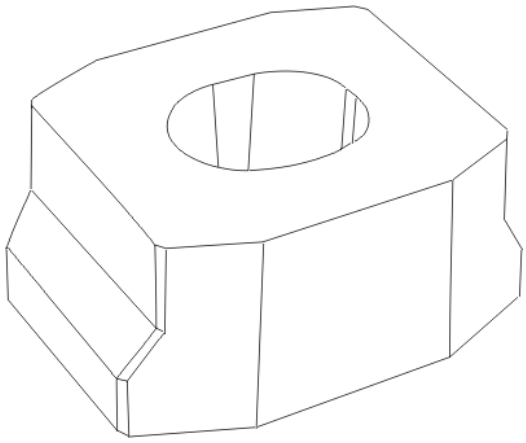
HARO®: A MASSIVE HOLLOW ARMOUR UNIT FOR EFFICIENT AND ECONOMICAL PROTECTION OF BREAKWATERS

Introduction

The HARO® is a design by Prof. Dr. ir. Julien De Rouck, Professor at Ghent University and former chief engineer in HAECON's Port and Coastal Engineering Department. HAECON owns the trademark. The HARO® is an artificial unreinforced concrete block designed for the protection of maritime structures (breakwaters, jetties and dikes) as well as for river embankments.

Hereafter the basic technical features of this new block are outlined.



Shape

The HARO® is a compact concrete armour unit characterised by a rectangular form in plan view, a large central opening, protuberances on both short sides and asymmetrically tapered corners.

The innovative shape eliminates the need for reinforcement and ensures a layer with a high porosity (P ≅ 51 %). The characteristic dimensions of the block are shown on the figure. The relationship between the volume and the characteristic width b is given by $V = 0.757\ b^3$.

Strength

The chunky shape of the HARO® gives it a high mechanical strength. Due to the central opening the hydration heat is lower than e.g. in massive cubes.

Early age cracking, which is a real problem for massive units, does not occur. The block was studied in a 3D finite element mathematical model. In addition several rupture tests on 150 kN and 15 kN blocks were carried out: static loading, dynamic loading and pendulum tests.

Stability

Numerous hydraulic stability tests (two-dimensional in a wave flume and three-dimensional in a wave tank) were carried out.

Considering Hudson's formula $W = \frac{\rho_r g H^3}{K_D \Delta^3 \cot\alpha}$ the results of these tests suggest K_D values of 12 for an armour layer of 2 layers on trunks and exposed to non-breaking waves. For a two layer armouring, the number of blocks per m^2 equals $1/(0.89b^2)$.

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Contractor's view

The HARO® is easy to manufacture. The blocks are prefabricated in a vertically-sided steel mould, composed of two parts: one external and one internal, which are connected to each other. Pouring of concrete and vibration are very easy. About 16 hours after casting the mould is struck upwards in a single lift without any opening at the corners.

The HARO® is easy to stack. The blocks can be stacked one next to the other or in several layers one on top of the other.

The HARO® is easy to place on the breakwater slope. There are no special requirements neither for the toe nor for the filter layer. Placement of the HARO® is comparable in all respects to that of the concrete cube. Placing HAROs® in a regular pattern gives a particularly pleasing effect. This may be useful for armour layers in marinas.

Smaller cranes can be used: a high hydraulic stability gives a reduced unit weight. This means that, compared with other blocks, smaller cranes can be used.

The HARO® is economical

Usually the unit is placed in two layers. A single layer may suffice for less exposed slopes. Due to the high porosity, the special shape and the reduced unit weight, the volume of concrete in the armour layer decreases by ca 35 % when compared to grooved cubes, and ca 25 % when compared to tetrapods. Those figures are valid for a two-layer armour.

With its innovative original shape the HARO® manages to combine the dual qualities of strength and stability leading to a two-layer protection with a very high porosity and procuring substantial savings.

Contact

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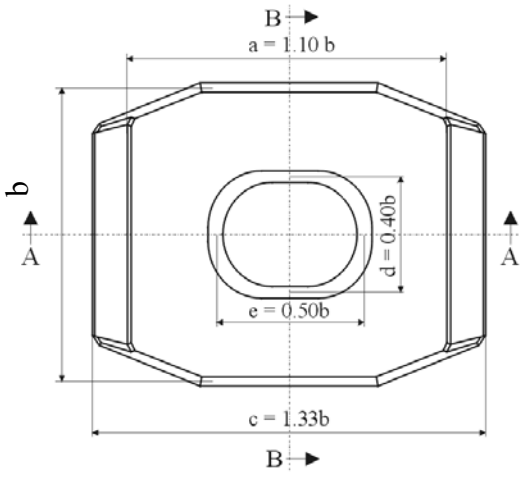
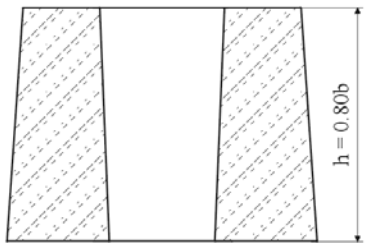


Planview of HARO



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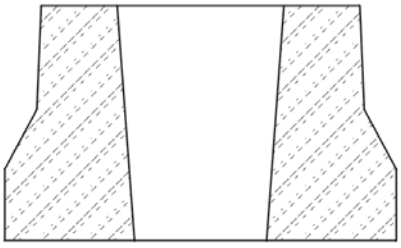

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