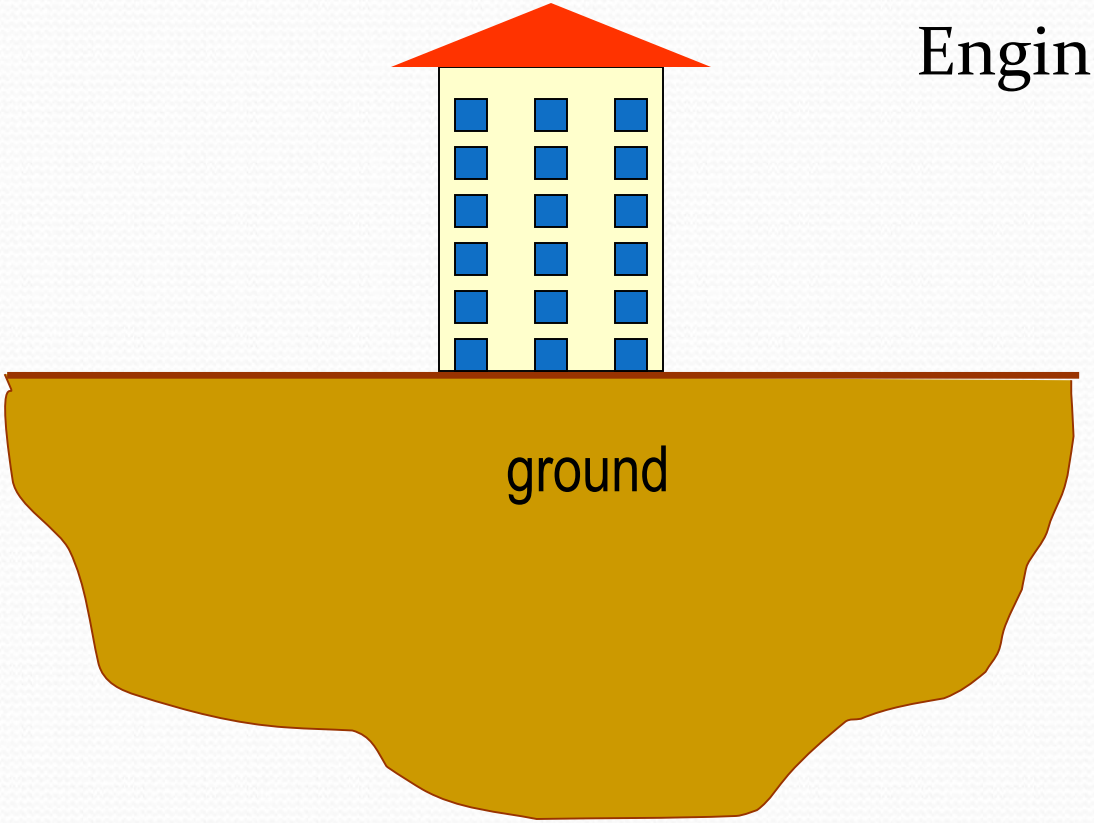
Introduction to Civil Engineering

Geotechnical Engineering

Introduction to Geotechnical Engineering

- All Civil Engineering begins with Geotechnical Engineering



Definitions

- **Soil mechanics** is a discipline that applies the principles of engineering mechanics to soils to predict the mechanical behavior of soil.

- **Geotechnical Engineering** is the branch of civil engineering that deals with soil, rock, and underground water, and their relation to the design construction and operation of engineering projects (Coduto 1998)

