



# **Fixed and floating breakwaters for small craft harbours: experience at Town Quay Southampton, Haslar Marina, Portsmouth and Parkstone Yacht Haven, Poole**

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## **Abstract**

The requirement for effective low cost protection against waves and ship wash is paramount for the current development of yacht harbours for marina berths that can no longer depend on natural protection.

Recent developments of a novel form of floating breakwater for the Town Quay Marina at Southampton, a fixed wavescreen for Haslar Marina in Portsmouth Harbour and off-shore rubble mound breakwaters at Parkstone Yacht Club in Poole Harbour are three such structures.

At Town Quay the floating breakwater is a continuously post-tensioned segmental structure of thin-wall fibre concrete construction around an expanded polystyrene core. The project was commenced in January 1993 and completed by July of that year.

In Portsmouth Harbour, shallow water with good sub-soil conditions for pile-driving resulted in an aesthetically pleasing timber and steel fixed wavescreen 197m long for Haslar Marina. Commenced in the autumn of 1993, the greenheart timber screen was completed in June 1994.

The yacht haven at Parkstone required off-shore breakwaters to protect the dredged haven and the artificial intertidal mudlands to satisfy environmental needs. Of conventional rock armoured construction, it was commenced in October 1994, and due for completion in April 1995.



## 1 Introduction

The demand for additional yacht berths resulting from greater public awareness and encouragement by government for the boating industry was assessed a few years ago for the south coast alone of England to be the order of 40,000 berths. This demand can obviously not be met by river or estuary moorings which need deep water and large swinging grounds and result in congestion of prime navigational waters. Rivers such as the Hamble and Lymington and harbours such as Poole and Chichester are good examples of how unrestricted moorings in the past have allowed navigable waters to become so congested by relatively few moorings as to spoil the environment and sailing pleasure for the many people coming fresh into the sport.

Commercial developments to fulfil this demand resulted in the late 70's and 80's of many yacht marinas in protected waters in existing river estuaries such as Lymington and the Hamble where construction could take place with the minimum of expenditure on infrastructure. Once these opportunities had largely been taken up, the second wave of marina development in the boom years of the middle 80's, such as Hythe Marina Village (1) in Southampton Water and Port Solent (2) at the top of Portsmouth Harbour, had relatively large infrastructure costs for main breakwaters or locked entrances funded by associated residential developments. Previous attempts to extend the sailing waters along the south coast to Brighton in the east and more recently Falmouth in the west, have similarly had to rely on associated developments to cover the large cost of harbour works, with disastrous results in the last few recessionary years, although the time span of these developments will undoubtedly outlive their current problems.

As marina developments in less favourable locations are thus contemplated, the requirement for effective but low cost protection against waves and ship wash is paramount, if dependence on residential and/or commercial development is to be avoided. The requirement for relatively very calm conditions in the marina for pontoon berthing is not only due to the chafing of fenders and lines, but also to the owners desire to sleep and eat on board. The often quoted figure for normal wave heights of the order of 300mm is far less than that experienced in old docks and harbours that are now becoming available for redevelopment for leisure use. Floating breakwaters and fixed wavescreeens are therefore required to attenuate waves in such locations down to the acceptable wave height for pontoon berths in enclosed marina situations of less than 500mm.



Previous examples of wavescreen and floating breakwater protection can be seen in Plymouth Harbour (Mayflower Marina, Queen Anne's Battery and Millbay Dock), Brixham (5), West Cowes and Gosport, all on the south coast of England, as well as many other locations world wide (3,4). Three recent designs of varying construction are described here.

The existence in 1992 of a physical model for **Town Quay** at Southampton allowed tests of prototype floating breakwaters up to 135m in length to be conducted. These were sufficient to convince ABP of the effectiveness of the designs for the conditions existing at the site. The economics of construction of the continuously prestressed Walcon System 4000 breakwater also proved viable for the 150 berth phase II marina. The number of berths were restricted in extent by the adjacent ferry berths for Red Funnel and Hythe ferry.

The site of **Haslar Marina** on Gosport Waterfront in Portsmouth Harbour lies at the entrance to Haslar Creek on an original large shingle bank. Dredging of this bank to provide berths for 600 yachts commenced in 1992 and exposed the site to winds and waves from the north east and to wash from passing ships. Protection was therefore provided on the north and north-east sides of the marina by a fixed screen of vertically boarded greenheart timber supported on transverse steel-piled frames.

