CE 4780 Hurricane Engineering II

Section on
Flooding Protection:
Earth Retaining Structures and Slope Stability

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Flooding Protection and Slope Stability Problems

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Need for Earth Retaining Structures

- Each year flooding causes more property damage in the United States than any other natural disaster.
- Annually, flood damages average over $3 billion (Lilli damages expected to raise to $ 600 million - Levitan).
- In 1985 the estimated flood damage was $6 billion and affected over 250,000 structures.

Need for Earth Retaining Structures

- Average flood damage for a home is approximately $20,000 per flood and is much higher for industrial buildings.
- Flooding is not only expensive to the homeowner and the taxpayer, but also causes despair and worry for its victims.
- Effective flood protection and preventive measures can significantly reduce the expense and trauma caused by flooding
- Source: National Flood Proofing Committee (2002).

Need for Earth Retaining Structures

The Landslide Problem

- Landslides constitute a major geologic hazard because they are widespread, occurring in all 50 states, and cause $1-2 billion in damages and more than 25 fatalities on average each year.
- Landslides pose serious threats to highways and structures that support fisheries, tourism, timber harvesting, mining, and energy production as well as general transportation.

Need for Earth Retaining Structures

The Landslide Problem (cont.)

- Landslides commonly occur with other major natural disasters such as earthquakes and floods that exacerbate relief and reconstruction efforts and expanded development and other land use has increased the incidence of landslide disasters.
- Source: The National Landslide Hazards Program (2002)

Need for Earth Retaining Structures

The Landslide Problem

Slope failure near McClure Pass, Colorado (The National Landslide Hazards Program 2002)

Need for Earth Retaining Structures

The Landslide Problem

The 1983 Thistle landslide at Thistle, Utah
(The National Landslide Hazards Program 2002)

Need for Earth Retaining Structures

The Landslide Problem

The 1983 Thistle landslide at Thistle, Utah:

- This landslide began in response to groundwater buildup from heavy rains the previous September and the melting of deep snowpack for the winter of 1982-83.
- Within a few weeks, the landslide dammed the Spanish Fork River, destroying U.S. Highway 6 and the main line of the Denver and Rio Grande Western Railroad.

Need for Earth Retaining Structures

The Landslide Problem

The 1983 Thistle landslide at Thistle, Utah:

- The town of Thistle was inundated under the floodwaters rising behind the landslide dam. Total costs (direct and indirect) incurred by this landslide exceeded $400 million, the most costly single landslide event in U.S. history.
- Source: The National Landslide Hazards Program (2002)

Flooding Protection

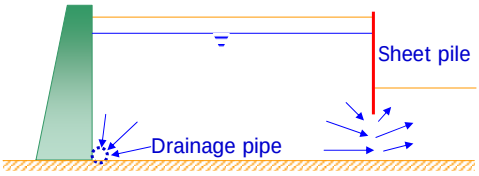
- Incomplete List…
  - Retaining walls
  - Sheet piles
  - Dams and reservoirs
  - Levees
  - Embankments

  - Other: diversion channels, retaining ponds, etc…

Flooding Protection

Retaining walls and sheet piles (Bowles 1988)

- Retaining walls are structures used to retained soils or other granular materials.
- Materials: masonry, concrete, wood, metal sheeting, reinforce earth, etc.
- The analysis and design of retaining walls is governed by the stiffness of the wall: rigid or flexible.

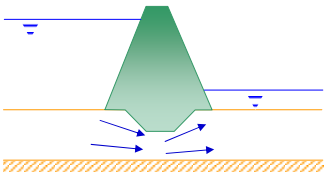


(Cheifetz 2002)

Flooding Protection

Dams and reservoirs (US Society on Dams 2002)

- A dam is built to control water. Dams are made from earth, rocks or concrete.
- Dams are usually constructed on rivers to store water in a reservoir.
- Dams help people have water to drink and provide water for industry, irrigation, fishing and recreation, hydroelectric power production, navigation in rivers, etc. Dams also serve people by reducing or preventing floods.



(from McCarthy 1998)

Flooding Protection

Levees (The Academy of Science of Saint Louis 2002):

- Levees are low ridges or earthen embankments made of silt, sand or clay, built along a stream of water.
- They help in the prevention of flooding of the adjacent land.
- Levees can be either naturally occurring or man-made.
- Man-made levees consist of an impermeable core surrounded by an earthen material, with some type of protection to minimize erosion.

