A NEW APPROACH TO BREAKWATER DESIGN - 2B BLOCK

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Breakwaters are one of the oldest and important marine structures. Rubble mound breakwater is a very common type in all around the world. If the heavier rock is necessary for the design, concrete armor units are used. Each unit has its own advantages and disadvantages. For example cube and antifer blocks are massive units and their interlocking is weak. Dolos and tribar units have good interlocking but rocking stresses in these units are extraordinarily high. The placement method is very important and requires special equipment and experienced staff for the later developed single-layered units like accropod and core-loc. Moreover, continuous touching of blocks to each other and fatigue of the material may cause the breakdown of legs and serious damage of armor layer. And in case of damage, it is necessary to remove the units in a wide area on the breakwater and then relocate them, so it is very difficult to repair. A new type concrete armor unit is developed considering all these problems. It is called 2B Blocks.

Keywords: new type breakwater; physical model; stability; wave overtopping; wave pressure; 2B Block

INTRODUCTION

Breakwaters are one of the oldest and important marine structures. While breakwaters protect the coasts and harbors from waves, they should be stable against waves during their life time. Rubble mound breakwater is a very common type in all around the world. The largest rock category yielded from quarries generally is not much than 12-15tons. If the heavier rock is necessary for the design, concrete armor units are used.

There are various type concrete armour units (Figure 1). Each unit has its own advantages and disadvantages. For example cube and antifer blocks are massive units and they resist to wave action by their weights but their interlocking is weak. Dolos and tribar units have good interlocking but Melby and Turk (1994) have shown that rocking stresses in these units are extraordinarily high and reinforcing for the associated high impact loads is not economically feasible.

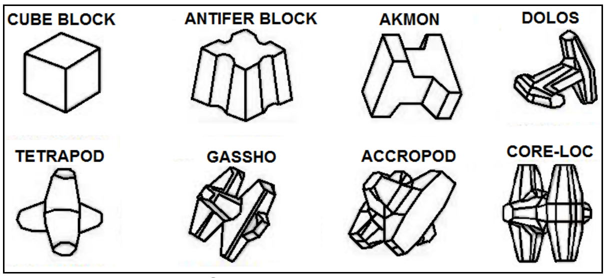

Figure 1. Some concrete amour units.

These problems are tried to be solved in later developed single-layered units like accropod and core-loc. But in these units, the placement method is very important and requires special equipment and experienced staff. The single-layered units are used for steep sloped (¾, ½) breakwaters. Moreover, continuous touching of blocks to each other and fatigue of the material may cause the breakdown of legs and serious damage of armor layer. And in case of damage, it is necessary to remove the units in a wide area on the breakwater and then relocate them so repairment is very difficult. In fact, damage reports (e.g. Mesa (2005)) on the breakwaters constructed with these units support that a new design of concrete armour units is necessary.

2B BLOCK

Considering the problems like stability, interlocking, cost and maintenance in the existing concrete units, a new type of concrete armour unit is developed. It is called as 2B Block. It is a single layer unit and it has three different models as shown in Figure 2. In order to decrease wave run-up and wave

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overtopping there are holes on the unit. The shape of the 2B Block is designed so that the center of gravity of the block is shifted from the center to increase the resistance on the sloped surface.

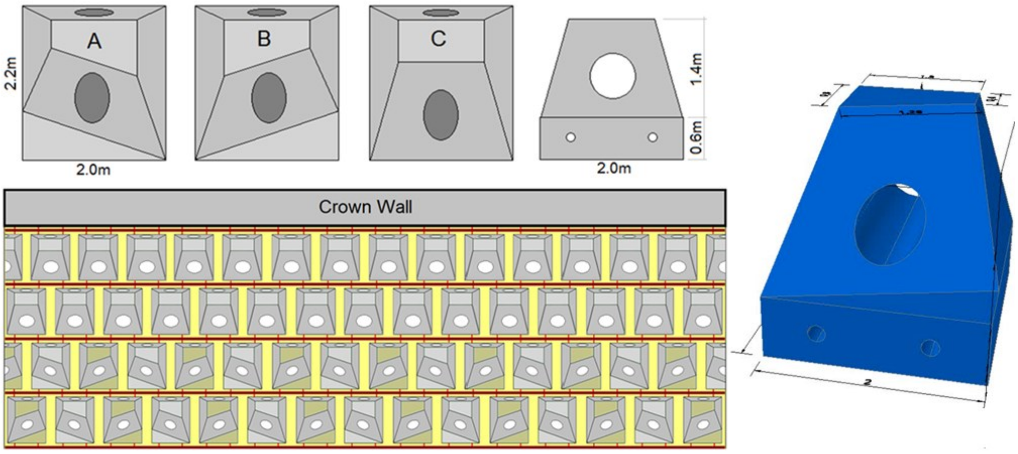

Figure 2. 2B Block models and installment on the armour layer.