Typical Geotechnical Project

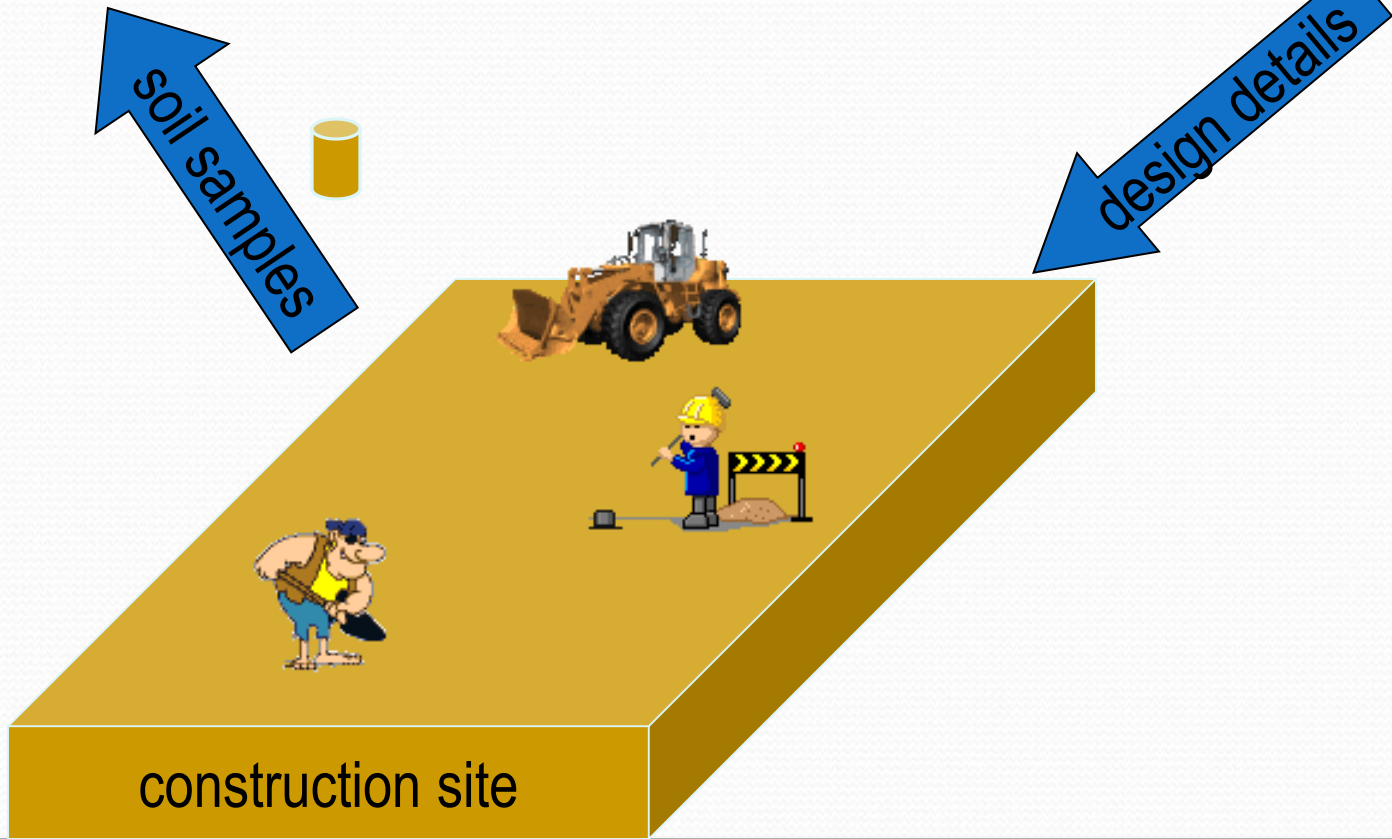
Geo-Laboratory
~ for testing

soil properties

Design Office
~ for design & analysis

soil samples

design details

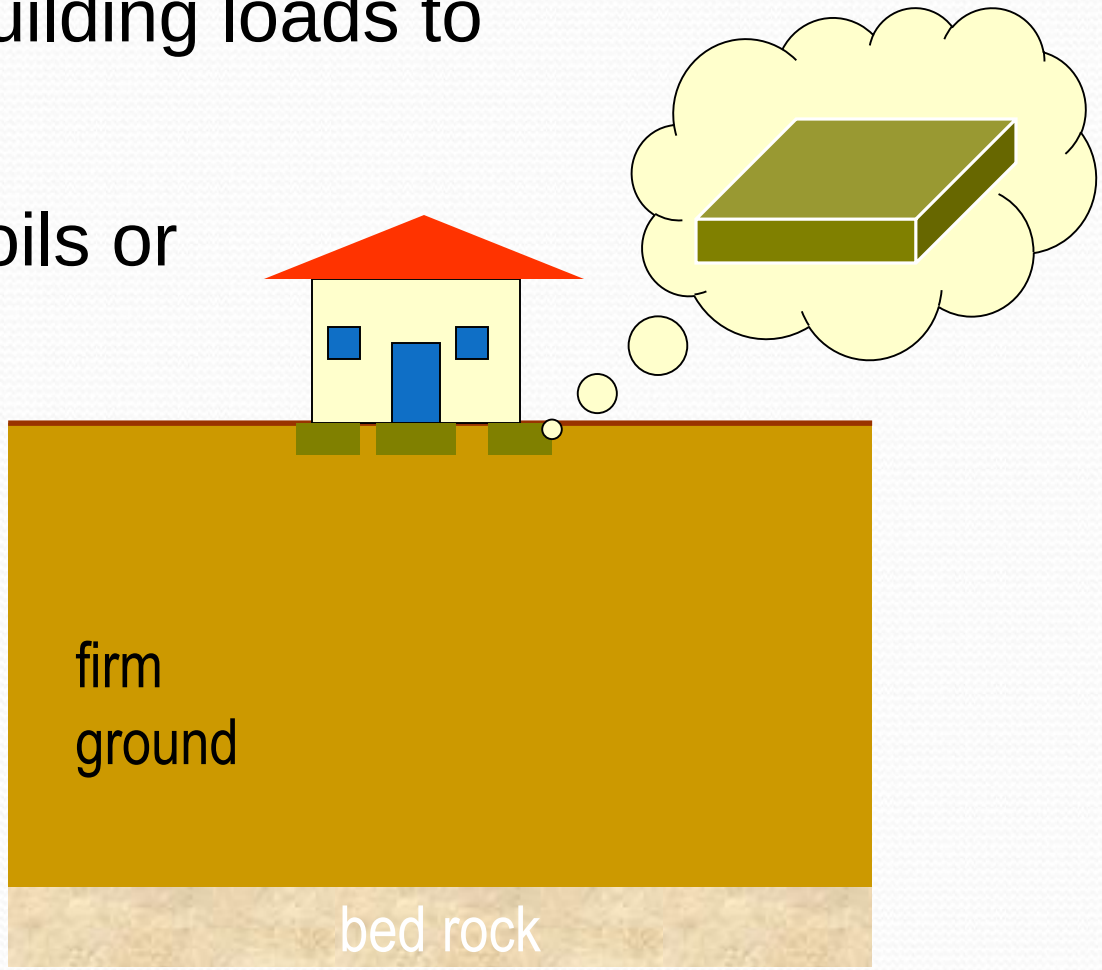


Geotechnical Applications

Shallow Foundations

~ for transferring building loads to underlying ground

