A DATABASE OF MAJOR BREAKWATERS AROUND THE WORLD

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Summary
This paper introduces a co-operative project between HR Wallingford UK (HRW) and Delft University of Technology, Netherlands, (TUD) to develop, populate, and then to apply a database on all major breakwaters around the world. It builds on, and revives, similar initiatives that originate in the late 1970s. The paper describes the objectives in developing the database, the structure and content fields of the initial data-base and presents key examples from the work to date. The paper then discusses a number of potential uses of the database and plans for its future development.

1. Introduction
This new database has been prepared mainly using data in the public domain and/or from technical papers, conference and seminar presentations and/or existing reports, including historical data held at HRW and TUD. Data were initially entered for four primary structural types:

Sloping breakwaters	Vertical breakwaters
Composite breakwaters	Others

In the initial phase, insignificant data were available to be entered under "Composite" or "Other" types, so most effort was spent on populating the data on Sloping and Vertical breakwaters. The initial creation of the database categories was relatively straightforward, being based on the main structural parameters and key aspects of design and construction. Each breakwater is identified by a three-part reference number covering Country, Location and Structural type. For the rubble mound category, for example, the following were tabulated where available:

Breakwater description

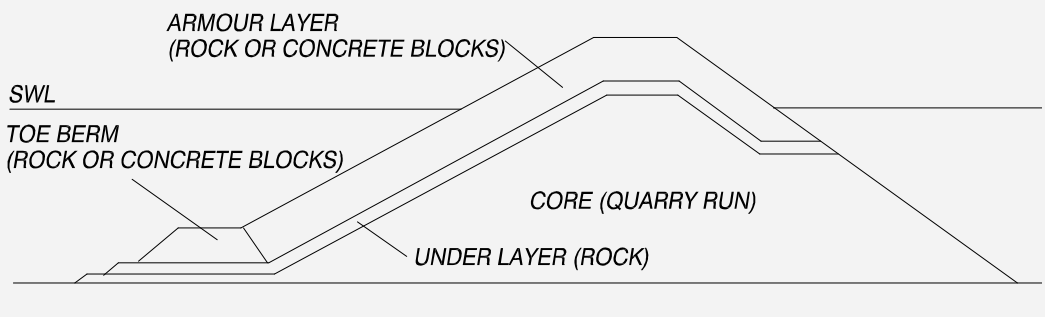
Harbour / location	Country	Breakwater description
Description of works	Length	Max depth
Damage to date	Storm conditions	

Construction

Construction start date	Completion date	Cost (Date)
Construction method	Contractor	Consultant

Design

Breakwater structural type	Design wave	Soil conditions
Primary armour	Front slope (s)	Rear armour
Rear slope (s)	Crest elevation	



Conventional rubble mound breakwater

2. Data collection / entry

Populating the database initially used available in-house data, but then became substantially more difficult to obtain the depth of information required for other structures. Most data are inherently partial (they have been collected by a sectional interest), dated (few owners up-date data), limited (almost no data are given on performance), and buried (data requires substantial effort to uncover). Many sources often only relate to a single structure. Lastly, data are not maintained (so information that was available to some people in the past has "evaporated" and is no longer found).

3. Example results

Rock armoured breakwaters dominate in many areas of the world, but are much less discussed in available literature. More details are available on mounds using (patented) concrete armour units because armour unit licensees keep records, so available data are biased towards such solutions. Even so, it is clear that the most frequently adopted designs are simple rubble mounds armoured by rock. Where rock armour is not available (size or durability), the most frequent solution is a steep rubble mound armoured by patented armour units, particularly favoured by clients of the "fit and forget" inclination. Berm breakwaters are generally confined to owners who are more familiar or are advised by specialised consultants. Caisson breakwaters are much more common in Japan than elsewhere, but examples of vertical walls are also found in UK, Italy and Spain, some of considerable age.

In considering the prevalence (or not) of any particular structural type, it is important to be aware of historical events which will have influenced designer / owner choices in their wake. Of particular importance would be the (apparent) increase of damage to large rubble breakwaters in the late 1970s, epitomised by the substantial damage at Sines (Portugal), Arzew (Libya), San Ciprian (Spain), Diablo Canyon (USA), Gioia Touro (Italy), and Tripoli (Libya). Some of these have been analysed in some detail, particularly Sines (see Baird et al, 1984) but data or analysis on most other failures are far less complete or publically available. Again fewer data are available on damage to rock armoured mounds, although see Willis et al (1988) for damage to berm breakwaters. Some rubble mounds settle slightly in early life, but generally then move or damage very little. Some rock may however deteriorate in time, and this may be exacerbated if the structure is subject to more armour movement than envisaged. These are however seldom reported. In contrast, reports of damage to caisson breakwaters, very widely used in Japan, may not have received the same extent of dissemination outside of Japan, so might have skewed designer opinions. Again, examples are discussed in review papers by (for instance) Goda, 2000 Takahashi, 2007 or Tanimoto, 1991.

4. Expansion and use

The initial database, prepared by HRW, is being extended in co-operation with TUD and with additional breakwater data provided from Spain, Japan, South Africa, and France. Advanced methods to hold and search data are being tested, and links to the USACE ECID database are being explored. The presentation at this conference will give the world breakwater community the opportunity to join this initiative. The database will be available for the benefit of breakwater designers, contractors, owners and developers worldwide. It is anticipated that the database will be subject to updating as information becomes available, however the development and maintenance of this database relies primarily on information supplied or published by third parties and no responsibility can be taken for the accuracy of data supplied. It is hoped that the next major presentation will be made at the PIANC MMX congress in Liverpool in May 2010.

Acknowledgements

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Figure 2 (left): locations of the breakwaters at present in the database

Figure 3 (below): sample print of one record from the database. The blue (grey) texts are hyperlinks. The link to the map gives a detailed Google map of the breakwater, the link to companies goes to the website of the company, the link on the blocktype to the PIANC directory of armourunits and the link to the reference provides a pdf of that reference.

International Breakwater Directory - detailed information

Netherlands - Scheveningen

(Lat: 52.102 Lon: 4.256 - click for map)

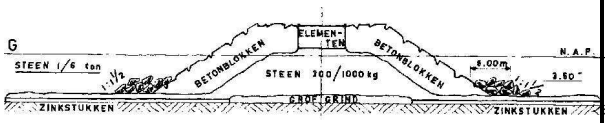
Zuiderdam

Rubble mound

Breakwater extension

Main breakwater data:			
Length (m)	600	owner	Rijkswatertaat
Waterdepth (m)	9	contractor	Boskalis
Construction time (years)	3	consultant	
Start date (year)	1969	Hydraulic Laboratory	Deltares
Completion date (year)	1971	comments	
Construction costs(10^6)	150		

click on picture for enlargement



Design criteria		
Hs (m)	6	
Tz (s)	12	
Tp (s)	0	

slope/crest info			
front slope 1:1.5	25	ton	Cubes
rear slope 1:1.5	25	ton	Cubes

Reference documents:

Roos, A [1971] Scheveningen uit de branding, Land+Water3-34-40

The database is accessible via http://www.breakwaters.nl.

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