In contrast to conventional placement technique of armour units i.e. from toe to crest, these new units are placed from crest to toe. But firstly, a crown wall is necessary on the crest. The first row of 2B Blocks on the crest consisted from model C is connected to crown wall by a cable or chain as it is seen in Figure 2. The second row is also on the crest and it is connected to the first row but eccentrically. When the breakwater slope surface starts then model 1 and 2 are used as one by one and they are also installed eccentrically both for reducing wave pressure effect and wave overtopping. Each unit is connected to the two units above.

HYDRAULIC MODEL EXPERIMENTS AND RESULTS

An experiment consisting of an extensive series of 2D and 3D small-scale physical model tests were conducted at the Port Hydraulic Research Center, Ministry of Transport in Ankara-Turkey. Model scale was 1/40. More than 1000 irregular waves were generated in each test by the irregular wave generator with an automatic absorption capability. In the tests, wave height Hs was increased in steps for different wave steepness values between 0.02 and 0.05. Stability and wave overtopping amounts were checked.

Stability of 2B Block

As it is presented in Figure 3., models of 2B Blocks were installed on permeable core and filter layers. Two structure slopes of ¾ and ½ were used for comparing with conventional one layer types.

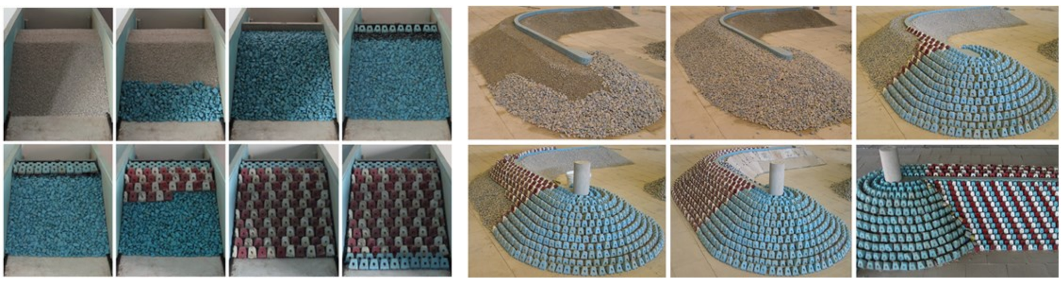

Figure 3. Construction of 2B Blocks' Model (2D-3D)

Result of stability tests show in Figure 4 that there was no damage even under the condition of the highest producible wave in the model tests i.e. Hs=9.07m Tm=14.69s. in prototype. No damage means no displacement and settlement. 2B Blocks were also tested for the low-crested and submerged breakwaters and it was observed that they were still stable.

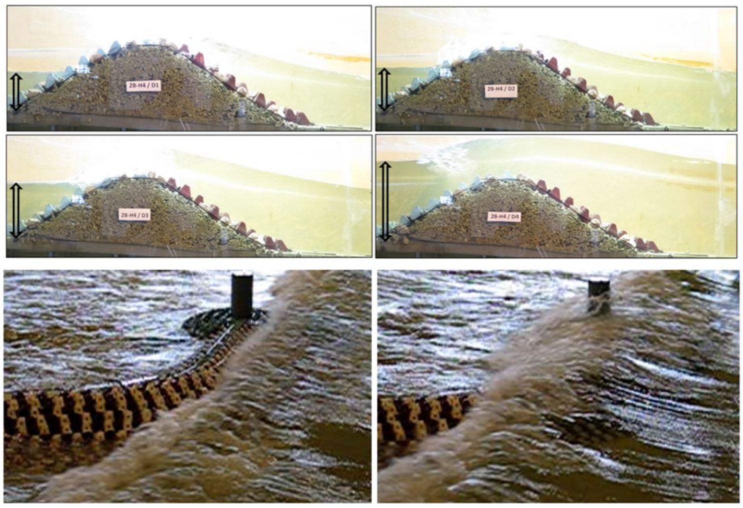

Figure 4.Model tests of 2B Blocks' (2D-3D)

When 2B Block, was compared with the other kind of concrete blocks such as Core-Loc, Accropod, Dolos and Tetrapod in terms of amount of concrete requirement under the same wave conditions are given in Table 1.