~ mostly for firm soils or light loads



Shallow Foundations

Foundation Systems

- Designing of Shallow Foundations Systems – Bearing Capacity Failure

Transcona Grain Elevator

(from Budhu 2000)

Foundation Systems

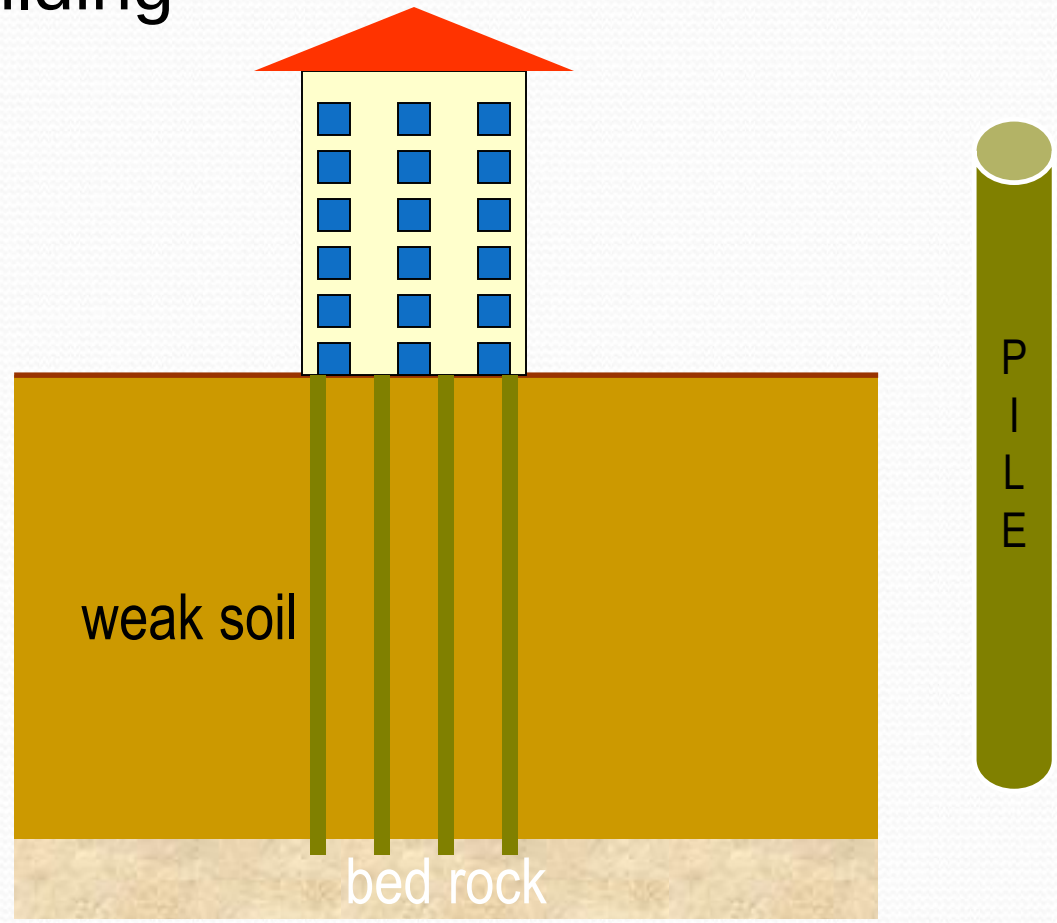
- Designing of Shallow Foundation Systems – Differential Settlement

