xbloc®

Effective wave protection for breakwaters and shores

ECONOMICAL  RELIABLE  EASY TO USE

Edition September 2011
Since 2001, Delta Marine Consultants has been developing an innovative interlocking armour unit designed to protect breakwaters and shores over the long term and in extreme conditions.

The armour unit, called the Xbloc®, is a simple, robust and reliable breakwater armour unit. It has considerable structural integrity as an individual element and has great hydraulic stability in the armour layer. Casting and positioning the Xbloc® unit is straightforward and is very cost effective. A special toe unit Xbase® has been developed for use with Xbloc® armour. This toe unit proved to be more stable than a conventional rock toe. The Xbloc® has been exposed to extensive research consisting of hydraulic model tests and structural tests. Xbloc® has been applied on shore protections and breakwaters all over the world since 2004.

**Cost benefits of the Xbloc®**

Xbloc® is the most economical single layer armour unit. The average saving yielded by incorporation of Xbloc® units [less concrete needed] is up to 15% compared to other single layer armour units. The difference is due to the high stability coefficient of the Xbloc® units and the low packing-density required, both of which result in a lower concrete demand. As there are no specific requirements on the orientation of the individual units to achieve good interlocking, the placement of the units is straightforward reducing both construction time and overall cost.
Delta Marine Consultants offers

Design stage
1. Advice on breakwaters and shore protection requirements
2. Concept design
3. Review of Xbloc® designs by others
4. Guidance during 2-D and 3-D hydraulic model testing
5. Hire of Xbloc® units for model testing
6. Execution of 2-D model experiments

Construction stage
1. Technical support
2. Quality control
3. Mould drawings
4. Placement drawings

Xbloc® is registered trademark and worldwide patents are applicable. To use Xbloc® please contact Delta Marine Consultants.
**Hydraulic Testing Facility**

In most projects, physical model tests are performed to confirm or optimise the design. Since 2008 Delta Marine Consultants offers 2D physical model tests for breakwaters and shore protections in their state-of-the-art wave flume in Utrecht, The Netherlands.

Since 2008, various project specific model tests have been carried out, such as breakwaters in Panama, Australia, Benin, UK, The Netherlands, U.A.E., Poland, Sri Lanka and Congo-Brazzaville. Due to the fact that DMC has various sizes of rock and Xbloc® scale model units available in the facility, it is possible to optimise a cross section during the test program in a quick and efficient manner. Apart from these project specific tests, various research projects have been carried out in order to increase DMC's knowledge on breakwater design and to test new applications.

Subjects which can be addressed in model tests are:
- Hydraulic performance including wave overtopping, reflection and transmission;
- Hydraulic stability of breakwater armour layer, breakwater toe and crest, scour protection and crown wall;
- Wave forces on structures.

**Wave Flume Characteristics:**

- Length 25 m
- Width 0.6 m
- Height 1.0 m
- Max. water depth 0.7 m
- Max. wave height up to 0.3 m

The 2D wave flume of DMC is equipped with an innovative Edinburgh Designs electric drive piston wave generator, which can generate regular waves and wave spectra. The wave generator is capable to absorb reflected waves. The resulting incident wave field which is determining for the design, is thus fully predictable even with highly reflective models.

**Xbloc® model units for tests at other facilities**

Apart from model tests at the DMC wave flume, many project specific tests are carried out at other hydraulic laboratories around the world. DMC has Xbloc® scale model units available for rent in various sizes to suit the required model scale and the properties of the wave flume. If you require model units for model tests, please contact DMC.
Hydraulic stability

- Excellent hydraulic stability:
  - For concept design a $K_D$ value [stability coefficient in the Hudson formula] of 16 [trunk section] and 13 [head section] should be applied;
  - The stability coefficient of the Xbloc® is the same for breaking and non-breaking waves;
  - Xbloc® has a safety margin of at least 20% without damage to the armour layer.

- Automatic interlocking:
  - Xbloc® units naturally find a stable position on the slope;
  - Self repairing of the Xbloc® armour layer after damage is enhanced by automatic interlocking;
  - The Xbloc® unit is simple to place as no specific orientation of the individual units is required.

- Low wave overtopping:
  - The highly porous armour layer minimises wave overtopping.

Structural integrity

The structural integrity of the Xbloc® was evaluated by using:

- Prototype drop tests [The Netherlands, Ireland and Georgia];
- Finite element calculations [FE].

All studies and project experience show that the Xbloc® is a structurally strong unit able to cope with the loads that can be expected during its lifetime from manufacture to operation. Ordinary concrete C25/30 can be used for the production of Xbloc® armour units.

Construction aspects

Production

Steel moulds can be used repetitively to produce large numbers of units. Various mould designs have been developed, consisting of 2 sections. The moulds are either vertically or horizontally assembled. Moulds on wheels or rails can be applied. Casting is easy because of large fill openings. At the construction yard the Xbloc® units can be handled with the aid of a fork, clamp or a sling. The units can be stored in various ways, for example side by side in a half-brick bond. The storage pattern can be arranged in 1 or 2 layers, depending upon the capacity of the subsoil. Using this pattern, the required storage area amounts to $0.72D^2$ for 1 layer storage and $0.36D^2$ for 2 layer storage ($D$ = unit height). Xbloc® units can be handled in the storage yard by a fork.

Placement

Placing Xbloc® units and Xbase® units can be executed in different manners. The Xbloc® and Xbase® units can be placed by an excavator or a crawler crane, equipped with either a sling, clamp or grab. It is also possible to cast a hole in the nose of the Xbase®, and lift it with a rod through the hole. To achieve the correct packing density a random orientation is required. Based on several projects the placement rate of Xbloc® armour units lies between 8 – 25 units/hour.
Design parameters for concept design

Main dimensions

The volume of the units varies between 0.75 m³ and 20 m³, depending upon the extreme sea-state.

Equations and design table are based on:

Slope $3V:4H$

\[ \rho_c = 2400 \text{ kg/m}^3 \] concrete density

\[ \rho_w = 1030 \text{ kg/m}^3 \] water density

For breakwater head sections armour units are 25% heavier than for trunk section \([K_D=13]\)

Table for concept design

Xbloc® unit volume

\[ V = \left( \frac{H_s}{2.77\Delta} \right)^2; \quad \Delta = \left[ \frac{\rho_c}{\rho_w} - 1 \right] \]

Xbloc® unit height

\[ D = \frac{3}{\sqrt{3 - V}} \]

Thickness armour layer

\[ h = 0.97 \cdot D \]

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Before using this table please check Guidelines for Xbloc Concept Designs, on our website www.xbloc.com
Delta Marine Consultants

Delta Marine Consultants was founded in 1978 with the purpose of providing consultancy, project management and engineering design services to clients on a worldwide basis. The firm holds strong links with the construction industry through its parent company (Royal BAM Group), which has helped to develop the ability to provide solutions to practical problems and to blend innovation with reliability in design.

DMC is recognized as having a wide range of experience in Coastal and Maritime Engineering and for over 30 years the firm has been involved in design, project management and construction supervision for projects all over the world. Covering the full chain from concept (feasibility studies, layout development, hydrodynamic studies, etc) to reality (design and construction supervision of breakwaters, quay walls, jetties, etc.), DMC has the know-how and ability to provide a tailor made design for each client.

DMC has extensive experience in the following areas:
- Coastal & Rivers
- Ports & Harbours
- Offshore
- Infrastructural
- Industrial

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