SUBMERGED GROYNES FOR BEACH STABILISATION

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INTRODUCTION

Typically, rubble mound groynes are constructed by end tipping from trucks for which the roadway level must be above high tide. Some adverse effects of such surface-piercing groynes include the generation of rips along their trunks (Fleming 1990; Scott *et al.*, 2016), which can transport sand off the beach and out of the groyne compartment. Further, rubble mound groynes have large footprints that may smother benthic habitat.

A submerged groyne may obviate such potential adverse impacts. Submerged groynes are used in England to stabilise shingle beaches (Simm *et al.*, 1996). The groyne extends offshore but underwater, protruding far enough above the seabed to arrest alongshore transport of littoral drift. However, scale modelling (Jensen 1997) showed that groynes remaining below the water surface allow for the expansion of rip currents and, hence, a reduction in their velocity and their capacity to transport littoral drift offshore and beyond the groyne compartment. Further, submerged groynes can comprise sheet piling, which may be timber (as used in UK), fibre-reinforced plastic, steel or concrete, which present a negligible footprint, having a minimal impact on benthic habitat.

Erosion at the somewhat sheltered Foreshore Road Beach, Botany Bay, followed its restoration as part of the Port Authority of NSW Port Botany expansion project (Figure 1), which also caused nuisance flooding in Botany from blocked stormwater drains (Figure 2).

Figure 1 – Foreshore Road Beach erosion 5 June 2012

Figure 2 – Back street flooding caused by blocked drains

This paper presents the design, the results of a mobile bed scale model study and the first practical application in Australia of a submerged groyne field solution for beach stabilisation.

GROYNE FIELD DESIGN

Recommended works (Figures 3 and 4) comprised two short rock armoured groynes enclosing the storm water pipes and extending into Botany Bay along with much longer submerged fiber-reinforced plastic sheet pile wall extensions. An additional plastic sheet pile groyne was included between the pipes to stabilise the beach further. Alongshore pedestrian access was provided at the root of each groyne. Visually, the groyne extensions were unobtrusive (Figure 5).

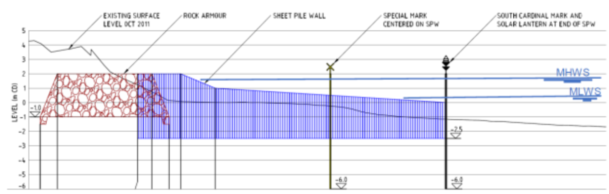

Figure 3 - Typical groyne section comprising rock root and plastic sheet pile wall extension submerged on high tide

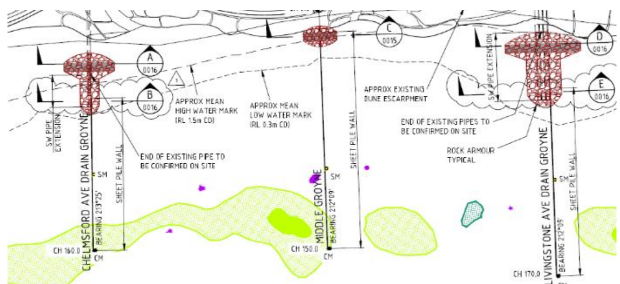

Figure 4 - Groyne field footprint and adjacent seagrass meadows (shaded green and purple).

Figure 5 - Rock work encapsulating storm water drains (nearest and farthest groynes). Yellow marker piles denote the midpoints of the submerged fibre-reinforced plastic sheet piling groynes

MOBILE BED SCALE MODELLING STUDY

Following the method of Nielsen *et al.* (2000), a novel mobile bed physical scale modelling study was undertaken at the NSW Public Works Manly Hydraulics Laboratory to determine the beach shapes that would develop between the novel groyne structures. Model testing was undertaken in a 30 m×18 m× 1 m wave basin at a natural scale of 1:80. The model sediment comprised plastic beads (S.G. = 1.37; D_{50} = 3.0 mm), chosen to be mobilised readily under the wave heights to be used in the model, creating a berm representative of a sandy beach berm under changing water levels. The model was run using bi-modal spectra of swell waves refracted into the bay and local seas.

The mobile bed scale modelling enabled the determination of future alignments for an eroded beach (Figure 6 left) and a beach stablilised with submerged groynes (Figure 6 right). The former confirmed model validation and the latter allowed for the determination of the required volumes of beach sand nourishment. The final alignments of the beach compartments as predicted in the model are shown in Figure 7.

Figure 6 – Mobile bed model of the eroded beach (left) and the beach stabilised with groynes (right)

Figure 7 – Alignments of the beach compartments predicted by the mobile bed model

PROTOTYPE PERFORMANCE

Works were constructed during Winter-Spring 2016. To date the beach has reshaped closely to the alignment predicted by the scale model study (Figure 8). The Port Authority continues to monitor the beach and the progress of seagrass colonisation through regular surveys.

Figure 8 –Development of the beach compartments in the field

CONCLUSIONS

A novel fibre-reinforced plastic sheet piling submerged groyne field has been used to stabilise Foreshore Road Beach on the northern shores of Botany Bay.

Beneficial features of the structures include:

- On high tides and during storm surge conditions the groynes are submerged, which obviates the formation of the rip currents that would take sand offshore from the beach during severe storms
- The minimal footprint of the structures obviates any significant impact on benthic habitat including the existing offshore seagrass meadows
- Ease of installation
- Non-corrosive properties
- Visual unobtrusiveness.

Small-scale basin modelling utilising plastic mobile bed sediments proved to be successful in predicting medium-term wave-generated plan-form beach response and, hence, nourishment requirements.

To the authors' knowledge, this is the first installation of such groynes in Australia.

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