Leaning Tower of Pisa

Deep Foundations

~ for transferring building loads to underlying ground

~ mostly for weak soils or heavy loads



Foundation Systems

Deep Foundation Systems: Driven Piles

Deep Foundations

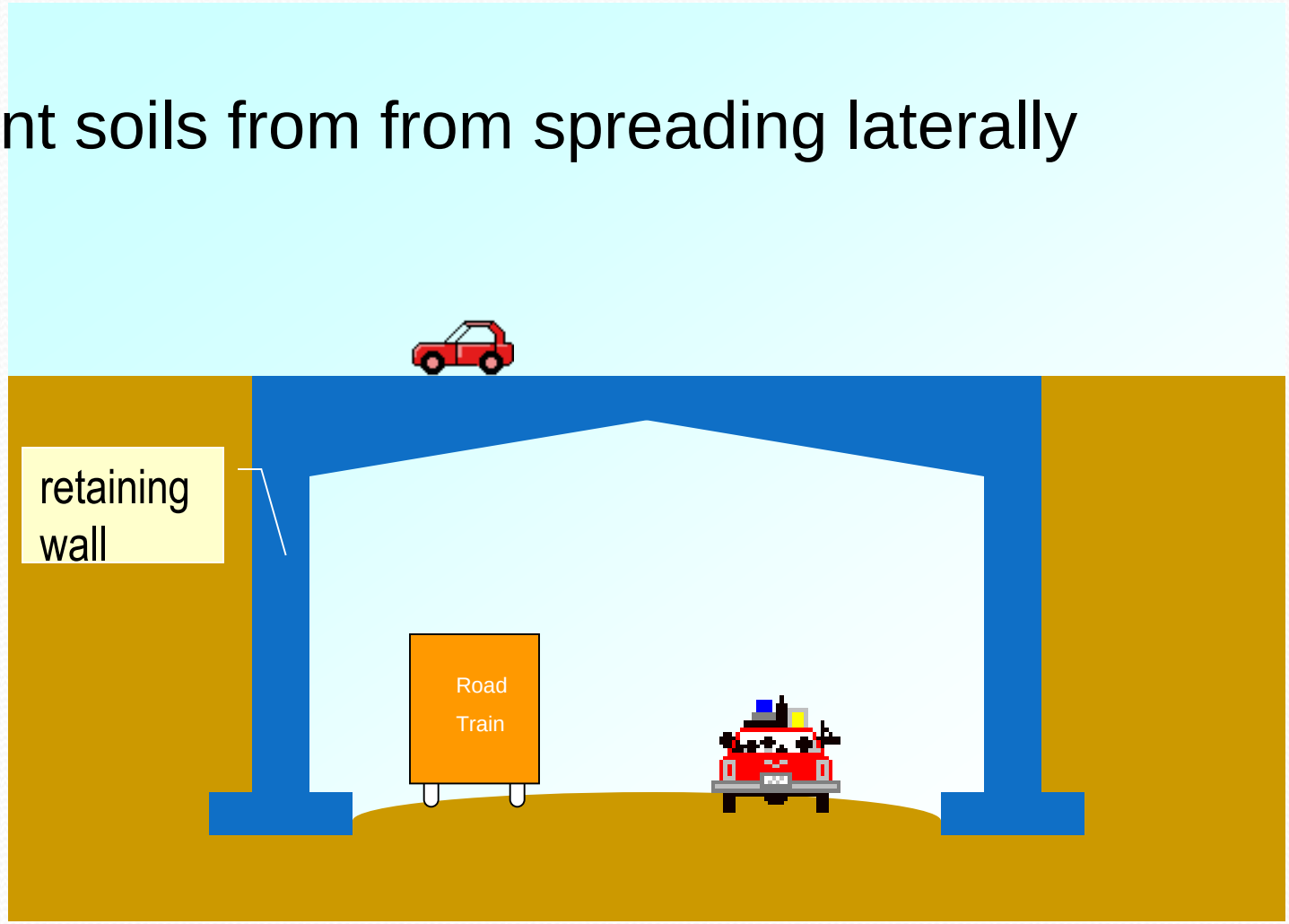
Driven timber piles, Pacific Highway

Foundation Systems