In the very shallow waters of Parkstone Bay in Poole Harbour, the **Parkstone Yacht Club Haven** has been constructed since October 1994 in an extremely environmentally sensitive area. The off-shore breakwaters not only protect the pontoon yacht berths, but also provide protection for the artificial intertidal mudlands, constructed on the inside of the main west breakwater, which replace the foreshore area dredged out for the yacht basin. Limited in height for planning reasons, the breakwater is designed for overtopping in extreme conditions of gale force winds and astronomic high tides.

## 2 Town Quay Marina Floating Breakwater

The physical model testing for the outer breakwaters for the proposed marina at Town Quay, Southampton has been previously described (6). However, due to the decision by Associated British Ports to introduce the fast ferry service to the Isle of Wight into the existing ferry berth at Town Quay, coinciding with the arrival of Red Funnel's new catamaran passenger ferries in 1992, the full size marina was no longer possible.

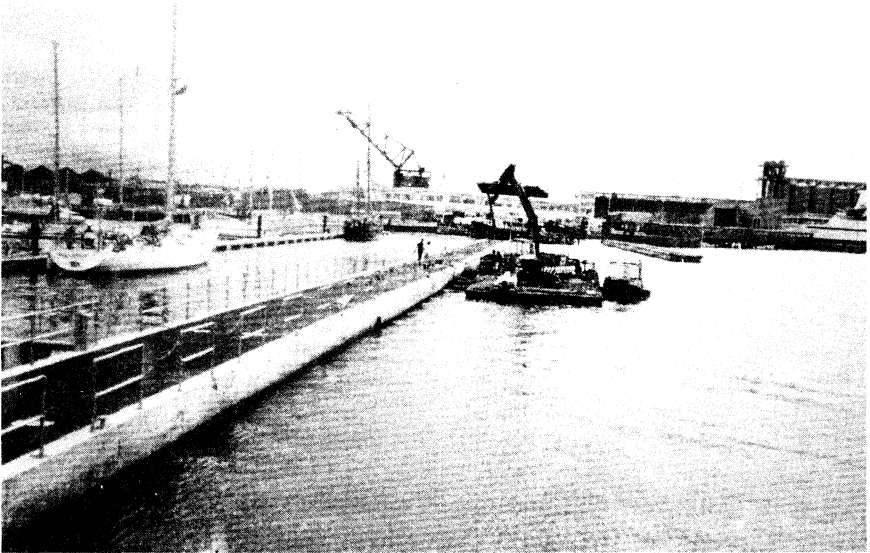


FIGURE 1 : Floating Breakwater at Town Quay

Consideration of a more modest proposal to augment the first phase marina pontoons already installed at Town Quay, but only used for the summer months in relatively calm conditions, was thus given in the knowledge that the physical model at ABP Research and Consultancy Laboratories was still available for further testing.

The existence of heavy concrete pontoons by SF Marine of Sweden, used to refurbish the floating breakwater at Mayflower Marina in Plymouth and a new design by Walcon Marine for a commercial pontoon made this proposal worth considering for a marina of some 146 pontoon berths. These pontoons had obvious capacity for use as floating breakwaters at costs of only a fraction of that for conventional designs. The existence of a deep trough in the seabed in the centre of the proposed location for the breakwaters made a piled solution impractical.

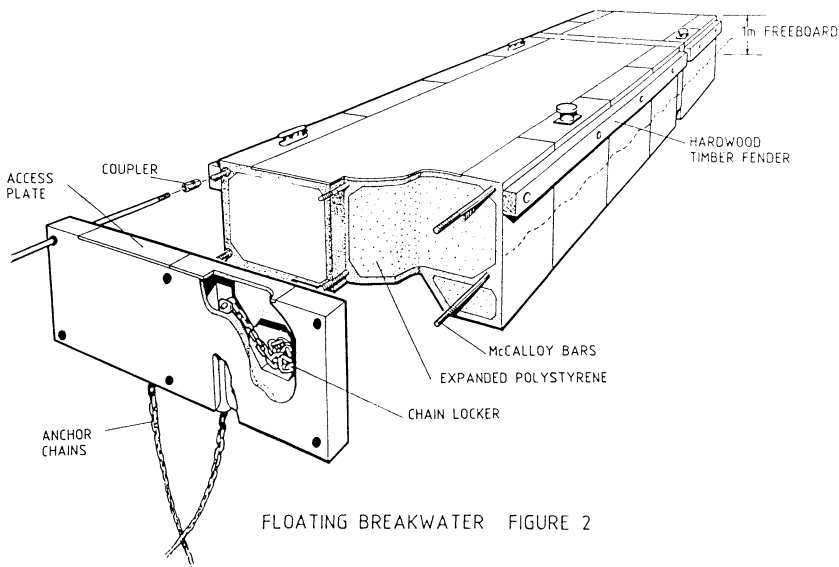
The model tests, funded jointly by ABP, SF and Walcon were carried out in the summer of 1992 and showed that in the wave climate predicted for Town Quay, of maximum wave height of less than 1.0m and a wave period of 3.0 to 3.5 seconds, the wave attenuation by the floating breakwaters was greater than 50%, resulting in a storm wave condition in the marina of less than 500mm and a normal annual maximum of less than the more acceptable figure of 300mm.



