

ROYAL BRIGHTON YACHT CLUB MARINA REDEVELOPMENT

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Abstract: Royal Brighton Yacht Club is one of the premier yacht clubs in Victoria catering mainly for racing yachts ranging from dinghies to ocean racing yachts. The timber jettied marina was in poor condition with rotting decks and piles subject to necking and other signs of age. This structure catering for up to 179 berths was originally constructed for the 1956 Olympic Games, and despite maintenance, was beyond its service life, and no longer met the expectations of the members. Following a lengthy approvals process and negotiation of a seabed lease, redevelopment of the marina was started in May 2002. The work was arranged in stages of demolition, dredging and reconstruction in three designated areas of the marina, in order to provide continued berths for a majority of its fleet and minimise disruption to the Club.

An existing solid timber wave screen providing some wave protection to the northern boundary of the marina was demolished and replaced with a floating wave attenuator, which was designed and tested in New Zealand. Dredging of about 50,000 cubic metres was required to achieve design depths of 3.1m to 3.7m in the basin and approach channel respectively. Dredging of about 25,000 cm of hard materials proved difficult and slow. Disposal of underlying clays proved to be difficult in terms of meeting environmental targets for turbidity, despite using the Cooking Pot methodology and a number of trials of various geometrical arrangements of barges and skirts.

This paper provides a brief description of some the key design and construction aspects of this project.

Keywords: Wave Attenuator, Dredging, Demolition, Turbidity, Construction, Waves

BACKGROUND

The Royal Brighton Yacht Club lies on the eastern shore of Port Phillip, approximately 15km south of the city of Melbourne. The marina is accessed by a 300m long reinforced concrete pier, and thence to a hardstand area which is used for the storage of mainly racing yachts such as Etchells and Dragons.

A 500m long rubble mound breakwater which is owned and maintained by Parks Victoria as the local waterway manager, provides protection from wind waves from the west, southwest and south primarily, and limited protection from NW waves.

The Club's timber breakwater provided some partial wave protection from northerly waves. Depths in the marina ranged from about 2 to 2.5m, with occasional shoal spots.

In May 2002, a contract was signed for the design and construction of the new marina, to provide a 1 for 1 replacement of berths. Soon after, work commenced on site.



Figure 1. Pre construction marina and simulation of completed marina

GHD SCOPE OF WORK

GHD were initially commissioned by Bellingham Marine Australia to undertake a wave analysis to provide the design wave conditions at and around the northern end of the breakwater, which is the least protected boundary of the marina. Shortly after, GHD were commissioned by the Royal Brighton Yacht Club to assist in the marina re-development project. This included design development and acting as site superintendent for the contract.

DESIGN WAVE CLIMATE

Waves impinging on the site are short period wind waves of periods up to 6 seconds, generated across fetches of the order of 15 to 60km and depths up to 25m. Based on coastal wind data for 7 years and extreme design wind speeds derived from AS1170 Part 2 for Melbourne, the model Wavgen (reference 1) was used to determine design wave conditions near the northern boundary of the marina, this being the least protected boundary. Wavgen is a spectral hindcasting model developed by GHD to model wave generation in various water depths. The model Mwave was then used to model the complex transformation process of the offshore waves into Brighton harbour. This model includes wave shoaling, refraction, diffraction, the spectral characteristics of the sea state and an allowance for wave breaking. Following an assessment of waves from the available 22.5° sectors, the design wave was determined to be from the north west. This design wave crest approached the line of the attenuator at about 45° at the western end, where diffraction effects about the tip of the breakwater dominate. The wave from the west is aligned nearly parallel to the attenuator and is thus not a critical condition for attenuation into the marina. Shown in Table 1 following are the design wave conditions at the attenuator for the 1:50 year ARI:

Table 1. Design wave conditions at the attenuator for 1:50 ARI

| Wave | North | NNW | NW | W |
|----------|-------|-----|-----|-----|
| Hsig (m) | 0.7 | 1.0 | 1.4 | 1.4 |
| Tp (s) | 3.3 | 3.4 | 3.9 | 4.6 |

WAVE ATTENUATOR

A floating wave attenuator was adopted for the project as it was considered that this form of breakwater compared to a conventional fixed breakwater would be more likely to get planning approval. The new wave attenuator was positioned approximately 30m north of the old timber wave screen, much closer to the tip of the breakwater and hence in more exposed sea conditions.