Deep Foundation Systems: Drilled Shafts

Retaining Walls

~ Prevent soils from from spreading laterally



Earth Pressure and Retaining Walls

- Reinforced Earth Walls

(The Reinforced Wall Company 2003)

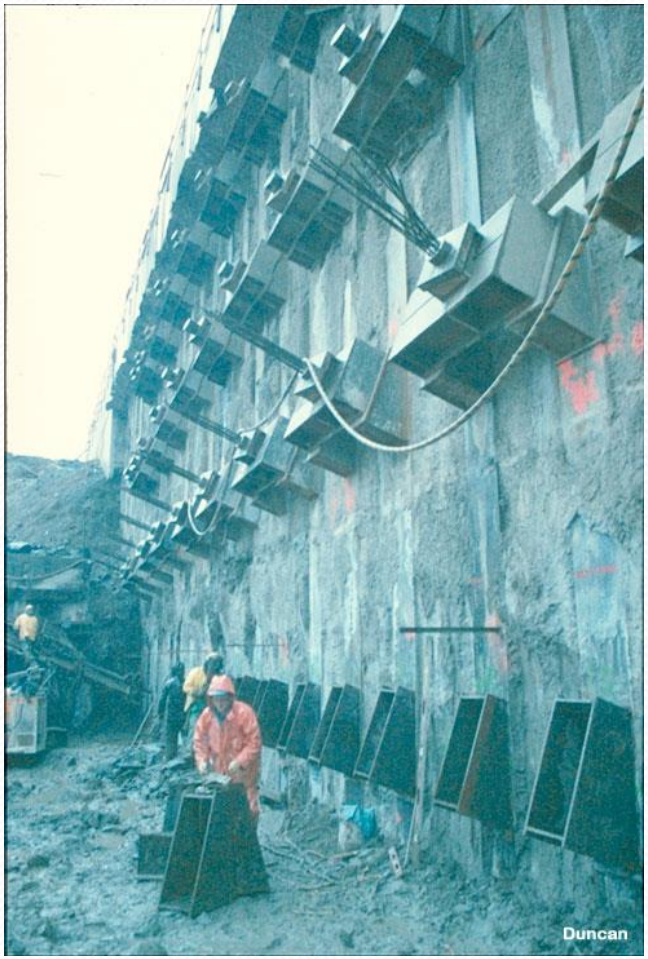
Retaining Structure Systems

- Gabions

(Gaviones LEMAC (2003)

