UPGRADING OF SEAWALLS AND BREAKWATERS FOR CLIMATE CHANGE

by

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1. INTRODUCTION

Many rubble mound coastal breakwater structures are typically designed for depth-limited breaking wave conditions.and have primary armour rock and/or Concrete Armour Units CAUs that are undersized, and require regular (and costly) repairs after storm events. This ongoing challenge will be further exacerbated by sea level rise (Church et al., 2013).

Breakwater design equations predict that the stability of breakwater armour is proportional to the cube of the design wave height and inversely proportional to the cube of the submerged density of the armour material. Therefore modest increases in wave heights (due to changes in wave climate and sea level rise with climate change) and material density will lead to either large losses or gains in stability respectively.

Many of these structures will require significant armour upgrades to accommodate changing design conditions (for example, a 25% increase in wave height will require the armour mass to be doubled). Increasing the armour mass is the simplest way to improve the stability of a breakwater, but this approach may not be practical in many situations Rock or CAU protected structures cannot be simply retrofitted with an additional layer of larger armour because different sized primary armour (rock nor CAU) units may not be available (armour rock in Australia is generally limited to 8 t) or do not necessarily interlock well (stacking layers of different-sized CAUs on top of each other can create weakness planes in the structure).

Much of the literature on seawall and breakwater adaptation is focussed on the economics of upgrades (e.g. Headland et al., 2011; Burcharth et al., 2014). Practical design guidance for retrofitting existing coastal structures with rock or concrete armour units is limited.

2. PHYSICAL MODELLING

This study followed on from preliminary work at Water Research Laboratory by Li and Cox (2013) and Harrison and Cox (2015), and was designed to investigate the effectiveness of retrofitting existing rock and concrete-armoured coastal structures with additional (and more stable) primary armour (Figure1). Physical modelling was used to enhance our understanding of unconventional designs that may arise when coastal structures are upgraded in response to sea level rise. Placing larger rock or CAUs over existing rock or CAUs armour can be undertaken but stability is dependent upon achieving sufficiently high placement densities during construction – model testing is essential

3. HIGH DENSITY CONCRETE

To significantly increase relative submerged density and primary armour stability, the density of conventional concrete can be increased by replacing gravel aggregate (SG = 2.6) with steel furnace slag (SG = 3.0). The concrete product is however prone to cracking because of chemical reactions between Portland cement and the steel furnace slag. Recent advances in concrete technology have enabled the development of new products where Portland cement can be entirely replaced with geopolymer cement. Geopolymer cement does not react with steel furnace slag, making it suitable for use in high-density concrete.

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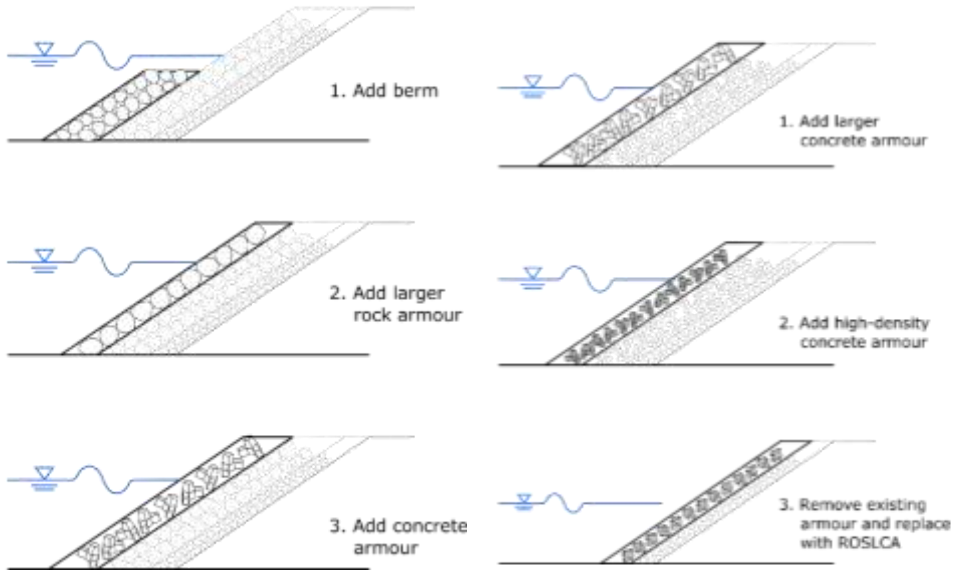

Figure 1: Potential upgrade options for rock and concrete armour.

High density concrete Hanbar CAUs have been found useful in model testing for upgrading existing CAU Hanbar structures, because they provide additional stability while retaining the same dimensions (ensuring good interlocking with existing armour units). This important result provides a potential upgrade pathway for all concrete armour unit structures in response to sea level rise. Prototype installation of 20t CAU Hanbars in a trial repair to a major coastal port in NSW Australia is planned for April 2018.

4. CONCLUSION

The paper has summarised extensive physical modelling undertaken over many years at Water Research Laboratory , synthesizes it with international literature and provides guidance for upgrading of breakwaters and seawalls with Climate Change including optimising financial decision making.

5. REFERENCES

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