Under the design and construct tender documentation, the contractor had to design the floating wave attenuator for the wave conditions reported previously. Tender submissions were received for a range of marina pontoon and wave attenuator designs using concrete, HDPE, fibreglass and mixes of these materials. The suppliers claimed performance of the wave attenuators varied significantly. Existing published information on the performance of wave attenuators was for normal approach cases, based on two dimensional flume tests. These tests suggested that a floating wave attenuator would not provide an adequate amount of attenuation. However in a flume test, the test section is usually constructed across the full width of the wave flume, and placed normal to the approaching wave train. The flume walls constrain the reflected wave energy between the flume walls and there is no lateral spreading of energy possible. In a realistic open sea situation, incident waves approach at varying angles spread around a principle direction and waves may be reflected at an equal angle to the incident angle. Wave reflection is thus a process which contributes to attenuation. As previously mentioned the design wave was calculated to have an angle of incidence to the wave attenuator of about 45 degrees and thus it was important that the wave reflection be properly considered to assess wave attenuation.

Some information from Bellingham Marine Australia indicated satisfactory anecdotal based performance at other installations, but all of these examples of existing wave attenuators were in water depths considerably greater than at Brighton. According to linear wave theory, in shallow water the velocity profile is modified such that orbital velocities near the surface and near the seabed become similar in magnitude, and the orbits become quite flattened. A wave attenuator in deeper water should intuitively intercept relatively more of the wave energy (for waves in deep water), compared to an attenuator in shallower water where there is relatively more energy at depth which can then pass beneath the attenuator.

This lack of convincing evidence led to the proposed attenuator design being accepted subject to model testing in a wave tank. Subsequent physical model testing indicated that the proposed attenuator would for the 1 in 50 year wave conditions provide “moderate” conditions generally in the marina in accordance with AS3962, Table 4.2. Wave conditions at Brighton are such that the higher probability design wave such as the 1 in 10 year wave is not much less in wave height and period than the 1 in 50 year wave. Hence the design needed to cater for the more probable wave events as well as the less probable wave events. Further testing indicated that an extension of the rock breakwater would reduce leakage of wave energy into the marina via the western entrance between the breakwater and wave attenuator, and this would improve conditions in the marina from “Moderate” to “Good” status.

Principle dimensions of the wave attenuator adopted are length 110m, nominal width 4m, draft 1.8m and freeboard 0.5m. The attenuator accepted is of straight form and is constrained in place by 18 circular steel piles, sand filled. The original concept was for a curved attenuator, the theory being that the curved shape is better able to resist a straight wave front that approaches the attenuator. In

practice the contractor was unable to roll the steel connecting walers to achieve this shape, and hence the straight shape was accepted. At some other locations where this type of attenuator has been installed, the steel piles were connected at the top by steel cross connecting yokes to stiffen the restraint system. This design was considered to be aesthetically unacceptable and not in conformance with the Planning Approval and hence the unconnected pile design was accepted.

Model tests were conducted at a scale of 1:25, with 3 incident wave probes, and 9 probes at strategic locations inside the marina basin. An initial 22 test scenarios were examined based on:

- Two directions – north west and north north west
- Two attenuators – the 4m and 5.4m beam
- Two water levels – simulating a spring high tide and an elevated water level
- Two ARI's – 1:1 and 1:50
- Varying the stiffness of the attenuator and main walkway leading to the attenuator.

Following these initial runs, a further 22 runs were undertaken for the 4m wide attenuator, with approach angles of 10°, 35° and 45° to examine sensitivity to approach direction.

The physical model tests indicated that the 4m wave attenuator provided generally “moderate” wave conditions in the marina in accordance with Table 4.2 of AS3962.