Retaining Structure Systems

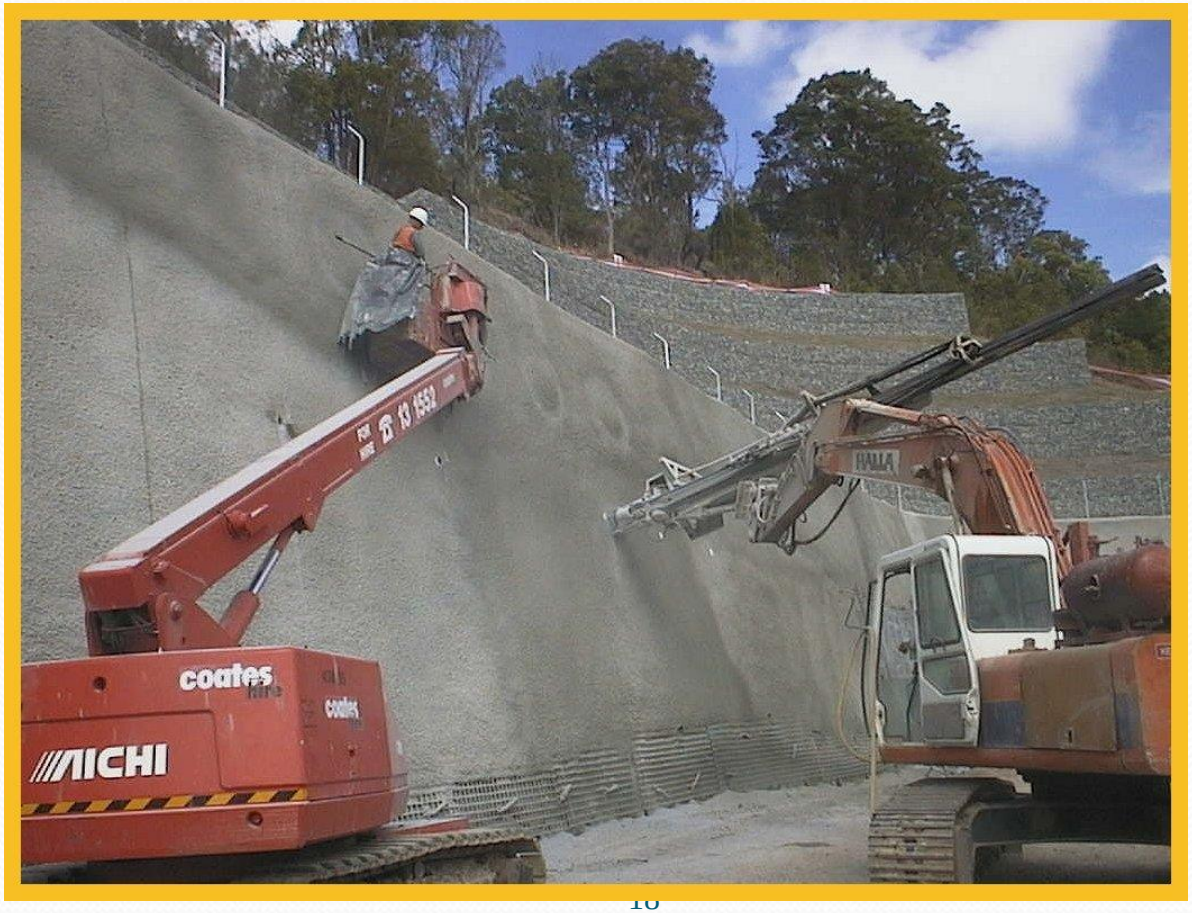
- Tie-backs



(Boulanger and Duncan 2003)

