operations in Panama and the region.