Flooding Protection

Levees (The Academy of Science of Saint Louis 2002):

- Dimensions of a levee are typically 2.5 m across the top, the height 0.30 m above the level of a predicted flood having once in 50-year frequency, the slope on the river side being three up per one across and the slope on land side five feet up per one foot across.
- There are federal standards for dimensions depending on the local material available, anticipated force of the river and the amount of development in the area.

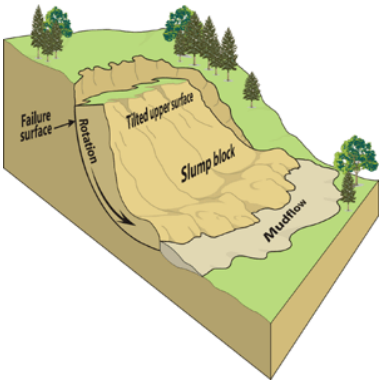
Flooding Protection

Levees (McMillan, J. - The Advocate 2002)

"Deep fissures on the batture - land between the levee and the Mississippi River - reveal the ground is again sinking at the spot where the levee collapsed in 1983."

Slope Stability

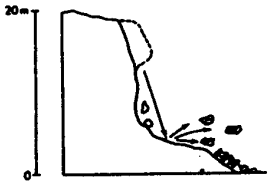
- Landslides Types and Processes

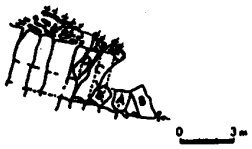


(Canada Natural Resources 2002)

Slope Stability

- Landslides Types
  - Fall: is the detachment of soil or rock from steep slopes along the surface. Little or no shear displacement (e.g. loess).
  - Topple: is the forward rotation of soil or rock mass about a point.

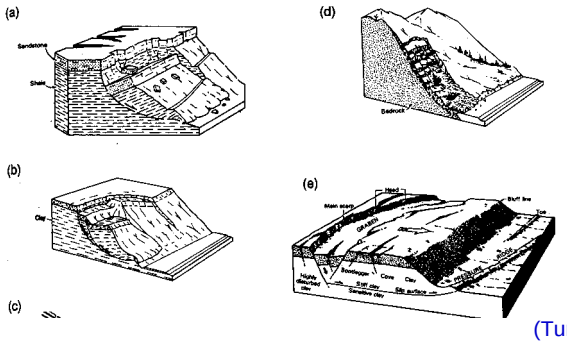




(Turner and Schuster 1996)

Slope Stability

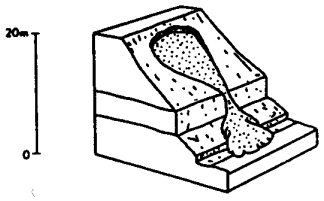
- Landslides Types
  - Slide: is the downslope displacement of soil or rock masses. It includes: rotational, translational, and debris slide



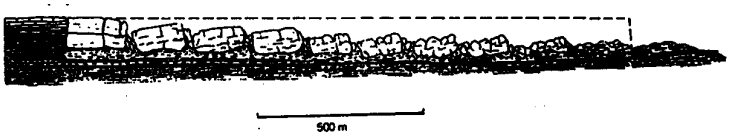
(Turner and Schuster 1996)

Slope Stability

- Landslides Types
  - Flow: continuous movement of soil masses where shear surfaces are short lived.
  - Spread: is the sudden movement of water bearing rock masses



(Turner and Schuster 1996)



Slope Stability

Triggering Mechanisms

- Intense Rain-Fall
- Water-Level Change
- Ground Water Flow
- Rapid Snowmelt
- Volcanic Eruption
- Earthquake Shaking

Slope Stability

- Slope Stability Analysis (Abramson et al. 2002)
  - understand the development and shape of natural slopes
  - determine the short-term and long term stability conditions
  - evaluate the possibility of failure of natural or engineering slides
  - analyze and understand failure mechanisms
  - enable the retrofit of failed slopes
  - understand the effect of seismic loading on slope and embankments

Slope Stability

Slope Stability Failure

(after Duncan)

Slope Stability

Slope Stability Failure

(after Duncan)

Discussion of Factors Influencing Design

- Social Requirements
- Engineering Requirements
- Economical Constrains
- Environmental Actions
  - Water level
  - Rain: intensity and duration
  - Wind action
- Soils – Material Properties
  - Grain size distribution
  - Degree of saturation
  - Void ratio
  - Strength

Next Classes

- Shear Strength of Soils
- Seepage Analysis

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