Fig 3 Floating Wave Attenuator

MARINA LAYOUT AND VESSEL MIX

The three key drivers for the marina layout were to provide a 1 for 1 replacement of berths to simplify the planning application in terms of a potential carparking issue, and to provide for current and projected future vessels. The design mix of vessels was determined primarily by the Principal based on discussion with other similar Clubs, trends in vessel size and popularity, issues with

crewing, promotion of class type racing and intuition. This information was used as the basis to commence the layout. The final layout provided the required berth numbers and vessel mix taking into consideration navigational requirements, the available geometrical area, dredging quantum and cost and access for owners and crew. The layout of the approach geometry was further complicated by the existing hardstand arrangement and the manner in which it is used, particularly in respect of the three dockside cranes. These are used to lift racing yachts into and out of the water. There is thus a peak demand for cranes and nearby short term berthing whilst vessels are readied for racing and later readied for storage on cradles. This intensive demand required suitable short term holding space for these vessels and clear and short path to the cranes.

The vessel mix adopted was as follows:

| Berth Size (m) | Number Vessels |
|-------------------|-------------------|
| 10 | 74 |
| 12 | 64 |
| 15 | 29 |
| 18 | 12 |
| Total = | 179 |

TENDER DOCUMENTATION

The tender documentation was prepared for an AS4300 Design and Construct contract. There were several interesting points about the contract.

Due to concern about probable debris on the seabed such as old mooring chain, anchor blocks, steel cable etc. a fixed lump sum for a quantum of debris collection and removal, with no claim for delay or costs was negotiated.

The probability of the dredging encountering hard materials was generally well known by local contractors based particularly on previous dredging campaigns in the harbour by the marine authorities over the years. Limited further information for dredging assessment was gained from boreholes (drilled for the marina pile design), and jet probing (to determine quantities of hard and soft materials specifically for the approvals). This information was provided to the head contractor on a "for information only" basis. The contract sought to place the responsibility for latent conditions on the contractor by including an item in the schedule for site investigations, and in several places within the specifications by explicit requirement for the contractor to be responsible for determining site conditions.

The project was put out to tender in October 2001. The Principal was delayed in negotiating a seabed lease, and a contract was not signed until 31 May 2002. Work commenced shortly afterwards.

DREDGING AND SPOIL DISPOSAL

For the anticipated racing yachts, the Club stipulated a uniform depth of RL -3.1m in the basin and RL-3.7m in the approach channel. The latter would allow all tide access to the eastern side of the marina for the largest racing yachts based in Port Phillip.

Based on the geotechnical investigations, the estimated quantities were 25,000 cubic metres of hard material, and about the same of softer materials comprising sands, silts and clays. Boreholes indicated ferruginous sandstone. Rock at the nearby shoreline indicated that this rock varied considerably in hardness depending on the quantum of ironstone, and varied considerably in terms of its structure and form.

Initial environmental studies indicated that soft materials in the marina area could be odorous when exposed to air and may provide some risk of complaint from neighbouring residences. The materials to be dredged were not generally suitable for shoreline disposal, and hence an offshore disposal was required. Soundings from the Chart AUS155 showed that water depths nominally a 1000m off the breakwater were of the order of 6m, and this depth was sufficient to provide for a spoil ground and still permit adequate water depth for the typical vessels using this area. Accordingly, dredging with a cutter suction dredge with disposal offshore via a pipeline delivery was preferred in terms of providing a methodology that would be practical and acceptable to the regulatory authorities. The tender documentation and methodology proposed to the regulatory authorities well prior to any contract being signed with the contractor allowed for possible excavation of hard materials. An offshore spoil ground 900m off the breakwater was selected after consideration of the existing nature of the area in terms of its biodiversity and existence of unique species, depth of water and practical pumping distance. To reduce the risk of turbidity, a cooking pot disposal methodology was employed. This simply aims to duct spoil downwards to the seabed by constraining the discharge into a skirted area. In theory the spoil is uniformly spread within the skirted area and the natural angle of repose and outflow of delivery water induces the spoil to flow out around the interface of the skirt and the seabed. Spoil is discharged generally at depth and for short period wind waves this may be at a point where orbital velocities are low. The discharge level is also much lower than the surface wind current. The risk of turbid water which might be generated by the disposal activity reaching the shore and shore reef areas was calculated for the chosen spoil site. This spoil site 1200m offshore in 6m of water, and dredging and disposal methodology were subsequently approved by the regulatory authorities.



