Earth Retaining Walls

CIVL455

CHAPTER I: INTRODUCTION
Classification of retaining walls

- Earth retaining structures are designed to overcome significant variation in ground levels to provide either a sloping or flat ground on the retained side.
- Earth retaining structures can help provision of workable space for other civil engineering structures to be built.
Classification of retaining walls

- They are also designed to stabilize unstable natural slopes or to provide more space for a road construction by increasing the gradient of a natural slope to a near vertical or vertical angle. They can be constructed to support fills.

- There are many types of earth retaining structures providing various levels of rigidity or stability with varying structural functions. Most common applications of earth retaining structures can be classified according to:
  - Load transfer mechanism,
  - Construction method,
  - System rigidity.
Classification of retaining walls

EARTH RETAINING STRUCTURES

Externally Stabilized
- In situ walls
  - Structural (Cut Walls)
    - Sheet-pile
    - Soldier pile-lagging
    - Cast-in-situ
      - Slurry walls
    - Bored pile
      - Contiguous
      - Tangent pile
      - Secant pile
      - Non contiguous
  - Chemical (Cut Walls)
    - Jet grout
    - Deep Soil Mix
- Gravity walls
  - Cast-in-place Concrete (Fill Walls)
    - Cantilever
    - Counterfort
    - Buttress
  - Modular Gravity (Fill Walls)
    - Masonry
    - Crib
    - Bin
    - Gabion
    - Concrete Module

Internally Stabilized
- Mechanically Stabilized (Fill Walls)
  - Metallic and polymeric reinforcing strips, grids and sheets
  - Anchored Earth
  - Reinforced Soil Slopes
- In situ Reinforced (Cut Walls)
  - Soil Nailing
  - Reticulated Micro Pile

Braced
- Cross-lot
- Rakers

Anchored
- Augered
- Belled
- Pressure injected

Reference: FHWA NHI-06-089
Soils and Foundations – Volume II

Will be studied as part of this course.
Classification of retaining walls

- Examples of Gravity Retaining Walls,

Cast-in place retaining walls (Reinforced Concrete Cantilever)

1. Inclined formation
2. Shear key

Cast-in place retaining walls (Counterfort Reinforced Concrete)

Cast-in place retaining walls (Mass concrete)

Reference; BS8002:1994
Cantilever retaining walls,

- This type of wall is constructed using in situ concrete or masonry and usually with steel reinforcement.
- It can utilize the weight of the retained soil mass as a stabilizing force with the help of its L shaped section and can also utilize a short embedded section called ‘Key’ to carry sliding forces more effectively with smaller dimensions compared to other types of gravity retaining walls.
- Cantilever walls can provide a sustainable soil retaining solution, however with an increased need for skilled labour.

![Diagram of a cantilever retaining wall with labels for Stem, Virtual back of wall, Pa, Heel, and Key.]
Classification of retaining walls

• Examples of Gravity Retaining Walls,

**Modular Gravity Wall (Gabion Wall)**

Reference; BS8002:1994

Reference; BS8002:1994
Classification of retaining walls

• Examples of Gravity Retaining Walls,

  Contin’ed - Modular Gravity Wall (Gabion Wall)

Hexagonal woven mesh
Gabion Cage

Reference; BS8002:1994
Gabion walls,

A Gabion Wall is formed of rectangular wire mesh baskets filled with stone or rock on site. It is a prime example for flexible, permeable, monolithic structures.

Gabions are flexible building blocks from which a broad range of structures can be built. They are also used for erosion control, bank stabilization, channel linings, and weirs.

The main advantages of gabions are their strength and flexibility. Their wire construction can tolerate differential settlement without fracture. Hydrostatic pressure does not build up behind the gabion units because of their permeable nature.
Classification of retaining walls

- Examples of Embedded Retaining Walls,

  Various configurations of embedded walls

![Diagram showing different types of embedded retaining walls: (a) Cantilever wall, (b) Anchored wall, (c) Propped wall.]

Reference; BS8002:1994
Classification of retaining walls

- Examples of Embedded Retaining Walls,

**Sheet pile walls**

- Sheet piles are often used for temporary works in excavations or where ground conditions are poor (such as soft clays).
- They are installed in parts connected to each other with various locking methods, hence they have the advantage of forming difficult shapes in plan.
- They are also considered as impermeable barriers especially for waterfront structures or when forming cofferdams.

Reference; BS8002:1994
• Examples of Embedded Retaining Walls,

Sheet pile walls

- High bending moments can be catered by sheet piles, and excavations can be carried out with less props due to high shear modulus and stiffness of the sheet pile sections.
- When used in temporary works, sheet piles can be extracted and reused.

Classification of retaining walls

- **Examples of Embedded Retaining Walls,**

**Sheet pile walls**

<table>
<thead>
<tr>
<th>Dominant SPT N Value</th>
<th>Minimum wall modulus Grade S275P mild steel to BS EN 10025:1990</th>
<th>Grade S355P high yield steel to BS EN 10025:1990</th>
<th>Recommended maximum driving length m</th>
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<tbody>
<tr>
<td>0 to 10</td>
<td>450</td>
<td>450</td>
<td>7</td>
</tr>
<tr>
<td>11 to 20</td>
<td>850</td>
<td>850</td>
<td>9</td>
</tr>
<tr>
<td>21 to 25</td>
<td>1300</td>
<td>1300</td>
<td>11</td>
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<tr>
<td>26 to 30</td>
<td>2300</td>
<td>2300</td>
<td>14</td>
</tr>
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<td>31 to 35</td>
<td></td>
<td></td>
<td>16</td>
</tr>
<tr>
<td>36 to 40</td>
<td></td>
<td></td>
<td>18</td>
</tr>
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<td>41 to 45</td>
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<td></td>
<td>20</td>
</tr>
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<td>46 to 50</td>
<td></td>
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</tr>
<tr>
<td>51 to 60</td>
<td>3000</td>
<td>3000</td>
<td>24</td>
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<td>61 to 70</td>
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<td></td>
<td>26</td>
</tr>
<tr>
<td>71 to 80</td>
<td>4200</td>
<td>4200</td>
<td>30</td>
</tr>
<tr>
<td>81 to 140</td>
<td></td>
<td></td>
<td>30+</td>
</tr>
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</table>