Construction of prototype section of breakwater by Walcon Marine, launched at the Southampton Boat Show in September 1992, resulted in an order for the Phase II Marina and Breakwater in January 1993 for construction of 205m of floating pontoon breakwaters and additional pontoon berths and walkways, for the 1993 season.

Now known as Walcon System '4000', the 4.0m wide pontoon breakwater is constructed of 2.5m long segments for ease of transport by lorry. Also 2.5m deep and designed to float with a freeboard of at least 1.1m, the segments are of 50mm thick thin-wall concrete construction around expanded polystyrene cores. With a central longitudinal diaphragm wall 75mm thick, the arrangement is shown in the expanded view in Figure 2.

Site casting of the units in fibre-concrete commenced in February 1993. The segments are held together by six continuously prestressed macalloy bars 50mm diameter in galvanised steel ducts at each corner and top and bottom of the central wall. Transverse solid concrete diaphragms at 10m centres provide attachment points for the mooring chains. The recessed bottom allows a slight catamaran effect to help floating stability which has proved quite adequate in practice. The breakwaters were finally moored in position by heavy chains attached to concrete sinkers in June 1993.



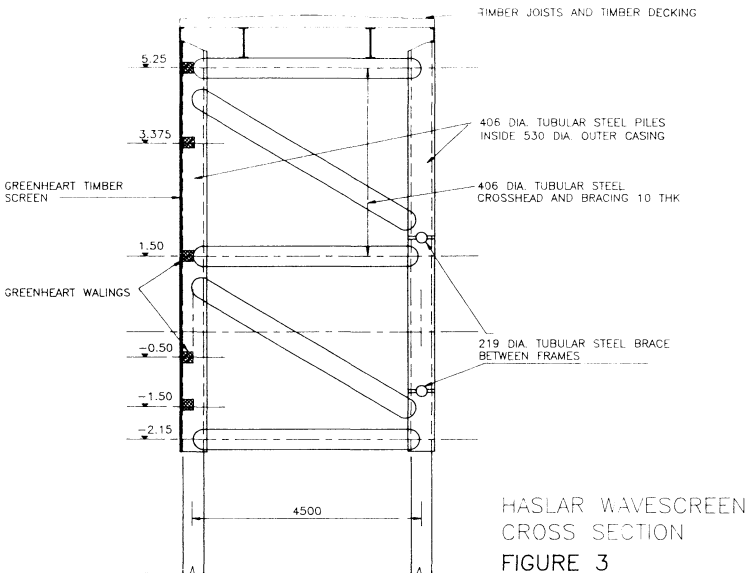
FLOATING BREAKWATER FIGURE 2

### 3 Fixed Wavescreen at Haslar Marina

The development of Haslar Marina commenced in 1993 on the site of a large shingle bank on Gosport waterfront on the west side of Portsmouth Harbour, at the entrance to Haslar Creek. Owned by the Crown Estate, planning approval for the site had been given five years earlier, with the requirement of public access along a fixed breakwater to be positioned on the northern boundary of the site, which was exposed to a 10km fetch from the north-east. Wash from naval vessels approaching HMS Dolphin shore establishment on the other side of Haslar Creek was also known to be a potential problem. Design wave height for these conditions was again of the order of 1.0m with a wave period of 3.0 to 3.5 seconds.

Development of the marina commenced from the south adjacent to Haslar Bridge and the first 200 berths were made available by April 1993. A very successful competitive pricing policy by the developers Dean & Reddyhoff led to an accelerated programme of development for the winter of 1993/94 and the need to bring forward the construction of the northern breakwater to replace the shingle bank protection that was rapidly being dredged out.