Table 1. The amount of concrete requirement for different armour layers

Unit	Mass (ton)	Total Concrete Mass (ton)	Total Concrete Mass (%)	Design Wave Height (m)
2B Block	**12.5**	**9 250**	**77**	**9.1**
Core-Loc	15.0	12 000	100	8.7
Accropod	17.4	13 700	114	8.7
Dolos	15.0	17 800	148	8.7
Tetrapod	21.7	25 200	210	8.7

www.core-loc-africa.com/htm/page3.htm

Wave Overtopping of 2B Block

In the wave overtopping tests, not only the wave overtopping discharges were measured for 2B Block but also they were compared with armour units of cube, antifer, tetrapod and rock which the units were designed under the same wave conditions (Figure 5).

Figure 5. Model of Rock, Cube, Antifer, Tetrapod and 2B Block

The comparison results indicate that the overtopping discharges of 2B Block was similar to rock and tetrapod armoured breakwater models. However in cube and antifer blocks, wave overtopping discharges were almost two times of 2B Block.

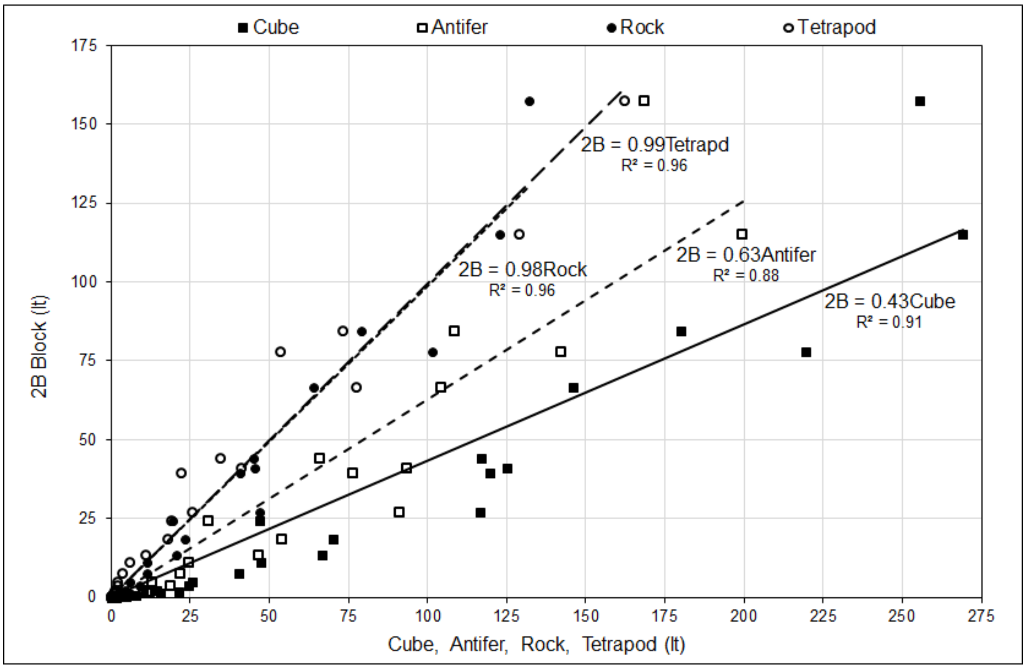

Figure 5. Wave overtopping comparison of 2B block with cube, antifer, tetrapod and rock units (designed under the same wave conditions)

The wave overtopping discharges were measured for 2B Block, rock, accropod and tetrapod which, the thickness of the armour layers were same. The comparison results (Figure 6) indicate that the overtopping discharges of 2B Block was better than others.

