OUTLINE OF PRESENTATION

- Introduction
- Function and Types of Seawalls
- Geotechnical Failure Modes
- Climate Change Impacts
- Seawall Preliminary Assessment Form

INTRODUCTION

- This project was undertaken by the Sydney Coastal Councils Group
- Funding provided by the Commonwealth Department of Climate Change and Energy Efficiency (DCCEE) through a Climate Adaptation Pathways (CAP) grant.
- The project was overseen by a National Reference Group comprising expertise from local government, state government, universities with coastal management expertise and industry specialists

Key elements of the project:

- Literature review of existing seawall types, remote sensing techniques, options for upgrading, certification requirements – WRL UNSW
- Geotechnical assessment of structure types and common failure modes - WorleyParsons.
- Economic aspects of the decision making process - Bond University under the direction of the Centre for Coastal Management (CCM) at Griffith University (GU).
- Field assessment utilised Ground Penetrating radar and air jetting to gain information on the structure of a buried seawall without disturbing the overlying dune and vegetation - UNSW.
- Three case studies: an open coast and an estuary seawall (WRL UNSW) and the current Gold Coast seawall (CCM GU).
INTRODUCTION
- This paper deals with **geotechnical issues**
- Key indicators for in/appropriate structures
- Describes the function of a seawall/revetment
- Identifies primary failure modes and risks
- Identifies geotechnical issues of stability and how these may change with climate change
- A pro forma checklist for key data that may be collected and added to an asset management system over time

FUNCTIONS OF SEAWALLS/REVETMENTS
- A seawall:
  - Is a near vertical structure that retains the ground landward of the structure
- A revetment:
  - Protects a stable slope from wave or current erosion or from wave inundation

FUNCTIONS OF SEAWALLS/REVETMENTS
- Seawalls/revetments are located in a harsh environment:
  - Breaking waves
  - Relentless rise and fall of the tide
  - Corrosive nature of seawater and salt spray
- Loadings are difficult to define:
  - Random in nature
  - Often exceeded over the design life
- Seawalls must be designed with maintenance in mind and with particular consideration given to the robustness of their fabric

TYPES OF SEAWALLS/REVETMENTS
- Massive or lightweight
- Rigid or flexible
- Vertical or sloping
- May comprise a wide range of materials including concrete, steel, timber, plastic, rock, stone-filled wire baskets and sand-filled geotextile bags
Types of Seawalls - Anchored Bulkhead

Earth pressure and hydrostatic loading scheme for an anchored bulkhead

Types of Seawalls - Anchored Bulkhead

Types of Seawalls – Free Standing Bulkhead

Types of Seawalls – Gravity Structure

Earth Pressure Vector
Reactive Force Vector
Water Pressure Vector
Base Friction Vector
TYPES OF SEAWALLS
Concrete Gravity Seawall – Bondi & Bronte

TYPES OF SEAWALLS
Blockwork Gravity Seawall

TYPES OF SEAWALLS
Sandbag Gravity Seawall (Geofabrics Australasia)

TYPES OF SEAWALLS
Rock Boulder (left) and Gabion (right) Gravity Seawall
TYPES OF REVETMENTS

Rock Revetment

Sandbag Revetment

Geofabrics Australasia

Rigid Sloping Revetment

Semi-Rigid Sloping Pattern Placed Unit Revetment
TYPES OF REVETMENTS
Flexible Reno Mattress Revetment

Geotechnical Failure Modes
Anchored Bulkheads - Rotational Slip Failure

Environmental Friendly Revetments

Geotechnical Failure Modes
Anchored Bulkheads – Anchor Pull-out Failure
Geotechnical Failure Modes
Rigid Gravity Seawalls – Rotational Slip Failure
Rotation slip failure of counterfort gravity seawall resulting from toe erosion