Devised by the piling contractor, Branford Marine, the proposed construction method incorporated prefabricated welded tubular steel 'H' frames, with 403 diameter piles driven through the 508 diameter vertical legs of the frames which acted as pile guides.



Accuracy of the frame positions was ensured by the installation of the permanent deck steel beams and temporary walings, acting together as braced frames to support the structure at the required height before piling. Temporary welding of the frames to the piles after driving to the required depth was subsequently replaced by modified cement grouting of the annular space between the pile and the frame to provide the permanent connection. At the outer end of the screen, deeper water required a two storey main frame, together with longitudinal bracing to the node points, as shown on the cross-section in Figure 4.

Externally the face of the screen is of vertical close boarded greenheart timber carried on similar timber walings spanning between the main frames at 8.0m centres and intermediate piles braced from the frames at deck level.

This system allowed for ease and speed of construction from floating craft and was very successful in practice. Fabrication of the steel main frames commenced in November 1993, prior to being floated out and located in position by the tubular steel piles commencing in March 1994.



FIGURE 4: Wavescreen at Haslar Marina

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Assembly of the panels of greenheart boards supported on greenheart walings was also carried out on land in the spring of 1994, for completion of the screen in June of that year.

The screen has since been extended by the introduction of a refitted lightship at its southern end to give added protection from the wash of passing vessels in Haslar Creek. The lightship also provides marina toilet facilities below decks and bar and restaurant accommodation on the upper decks, run by the Royal Albert Yacht Club.

### 4 Parkstone Yacht Haven Breakwaters

The development of Parkstone Haven for the Parkstone Yacht Club in Poole Harbour is in a particularly sensitive location. Planning Permission had only been granted on appeal to the Secretary of State after an environmental assessment by HR Wallingford, which proposed that the intertidal mudland lost through dredging of the inshore area for a yacht basin, be replaced by artificial mudland on the inside of the west breakwater, which was required to give protection to the proposed pontoon yacht berths.

Only the construction aspects of the haven project relating to this breakwater protection will be related here as the environmental issues will no doubt be discussed elsewhere.

In the relatively protected waters of Poole Harbour, the requirement for a breakwater that provided sufficient protection from south-west gales, while still being aesthetically acceptable and with a sufficiently low crest to avoid planning objections, resulted in the design of a rubble mound breakwater. Of conventional design with rock armouring to absorb wave energy, the breakwater is designed for overtopping when westerly gales coincide with astronomic high tides.

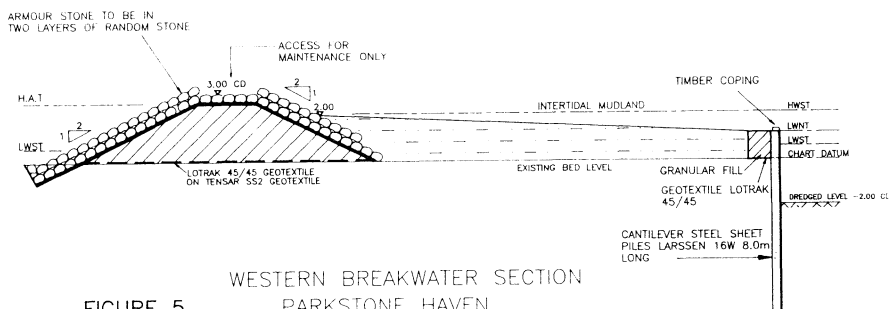


FIGURE 5



A cross-section of the breakwater is shown in Figure 6, indicating the sheet-pile toe wall on the haven side of the breakwater to retain the artificial intertidal mudland. The crest level of this wall is at around low water neap tide level to ensure that the mudlands are alternatively covered and exposed during each tidal cycle.

Construction of the west breakwater commenced in October 1994 with mainly rock fill to provide access to the breakwater site from the north west corner of the club boatyard. The Contractor Edmund Nuttall elected to carry out the construction with shore based plant because of the very shallow nature of Parkstone Bay and the small tidal range present in Poole Harbour. A period of surcharging allowed for in design from original soil mechanics testing was found to be unnecessary and to date measured settlement has been far less than expected. In order to achieve competitive tenders, reliance was placed on geotextiles in designing the breakwaters, avoiding costly filter layers and restrictive material specifications.

Geotextile reinforcement placed on top of a geotextile filter membrane beneath the core of the breakwater ensured that the load from the rubble mound was dispersed into the underlying strata without undue local settlement. The filter membrane was also placed on either side of the rubble mound beneath the armour layers to prevent wash out of fine material. The choice of membrane was determined by tensile strength requirements as well as adequate porosity and has performed well.

