CHAPTER ONE HUNDRED SIXTY NINE

Case History of a Spaced Pile Breakwater at Half Moon Bay Marina Auckland, New Zealand

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Introduction

Half Moon Bay Marina is a privately owned small boat harbour located on the Tamaki Estuary of the Auckland Harbour. The marina was built in 1970 for 485 boats moored to floating marina berths, Fig. 1, and is sheltered by a spaced pile breakwater.

Figure 1 : View of Half Moon Bay Marina

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The marina is well protected by land from the prevailing south-westerly winds and from the north-easterly gales which are experienced in the region, Fig. 2. However, the marina entrance is exposed to the less frequent north-westerly and westerly winds blowing across the Tamaki River. For winds from a northerly direction at high tides the calculated significant wave height is 1 metre with a 3 second period and 0.7 metres with a 2.7 second period with westerly winds. During low water the fetch is further reduced to the relatively narrow width of the estuary by the drying shallows at the opposite side of the river.

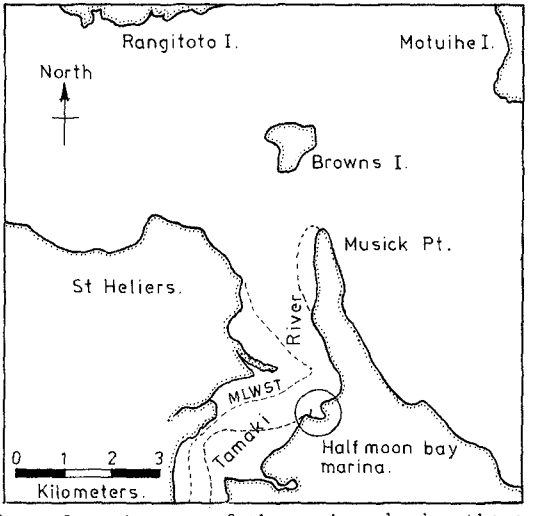

Figure 2 : Location map of the marina showing the narrow sector of exposure to wind waves

Because of space restriction and cost it was not desirable to use a cover breakwater to protect the entrance and no such shelter was provided. The entrance to the marina was kept narrow, at 33 m width, in order to minimise the amount of wave energy entering. However, even with this narrow entrance full height waves can enter the marina and affect the boats and outer marina berths.

Aims

The object of the breakwater design was to provide shelter for the marina at least cost. A stone breakwater in the 4 m deep water would have been very expensive and would have occupied an unacceptable width of the river channel. A steel sheet pile breakwater would have been even more expensive and would have both reflected waves across the navigation channel and deflected some of the tidal flow. Floating breakwaters were considered but were not considered to provide a sufficiently positive breakwater. The final design used a spaced pile breakwater which has proved satisfactory when used in conjunction with robust steel tube marina berths in the area facing the entrance.

Breakwater Design

Model tests to a 1:12 scale, were carried out in a wave flume at the Auckland University School of Enginneering, and showed that a 50% reduction of wave height could be obtained by using vertical 300 mm timber piles spaced 37 m apart. This spacing gave a horizontal force of 22 kN per linear metre of breakwater. The force on a solid breakwater would have amounted to 53 kN per metre. These results compare well with those reported by Grüne and Kohlhase (1) and Hayashi et al. (2).

This reduced load from spaced piles allowed a breakwater to be built using treated pine piles supported on an orthodox plumb and raker pile structure, Fig. 3.

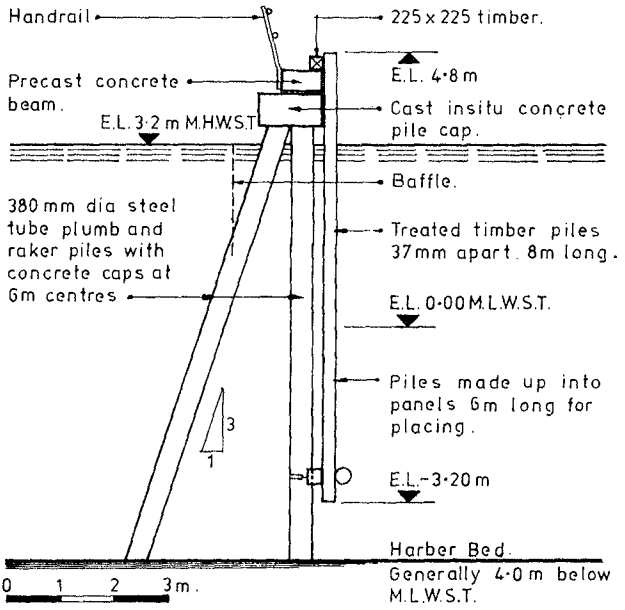

Figure 3 : Typical cross section of the breakwater

It was also found that a barrier 2 m deep, 1.5 m behind the spaced pile breakwater provided very effective additional wave energy dissipation without significantly increasing the loading. The water level in this gap oscillated gently up and down. With this additional skirt the wave height transmitted was reduced to 30%. However, this secondary barrier was not used in final design.

Breakwater Construction

Site investigations showed that there was no firm ground at a reasonable depth on which to found point bearing piles. It was therefore decided to use friction piles. To assess their friction capacity a factor of safety was applied to the shear strengths of the clays encountered. The 6 mm thick 380 mm diameter plumb and raker piles at 6 m spacing were driven using a 1 ton hammer striking on a pad about 2 m of sand and gravel in the bottom of the pile. The piles were filled with sand to 3 metres below the top and the top portion was filled with concrete reinforced to connect the piles to the cast in situ cap which supported the longitudinal precast concrete beam.

