OVERTOPPING AND STABILITY OF A RUBBLE MOUND BREAKWATER WITH CORELOC ARMOUR UNDER OBLIQUE CYCLONIC WAVES

L. Martinelli[1], P. Ruol[1], C. Favaretto[1], M. Volpato[1]
[1] ICEA Department- Università di Padova, Padova, IT, luca.martinelli@unipd.it

INTRODUCTION

This note presents the physical model tests carried out on the new breakwater in the fishing harbour of Mirbat (Sultanate of Oman), designed for a cyclonic wave Hs = 6.0 m and for a 200 year return period wind wave Hs = 3.2 m.

Based on this experience, the behaviour of a rubble mound breakwater subject to wind waves that are much smaller than the design cyclonic wave height is discussed. We shall define the wave climate in this case as "cyclonic".

The initial interlocking (during construction) that does not "grow" during the lifetime as usual and the expected cyclonic wave is likely to produce larger damage than predicted by the design formulae, that on the contrary rely on such interlocking.

Under oblique waves, the importance of unit interlocking is even greater due to the sub-horizontal loads and therefore the case of cyclonic wave climates requires a larger safety margin.

AIM

This study aims at investigating the effect of wave obliquity on overtopping and stability, for a rubble mound breakwater with CoreLoc armour layer, under cyclonic wave climates.

For this purpose, the tests carried out for the fishing harbor of Mirbat, comprising 2D and 3D tests on the Coreloc armored main breakwater, as well as the damage caused by wind waves during construction, were analyzed.

PHYSICAL MODEL TESTS

Physical model tests were carried out in the wave flume and in the wave basin of Padova University. Both tests were carried out in geometrical scale 1:40.2, according to Froude similarity. The scale has been defined according to the dimension of the artificial model units (CoreLoc) available at Concrete Layer Innovations (CLI, patent owner).

The bottom of the 2D and 3D models is fixed and non-erodible and reproduces the bathymetry; the geometry of the breakwater, including the stability properties of the elements forming its section is also accurately reproduced.

The test programme is given in Tab. 1. The tested waves are characterized by a peak period T_p variable between 9.5 and 12.0 s and a significant wave height H_s variable between 2.80 and 6.00 m. Wave obliquity in the 3D tests is 60°. Four different water levels were considered, i.e. +0.70 m CD (MLLW), +1.32 m CD (MSL), +1.70 m CD (MHHL) and +2.3 m CD (MHHL + Cyclonic Surge).

Damage S and N_{od} are evaluated based on a photographic overlay technique. Moreover, a 3D graphical reconstruction was carried out in order to give a quantitative description of the settlement of the structure and possible deformation of the structure cross section. The latter is an essential tool to investigate the model structure settlement and the degree of interlocking during testing.

The overtopping discharge was evaluated in 2D and 3D tests collecting water passing over the structure's crest .

Tab. 1 Test programme

WS	Wave type	Investigated phenomena
1	Wind wave, 10 YRP, MHHL	Stability, transmission, overtopping
2	Wind wave, 200 YRP, MHHL	Stability, transmission, overtopping
3	Cyclonic wave, 200 YRP, MHHL	Stability, transmission, overtopping
4	Cyclonic wave, 500 YRP, MLLW	Stability
5	Cyclonic wave, 500 YRP, MSL	Stability
6	Cyclonic wave, 500 YRP, MHHL+ cyclonic surge	Stability, transmission, overtopping
7	Cyclonic wave, 1000 YRP, MLLW	Stability
8	Cyclonic wave, 1000 YRP, MSL	Stability
9	Cyclonic wave, 1000 YRP, MHHL+ cyclonic surge	Stability, transmission, overtopping

WAVE FLUME TESTS

The flume is 36.0 m long, 1.00 m wide, the maximum depth is 1.30 m, and it is equipped with a piston/flap type wavemaker, capable of generating regular and irregular waves, with active wave absorption.