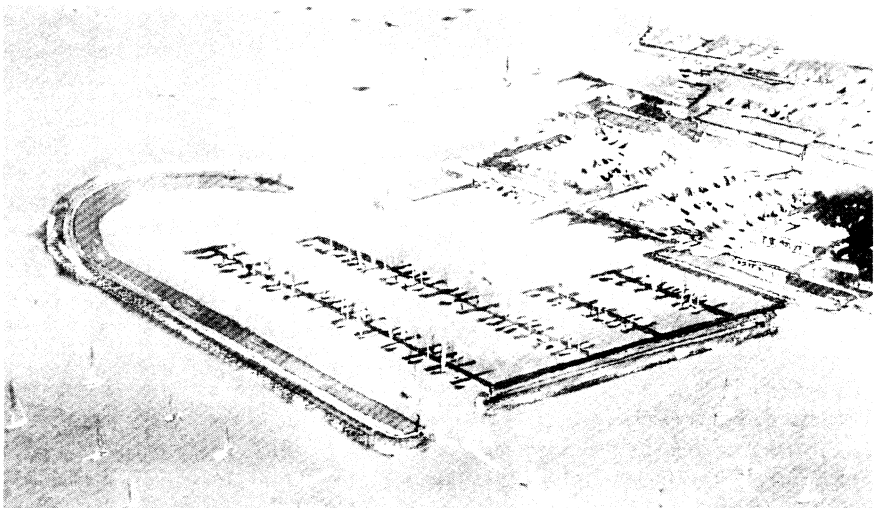


FIGURE 6 : Artists impression of the completed Parkstone Yacht Haven



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Completion of the west breakwater and haven dredging early in March 1995, allowed the driving of tubular steel guide piles for the pontoon berths to take place in good time for the installation of the walkways and access bridge in April this year. Completion of the project for 158 yacht berths is expected by June 1995.

### 5 Summary and Costs

The floating breakwater at Town Quay has performed well in this relatively well protected location; the design storm wave is very similar to the maximum expected from the wash of passing ships with a period of up to 3 seconds. However, the fast catamaran ferries located just outside the marina produce an extremely short steep wash at their operating speed of 35 knots, which is released when approaching their berth into a long period swell that penetrates into the marina causing slow motion disturbance.

In all other respects, the floating breakwaters have performed in excess of expectation and are often used for the temporary berthing of large visiting craft, as well as the passenger berth for the local Hythe ferry. At a cost of approximately \$600,000, the 205m of floating breakwaters equate to a price of less than \$3,000 per metre run.

Designed for a similar wave climate, but with a very different requirement for permanent construction and public access, the fixed wavescreen at Haslar proved to be economic in construction time at reasonable cost. Not including deck surfacing, yet to be installed, the tendered price of \$900,000 for nearly 200m run of screen equates to a price of around \$4,500 per metre, which reflects the 5.0m rise and fall of the tide and the bed level down to 3m below chart datum.

Again in very different circumstances, but with similar design wave parameters, the rock armoured breakwater at Parkstone Yacht Haven is another example of economic design using modern materials in a conventional setting. Although in considerably shallower water compared to the proceeding examples, the construction of the breakwaters for a tendered price of approximately \$1.0 million for a combined length of some 500m is approximately \$2,000 per metre run.

The range of costs for the fixed and floating breakwaters described above of the order of \$2,000 to \$4,500 per metre run, compares very well with often experienced costs of from \$7,500 to \$10,000 per metre for breakwater construction, indicating that by careful design and location, economies of construction are possible to ensure the viability of marina projects in exposed estuarine locations.



The choice of fixed or floating, solid breakwater or piled screen will depend on the particular conditions existing at any given site and can only be made after careful site investigation and design studies. The low cost of the Parkstone breakwater, for instance, has resulted from the almost mediterranean style low tidal range existing in Poole Harbour and the shallow water approach. Wave period is also very critical when considering floating breakwaters and should be restricted to a 3.5 second period until further information on the performance of breakwaters for longer wave lengths is known.

### **Acknowledgements**

The breakwaters described in this paper would not have gone ahead without the commitment and cooperation of Associated British Ports Research and Consultancy, Messrs Dean & Reddyhoff, the Parkstone Yacht Club, HR Wallingford and Walcon Marine.

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