SUMMARY

The main goal of this publication is the proposal of new design formulas for overtopping and submerged breakwaters. This methodology is based on the results of stability laboratory tests performed at the University of Cantabria and its numerical simulation with 2DV RANS MARIFE model. These numerical results have helped us to understand the damage processes and the influence of hydrodynamic variables in the shape and intensity of the structure´s deformed geometry.

This knowledge of flow kinematics, will allow us to create new design formulas for damage prediction, dependent on the structure´s freeboard, which has been revealed has the most important variable to determine the shape of the damage along the structure:

1. For negative freeboard structures, it can be observed that the measured damage is caused by the drag associated to the velocities under the crest and the trough passage. It is also observed that the cross-section calculated maximum velocity follows a similar pattern as the cross-section measured damage. For this reason, a new design formula that relates predicted damage with the integral of mobility parameter along the cross-section of the structure has been formulated.

   Anyway, in the current state of practice, for probabilistic calculations, this proposed integral methodology would imply a large number of simulations with a 2DV numerical model based on VARANS equations, with a such computational time that the calculation would become inefficient. For this reason, it is advisable to look for design formulas that relate the structure damaged with simple non-dimensional parameters, in order to simplify these calculations. For these new formulas, we can use the knowledge acquired in our numerical test.

2. The damage type observed in Submerged Breakwaters (defined as breakwaters or bottom protections with high negative freeboard that can cause or stop the waves to break but whose armour layer is not directly attacked by the broken waves) could be obtained evaluating the sediment transport in the landward side of the structure´s crest, since most of the units are displaced from the breakwater´s crest, moving landward and setting on the landward slope.

   A simplification of this concept could be the use of the new Critical Mobility Parameter (MP_{crit}), which is an improvement of the traditional MP, substituting the theoretical velocity, for the difference between the maximum velocity evaluated in the landward edge of the crest and the velocity for the threshold of rubble movement.

   $$Mp_{crit} = \frac{\left(U_{\max} - U_{crit}\right)^2}{\Delta \cdot g \cdot D_{50}} \quad \text{if} \quad \left(U_{\max} - U_{crit}\right) > 0$$

3. When the structure's crest is near the still water level, defined as Low Crested Breakwaters, armour layer is attacked by the hydrodynamics of the breaking waves and there are some damage-producing mechanisms, such as pressure gradient, shear stresses induced by wave breaking, etc. that configure a very complex mechanism.

   For this type of structures, the improvement of the non-dimensional Vidal method has been proposed, with the use of all available test of LCBs stability databases and using wave parameters which can describe the evolution of damage.