CE 406: Part B
Retaining Walls
Lecture No. (11): Introduction

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Function of Retaining structures

- Earth retaining structures are used to hold back earth and maintain a difference in the elevation of the ground surface.

- The retaining structures is designed to withstand the forces exerted by the retained ground or “backfill” and other externally applied loads, and to transmit these forces safely to a foundation.
Function of Retaining structures

- In general, the **cost** of constructing a retaining structure is usually high compared with the cost of forming a new slope. Therefore, the need for a retaining structure should be assessed carefully during preliminary design and an effort should be made to keep the retained height as low as possible.
CLASSIFICATION OF EARTH RETAINING STRUCTURES

• Load support mechanism,
  • i.e., externally or internally stabilized walls.

• Construction method,
  • i.e., fill or cut walls.

• System rigidity,
  • i.e., rigid or flexible 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

Hybrid Walls
- Tailed Segmental
- Low density Fills

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

* can also be used in fill conditions
Retaining Walls - Applications
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basement wall
Typical applications for earth retaining structures

- New or widened highways in developed areas;
- New or widened highways at mountain or steep slopes;
- Grade separation;
- Bridge abutments, wing walls and approach embankments;
- Culvert walls;
- Tunnel portals and approaches;
- Flood walls, bulkheads and waterfront structures;
- Stabilization of new or existing slopes and protection against rock falls
Types of Retaining Walls

- Gravity Walls:
  Walls rely on the mass of the wall for stability,
  Unreinforced Concrete and masonry (bricks and stone).
- Cantilever walls.
- Counterforted walls.
- Buttressed walls.
- Gabions (wire baskets filled with stone).
- Crib walls (hollow crib formwork filled with soil).
- Reinforced earth wall
Types of Retaining Walls

- **Gravity Retaining Wall**
- **Crib gravity wall** (concrete, timber)
- **Reinforced earth wall**
- **Gabion gravity wall**
Types of Retaining Walls

Reinforced earth walls are increasingly becoming popular.

geosynthetics
Types of Retaining Walls

Crib walls:

Good drainage & allow plant growth.

Looks good.

Filled with soil

Interlocking stretchers and headers

CE 402: Foundation Design
Slope Retention works
Wall Selection Considerations

- (1) Ground type,
- (2) Groundwater,
- (3) Construction considerations,
- (4) Speed of construction,
- (5) Right of way,
- (6) Aesthetics,
- (7) Environmental concerns,
- (8) Durability and maintenance,
- (9) Tradition and
- (10) Local contracting practices.
Lateral Earth Pressures

Three different types of lateral earth pressure are usually considered:

(1) At-rest earth pressure;
(2) Active earth pressure; and
(3) Passive earth pressure.

These conditions are relative to lateral deformation of the walls.
Lateral Earth Pressures

![Graph showing lateral earth pressures with different soil conditions and wall rotations to reach failure.](image)

<table>
<thead>
<tr>
<th>Soil type and condition</th>
<th>Rotation, Y/H</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active</td>
<td>Passive</td>
</tr>
<tr>
<td>Dense cohesionless</td>
<td>0.001</td>
</tr>
<tr>
<td>Loose cohesionless</td>
<td>0.004</td>
</tr>
<tr>
<td>Stiff cohesive</td>
<td>0.010</td>
</tr>
<tr>
<td>Soft cohesive</td>
<td>0.020</td>
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</tbody>
</table>
Coulomb coefficients $K_a$ and $K_p$

**ACTIVE CASE**

$$K_a = \frac{\cos^2(\phi - \delta)}{\cos^2 \theta \cos(\theta + \delta) \left[ 1 + \frac{\sin(\phi + \delta) \sin(\phi - \beta)}{\cos(\theta + \delta) \cos(\theta - \beta)} \right]}$$

**PASSIVE CASE**

$$K_p = \frac{\cos^2(\theta + \delta)}{\cos^2 \theta \cos(\theta - \delta) \left[ 1 - \frac{\sin(\phi + \delta) \sin(\phi + \beta)}{\cos(\theta - \delta) \cos(\theta + \beta)} \right]}$$
Clayey Soils As Backfill For Fill Wall Applications

- Clayey backfills generally have lower drained shear strength than cohesionless soils.
- Clayey backfills have poor drainage and the potential for the development of water pressures behind the wall.
- Clayey backfills have the potential to undergo creep deformations that can lead to higher earth pressures.
Terminology for Retaining Wall

- **Front face**
- **Front batter**
- **Back batter**
- **Wall**
- **Backface**
- **Base**
- **(Toe)**
- **(Heel)**
- **Surcharge loads**
- **Failure surface**
- **Restraining element (e.g., Deadman)**
- **$Q_1$ = Lateral pressure**
- **$p_1$ = Lateral pressure**
- **$Q_2$**
- **$p_2$ = Bearing pressure**
Modes of Failure

- Sliding
- Overturning
- Overstressing
- Deep Seating
- Excessive Settlement
Design Steps

1. Select the suitable type of wall
2. Determine the dimensions of the wall (empirical)
3. Estimate Earth Pressures.
4. Estimate uplift forces
5. Estimate gravity forces (weights)
6. Determine external forces
7. Check factor of safety against sliding
8. Check factor of safety against overturning
9. Check soil over stress
10. Check deep seated Failure (slope failure)