Geotechnical Failure Modes
Rigid Gravity Seawalls – Backfill Wash-out Failure
Loss of backfill of mass gravity seawall at South Bondi Beach 13th June 1974 as a result of toe scour and undermining of the footing

Geotechnical Failure Modes
Rigid Gravity Seawalls – Toe Bearing Failure

Geotechnical Failure Modes
Rigid Gravity Seawalls – Sliding and Overturning Failures
Overwash scour
Geotechnical Failure Modes
Blockwork Gravity Seawalls – Wave Overtopping Failure

Geotechnical Failure Modes
Flexible Sandbag Revetment – Wave Overtopping and Bag Pull-out Failures (low Gtx/Gtx friction)

Geotechnical Failure Modes
Rigid Sloping Revetment – Push-out and Subsidence Failure
Geotechnical Failure Modes
Rigid Sloping Revetment – Toe Erosion Failure

Geotechnical Failure Modes
Flexible Sloping Revetment – Overtopping Failure

Geotechnical Failure Modes
Flexible Sloping Revetment – Toe Erosion Failure

Geotechnical Failure Modes
Flexible Sloping Revetment – Subsidence Failure
CLIMATE CHANGE IMPACTS

Climate Change Variables
- Key climate change variables are mean sea level and wave climate (Guidelines for Responding to the Effects of Climate Change in Coastal and Ocean Engineering, NCCOE, 2011).
- Changes to mean sea level can result in changes to bed levels, water depths, the incident wave climate and ground water levels.
- 1 m by 2100 would be significant in most locations.
- A sea level rise is likely to:
  - increase nearshore wave heights (increasing nearshore water depths)
  - decrease freeboard on the crest levels thereby increasing the risk of wave overtopping
- Ground water levels also would rise commensurate with the sea level rise.
- Changes to the offshore wave climate can affect beach alignments, nearshore wave conditions and, hence, scour levels and wave impact forces.

Effects of Climate Change
- The width of the beach berm fronting a promenade seawall would reduce.
- Increase in the frequency of wave impact onto seawall structures.
- Increasing incident wave heights as water depths increase.
- Increasing toe scour.
- Relative reduction in crest levels.
- Rise in ground water levels.

Potential Remedial Works
- Constructing “falling toe” scour blankets for mass gravity seawalls.
- Extending toe protection for flexible revetments by increasing the extent and mass of the toe armour.
- Increasing armour size on flexible sloping revetments by placing an additional layer of larger units, building upon what is there already.
- Increasing revetment crest levels by placing armour on top or by constructing a wave deflector wall.
<table>
<thead>
<tr>
<th>POTENTIAL FAILURE MODE (BASED ON OBSERVATION ABOVE)</th>
<th>When “Yes” to any of the questions as numbered</th>
</tr>
</thead>
<tbody>
<tr>
<td>o Overall / global stability</td>
<td>1, 7, 11, 12</td>
</tr>
<tr>
<td>o Bearing failure</td>
<td>1, 3, 6 or 7, 8</td>
</tr>
<tr>
<td>o Overturining</td>
<td>2, 6, 9</td>
</tr>
<tr>
<td>o Anchor or tie rod pull out</td>
<td>2, 6, 9, 16</td>
</tr>
<tr>
<td>o Sliding at the base / dislodgement of blocks</td>
<td>3, 4, 5, 9</td>
</tr>
<tr>
<td>o Internal erosion</td>
<td>3, 4, 9, 11, 14, 15</td>
</tr>
<tr>
<td>o Toe Erosion / frost</td>
<td>2, 3</td>
</tr>
<tr>
<td>o Overwashing / overwash scour</td>
<td>9, 10, 11, 13, 14, 15</td>
</tr>
</tbody>
</table>

Other comment (i.e., structural condition of the wall, corrosion, spalling, vandalism, etc.)

Is further assessment by a geotechnical consultant required? (Y/N)
Is any remedial action / work needed to be undertaken immediately? (Y/N)

If yes, what is the remedial action required?