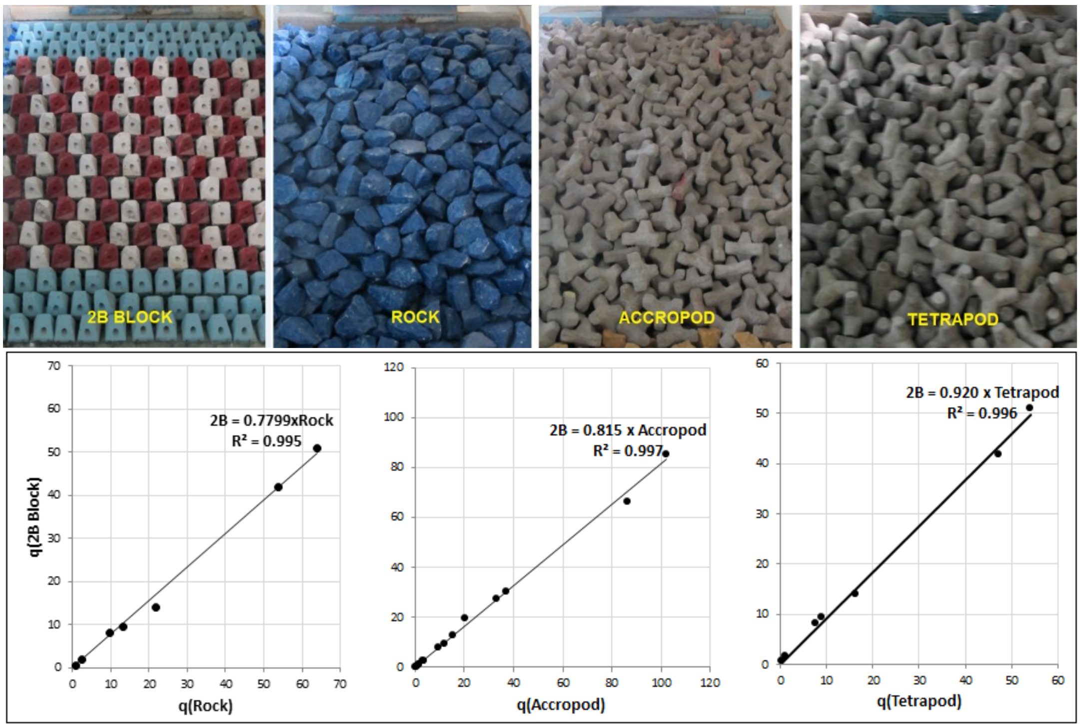

Figure 6. Wave overtopping comparison of 2B blocks with rock, tetrapod and accropod (the thickness of the armour layers were same)

Wave Pressure on the 2B Block

In order to determine the wave pressure effect on the 2B Block, pressure gauges were installed on the block at different elevations from crest to toe. Wave pressure was measured for different bottom slopes (1/10, 1/30, 1/50) and different wave steepness (H/L_0=0.03 and 0.05) while the water depth was same.