The upper 10 m of piles were sandblasted and treated with epoxy tar. The lower sections of the piles, which were in the harbour bed, were left untreated.

The spaced timber piles were prefabricated ashore into 6 m long panels and placed by a crane into position. The panels were supported by the precast concrete at the top and were fixed to the vertical steel piles at the lower end.

Breakwater Maintenance

Virtually no maintenance has been required during the first twelve years of the breakwater's life, except that in 1983 it was found that some of the timber piles were loose and inspection by divers found that the bolts fixing the piles to the lower walings were pulling out. It was also found that the U bolts used to fasten the lower end of the panels to the vertical steel piles had failed.

In 1984 a contract for NZ$56,000 was let for the repair of the breakwater. A detail, using 19 mm mild steel plate and 36 mm mild steel bolts was used to replace the original U bolts and timber yokes. The exposed steel bots and nuts were wrapped in 'Denso tape'. It was found that the original 19 mm bolts and their threads were sound and that in all cases the nuts had corroded, sometimes completely, leaving the thread intact. The vertical piles bolted to the horizontal walers had also come loose due to the corrosion of the nuts with the bolts again left relatively intact.

Analysis of the steel has shown that different steels had been used to make the nuts and bolts and this led to an electrolytic action and corrosion of the nuts.

The pinus radiata piles had been treated with a copper chrome treatment to a concentration of 22 lbs per cubic foot (350 kg per m^3). To date there has been no indication of marine borer attack of the piles.

Marine Design

The floating marina was constructed using timber walkways supported on fibreglass pontoons. In New Zealand, because of the frequent strong winds experienced, boats are usually moored in marinas to float

clear of piles and the marina structure, using four mooring lines, Fig. 4. With this method of mooring boats need little supervision and fenders are not required. At Half Moon Bay it is only the marina berths near the entrance where the sea condition has caused deterioration of the timber marina structure. During northerly winds the waves which enter the marina through the entrance, combined with the half wave height entering through the spaced pile breakwater, cause a considerable amount of wave disturbance over the area just inside the entrance.

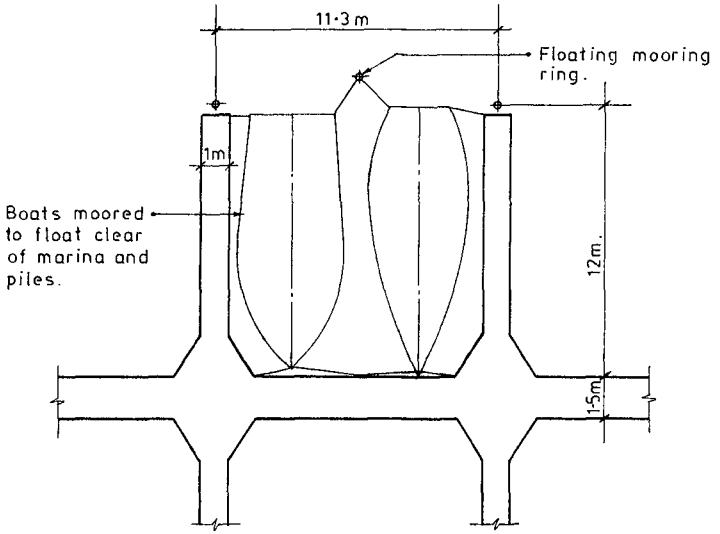

Figure 4 : Typical dimensions of the marina, showing the four line mooring system

The end fingers near the entrance have now been replaced using continuous 600 mm diameter steel pipe, Fig. 5, to support the walkway and fingers. This construction was first used over 20 years ago when the first marina berths were built by the Auckland Harbour Board at the Westhaven boat harbour.

Conclusion

A spaced pile breakwater has provided satisfactory economical shelter to a 485 boat marina. Only near the entrance did the original timber structure of the marina berths deteriorate due to wave action and it has been necessary to replace the light timber and fibreglass marina and fingers with more robust continuous 600 mm diameter steel pipes. Boats are moored to float clear of the fingers and do not require fenders.

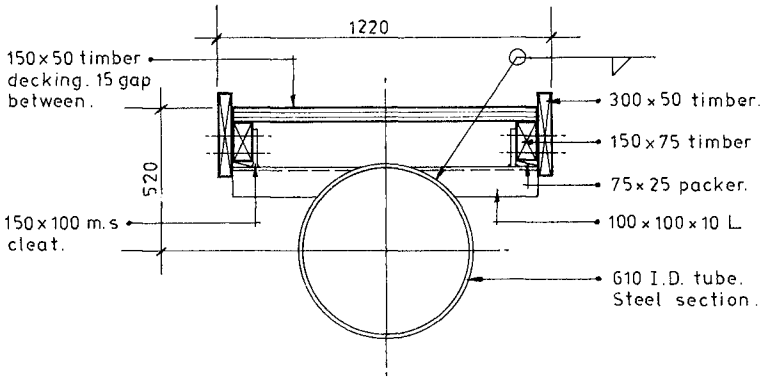

Figure 5 : Typical section through walkway

Acknowledgements

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References

1. GRÜNE, J. and KOHLHASE, S., Wellentransmission an Schlitzwänden, Die Küste, Vol. 27, 1975, 74-82

2. HAYASHI, T., KANO, T. and SHIRAI, M., Hydraulic Research on closely spaced pile breakwater. Proc. 10th Conference on Coastal Engineering, Tokyo, 1966, Vol. 2, 873-884