Fig. 1 shows an overtopping event for WS 9, that clearly endangers the CoreLoc stability in the rear side of the crest, whose interlocking is typically very low. Design of these elements is affected by the Cyclonic nature of the wave climate, because of the peculiar crest settlement during the wave event.

Figs. 2 and 3 shows the outputs of the methods used to study the structure stability in the wave flume, i.e. photographic overlay technique and the 3D graphical reconstruction.

Fig. 4 shows a test carried out for an uncompleted structure, i.e. only partially covered by artificial units, that should resist typical wave storm with a return period of a few years.

Fig 1. Overtopping event for WS 9

Fig 2. Example of output of the photographic overlay technique to investigate the structure stability

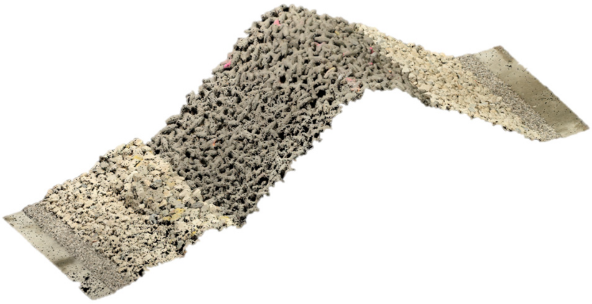
Fig 3. Digital model elevation of trunk section


Fig 4. Top view 2D model, tests of structure loaded by a storm during a simulation of the construction phase

WAVE BASIN TESTS

The wave basin dimensions are 20.6 m x 17.8 m x 0.8 m. The wave maker width is up to 12.0 m and can generate irregular, long-crested waves.

Fig. 5 shows the layout of the 3D model in the wave basin and an example of directional wave analysis carried out on the basis an array of 7 resistive type wave gauges.

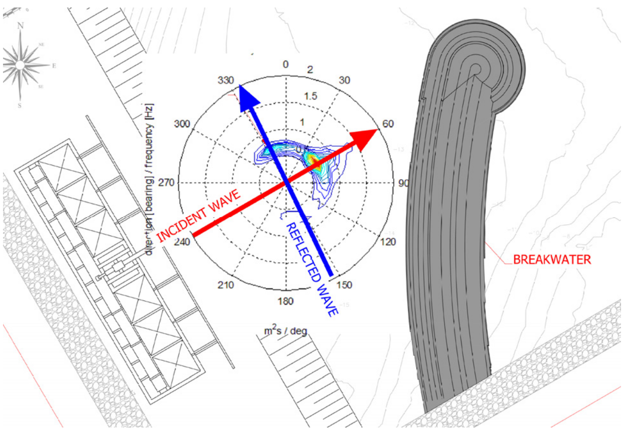

Fig 5. Layout of the 3D model in the wave basin

Fig. 6 shows an overtopping event for WS6 for a very oblique incident wave. The wave front propagates along the breakwater up to the roundhead, applying an horizontal load that endangers the stability of the CoreLocs placed in the front side of the crest. These elements require special attention at design phase for cyclonic wave climates, since the expected low-degree of interlocking may be critical.


Fig 6. Overtopping event for WS 8

RESULTS

The issues important for the design of such a structure are:

1) the unit interlocking during construction (the concentrated settlement of the armour over the filter may occur rapidly during the cyclone, applying unexpected loads on the other layers);

2) the resistance of the lee side support of the armour (the armour may require longer extension compared to traditional design);

3) the role of overtopping (acceptable limit and damages to the lee side caused by oblique overtopping waves);

4) stability of the filter layer if exposed to wind waves during construction phase (in order to avoid damages to the partially deployed armour layer).

Overtopping were found to be in good agreement with Andersen (2009).

REFERENCES

Andersen, T. L., & Burcharth, H. F. (2009). Three-dimensional investigations of wave overtopping on rubble mound structures. Coastal Engineering, 56(2), 180-189.