Fig 4 Cooking Pot (Mark 1)

CONSTRUCTION ISSUES

At the commencement of construction there were of the order of 130 vessels in the marina. This number was reduced slightly when some owners were able to relocate their vessels elsewhere, but generally the construction needed to keep the marina operational. A key logistical issue was the need to carefully plan and stage the works such that vessels could be relocated temporarily within the marina and then later to the new marina areas. The marina was “divided” into three areas with the cycle of operations being relocation of vessels, demolition of decks, pile removals, sweeping for debris, dredging, piling and then marina and services installation. Yachts were installed into new marina areas as soon as possible in order to facilitate a start on the next stage. This process worked reasonably well with good co-operation and communication between the marina manager and the contractor. The neat division into three areas was later varied considerably as hard rock was encountered.

Fine clay was encountered generally at depth below RL -3m. Once in suspension this material was in practice impossible to control and large turbidity plumes were generated despite the endeavours of the contractor. The environmental impact of these plumes was assessed by GHD’s independent consultant to be minimal at worst as the fine material had little effect on light penetration or posed any risk of smothering or any other threat. Subsequent investigations showed that the turbidity did not stress any marine biota. Nevertheless the works were stopped by the EPA for a period of three weeks, largely as a reaction to complaints by the public. Following a re-assessment of procedures, the environmental assessment and construction of a larger cooking pot, works were permitted to resume. In all, four cooking pots were built and used in response to varying needs including control of turbidity, life of the skirt fabric, freeboard, ease of moving the cooking pot to effect a uniform distribution of spoil within the approved spoil ground boundaries, and buoyancy requirements. The latter became a concern when the contractor changed from poly pipe to steel pipe in response to premature wear of the pipeline caused by pumping of rock fragments.

Seabed debris in the harbour was removed by use of an excavator fitted with large tynes. In all over 50 tonnes of debris including engine blocks, chain, anchors, steel cable and a yacht keel were removed. This amount vastly exceeded expectations.

Following timber deck removals, the timber piles were extracted from the seabed. Initially this was undertaken with a vibrating head. Piles were faced with two parallel faces in order for the grips to attach to the pile, and with vibration and tension applied with a crane, the pile was extracted. This technique proved to be slow and cumbersome, and crane loads of up to 12 tonnes were still required, for typical embedment lengths of around 4 to 5m. In order to speed up the works, a jack up barge with vertical load capacity of 500 tonnes was used to directly pull out piles. This increased the extraction rate from several per day to about 40 per day.

Dredging of hard materials was initially attempted using the standard rosehead cutter. As mentioned, materials comprised ferruginous sandstones of varying hardness depending on the amount of ironstone. The rock is locally referred to as coffee rock, presumably based on its colour. Although not specifically hardness tested, some visible examples on nearby reef areas appeared quite hard. The first encounter using the standard rosehead cutter proved unsuccessful with high teeth wear and damage. At tender stage, the contractor proposed use of a Jaden cutter wheel on any hard material, and failing this the contractor proposed ripping with a large excavator. A Jaden wheel cutter was

fitted to the dredge, and on the hard rock, teeth were damaged and large rock fragments with some in excess of 300mm were created. The rock fragments allegedly caused damage to the pipeline and accelerated damage to pumps. The Jaden wheel was removed and the rosehead cutter was fitted with trials of various hardfacings. Following a trial and error approach, a satisfactory hard facing was found which enable production of about 500 cubic metres per day to be established, which was around 50% of target production. Rosehead cutters were changed over daily, with one in service and the other being hard faced.

Piling for the marina was undertaken from a barge fitted with two stabilising spuds, with location of the barge controlled by anchors and wires to winches. For marina piling, tight tolerances within the range of the adjustment of the pile guides on the pontoons is necessary and this dictates a tolerance in horizontal positioning of better than +/- 20mm. In virtually any conditions other than fairly quiet winds, positioning of the barge to hold a location within tolerance proved to be slow and cumbersome. This and the need to pre auger some pile locations translated into typical pile installations of only two per day.



Fig 5 New Marina in progress (pre the floating arms and wave attenuator)

CONCLUSIONS

The redevelopment of the marina with all floating jetties and wave attenuator, and deepening of the marina basin and approach channel by dredging has been successfully undertaken. Disposal of a range of sediments to an offshore spoil ground and control of turbidity by careful design has been generally achievable.

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