**NOTE 1** N is the standard penetration test (SPT) blow count. Dominant means the high average for the soils. Where piles are to be driven only to a toe hold in rock, the SPT value should be divided by a factor of 4 for that stratum only.

**NOTE 2** For SPT values exceeding 50, pile damage, declutching and/or refusal may occur. Additional consideration should be given to the presence of cobbles or boulders, which may give rise to obstructed driving, damage and/or declutching.

<table>
<thead>
<tr>
<th>Clay description</th>
<th>Minimum wall modulus Grade S275P mild steel to BS EN 10025:1990</th>
<th>Grade S355P high yield steel to BS EN 10025:1990</th>
<th>Maximum length m</th>
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<tbody>
<tr>
<td>Soft to firm</td>
<td>450</td>
<td>400</td>
<td>6</td>
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<tr>
<td>Firm</td>
<td>600 to 700</td>
<td>450 to 600</td>
<td>9</td>
</tr>
<tr>
<td>Firm to stiff</td>
<td>700 to 1600</td>
<td>600 to 1300</td>
<td>14</td>
</tr>
<tr>
<td>Stiff</td>
<td>2000 to 2600</td>
<td>1300 to 2000</td>
<td>16</td>
</tr>
<tr>
<td>Very stiff</td>
<td>2600 to 3000</td>
<td>2000 to 2500</td>
<td>18</td>
</tr>
<tr>
<td>Hard ($c_u &gt; 200$ kN/mm²)</td>
<td>Not recommended</td>
<td>4200 to 5000</td>
<td>20</td>
</tr>
</tbody>
</table>

**NOTE**. The ability of piles to penetrate any type of ground depends upon attention being given to good pile driving practice.

Classification of retaining walls

• Examples of Embedded Retaining Walls,

**Bored pile walls**

• Bored pile walls can be constructed in almost any ground conditions.
• Due to relatively low noise during construction compared to sheet piles, they can be favoured in cases where construction near an existing structure is considered.
• Bored piles can both be used as a retaining feature as well as deep foundations, transferring superstructure loads to deeper strata.
• Bored pile walls can be installed with various configurations. Where there is high groundwater, ‘Contiguous’ type pile walls may allow for seepage through the retained mass or if ‘Secant’ type pile walls are used they can be designed to provide almost an impermeable barrier.
• They are mostly used as permanent walls, and for finishing they act as a back shutter for basement walls.

Reference; BS8002:1994.
Classification of retaining walls

• Examples of Embedded Retaining Walls,

**Bored pile walls**

Classification of retaining walls

• Examples of Embedded Retaining Walls,

**Contiguous pile walls**

Contiguous piles, typical diameters and spacing.

<table>
<thead>
<tr>
<th>Diameter (mm)</th>
<th>Spacing (mm)</th>
<th>Diameter (mm)</th>
<th>Spacing (mm)</th>
<th>Diameter (mm)</th>
<th>Spacing (mm)</th>
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<td>400</td>
<td>900</td>
<td>1000</td>
<td>1800</td>
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<tr>
<td>750</td>
<td>850</td>
<td>1500</td>
<td>1600</td>
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<td></td>
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Reference; Clayton et al, 2013, CIRIA C580.
Classification of retaining walls

• Examples of Embedded Retaining Walls,

**Secant pile walls**

Hard – Soft Secant Pile Wall.

Hard – Firm Secant Pile Wall.

Hard – Hard Secant Pile Wall.

<table>
<thead>
<tr>
<th>Diameter mm</th>
<th>Spacing(mm)</th>
<th>Diameter mm</th>
<th>Spacing(mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male Female</td>
<td>600</td>
<td>Male Female</td>
<td>1100</td>
</tr>
<tr>
<td>450</td>
<td>450</td>
<td>900</td>
<td>600</td>
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<tr>
<td>600</td>
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<td>1200</td>
<td>600</td>
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<td>750</td>
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<table>
<thead>
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<th>Diameter mm</th>
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<tr>
<td>Male Female</td>
<td>750</td>
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<tr>
<td>750</td>
<td>650</td>
</tr>
<tr>
<td>880</td>
<td>760</td>
</tr>
<tr>
<td>1180</td>
<td>1025</td>
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</table>

Reference; CIRIA C580.
Wall Selection

• Wall selection depends on a number of factors;
  • Prior to selection of a wall type, preliminary designs should be carried out for a number of suitable wall options to enable comparison and a decision to be made for the most appropriate solution.

Reference; Clayton et al, 2013.
Wall Selection

• For a decision to be made, the following factors are considered;
  • Ground and groundwater conditions, environmental issues, ground contamination.
  • External loads, required retained height.
  • Cost, temporary works, method of construction.
  • Project specific requirements: wall displacement criteria, impact assessment for surrounding structures, appearance.
  • Time/speed of construction, space available for construction equipment and materials, other site restrictions.
  • Durability of wall materials, availability.

Reference; Clayton et al, 2013, CIRIA C580.