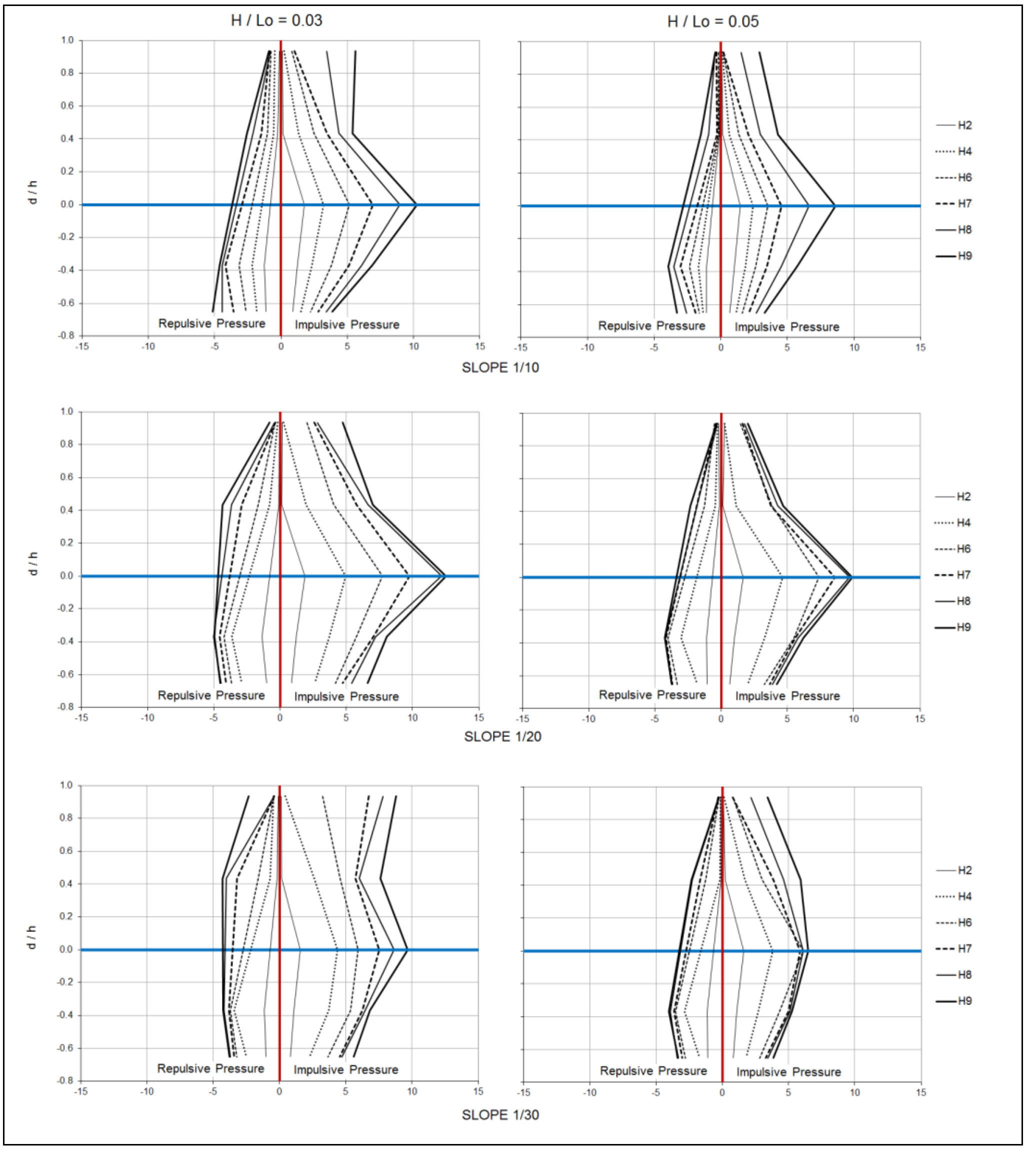

Figure 7. Impulsive and repulsive wave pressure on 2B Block

The wave pressure result indicate that maximum pressure was near SWL and when the waves were breaking in front of the toe, impulsive pressure was acting the blocks above the SWL. Although the repulsive pressures were small comparing to impulsive ones, they were increasing in deeper parts.

In many physical model experiments on related with conventional breakwaters show that the armour layer was damaged especially under repulsive pressures effect.

A simple long wave was generated in the wave channel by using a barrier. The barrier which was preventing the water passage was suddenly removed and a long wave ($T_{prot.}$=145sn) similar to tsunami was produced (Figure 8).

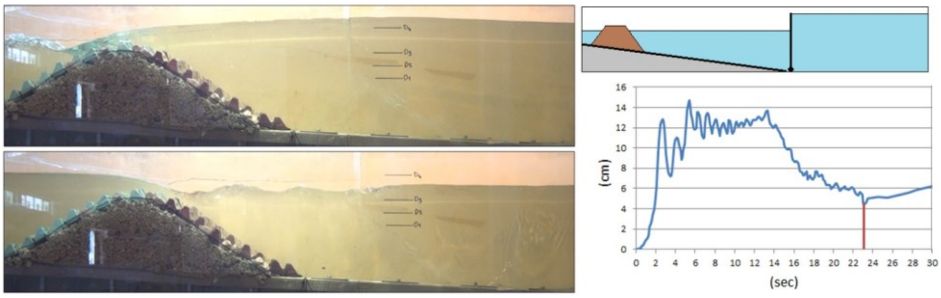

Figure 8. Generated of long wave in model test

This wave caused a green water overtopping and then returned back. And still any damage was not observed.

CONCLUSION

A new type of concrete armour unit is developed for breakwaters in considering the problems like stability, interlocking, required special equipment and experienced staff, cost and maintenance in the existing concrete units. It is called as 2B Block.

Advantages of 2B Block

1. The main advantage of 2B Block is that it can be applied any sloped breakwaters easily and no special placement method is required.
2. Since the system works as a whole, there is a considerable saving in the weight of the units. Because the blocks are tied to each other.
3. Hitting each other is prevented.
4. As the weight is low, there is no requirement of high capacity equipment.
5. They reduce wave run-up and wave energy more compared to other units due to out of alignment.
6. System can fit itself to the different settlements that may occur in soil eventually due to surcharge or in the fill due to waves or earthquake, so the homogeneity is not disturbed.
7. It is quite easy to repair any breaking in the connections or replace the concrete blocks. Because the system is stationary without and deflections.
8. It is possible to be used as an artificial reef.
9. Dimensioning can be determined according to available equipment not necessitating any stability calculations (Hudson, Meer).

Disadvantages of 2B Block

1. The main drawback of 2B Block is that the material joining the blocks each other should be sea water resistant one.
2. Joining material should be controlled periodically and replaced when necessary.
3. Since the placement of blocks are performed from top to bottom and firstly crown wall is constructed and block tying starts here, crest width should be some more wider than the other structures not to prevent working of equipment during the construction period.

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