Retaining Structure Systems

Soil Nailing: steel rods placed into holes drilled into the walls and grouted

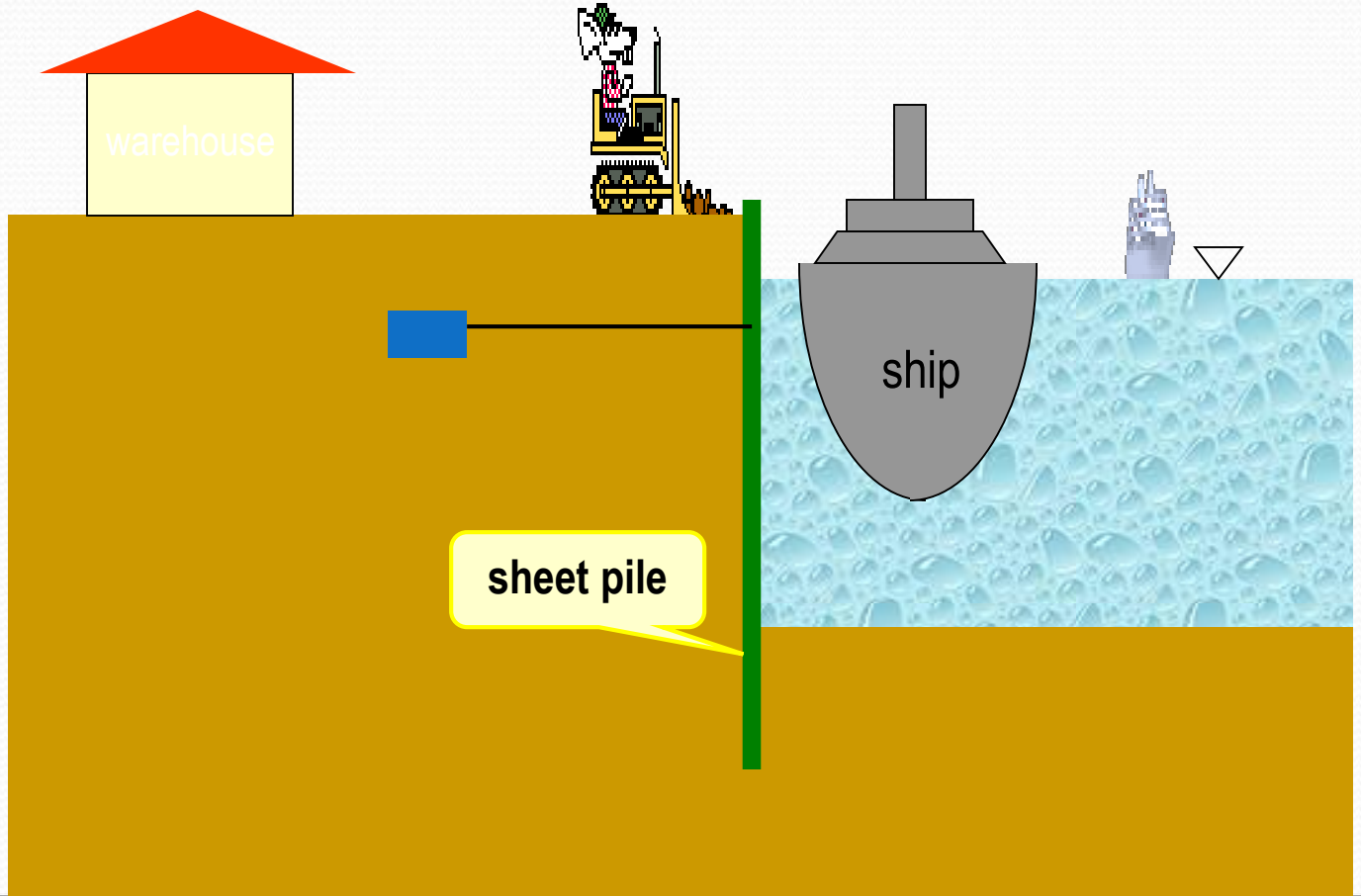


Retaining Structure Systems

- Excavation Support Systems

Sheet Piles

~ sheets of interlocking steel or timber driven into the ground, forming a continuous sheet



Sheet Piles

~ resist lateral earth pressures

~ used in temporary works

~ used in excavations, waterfront structures

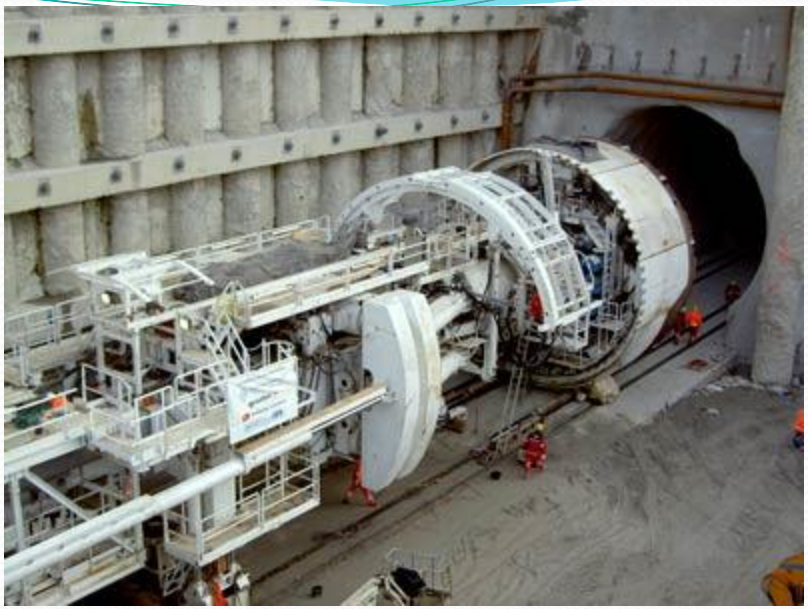
Sheet Pile Walls

(Boulanger and Duncan 2003)

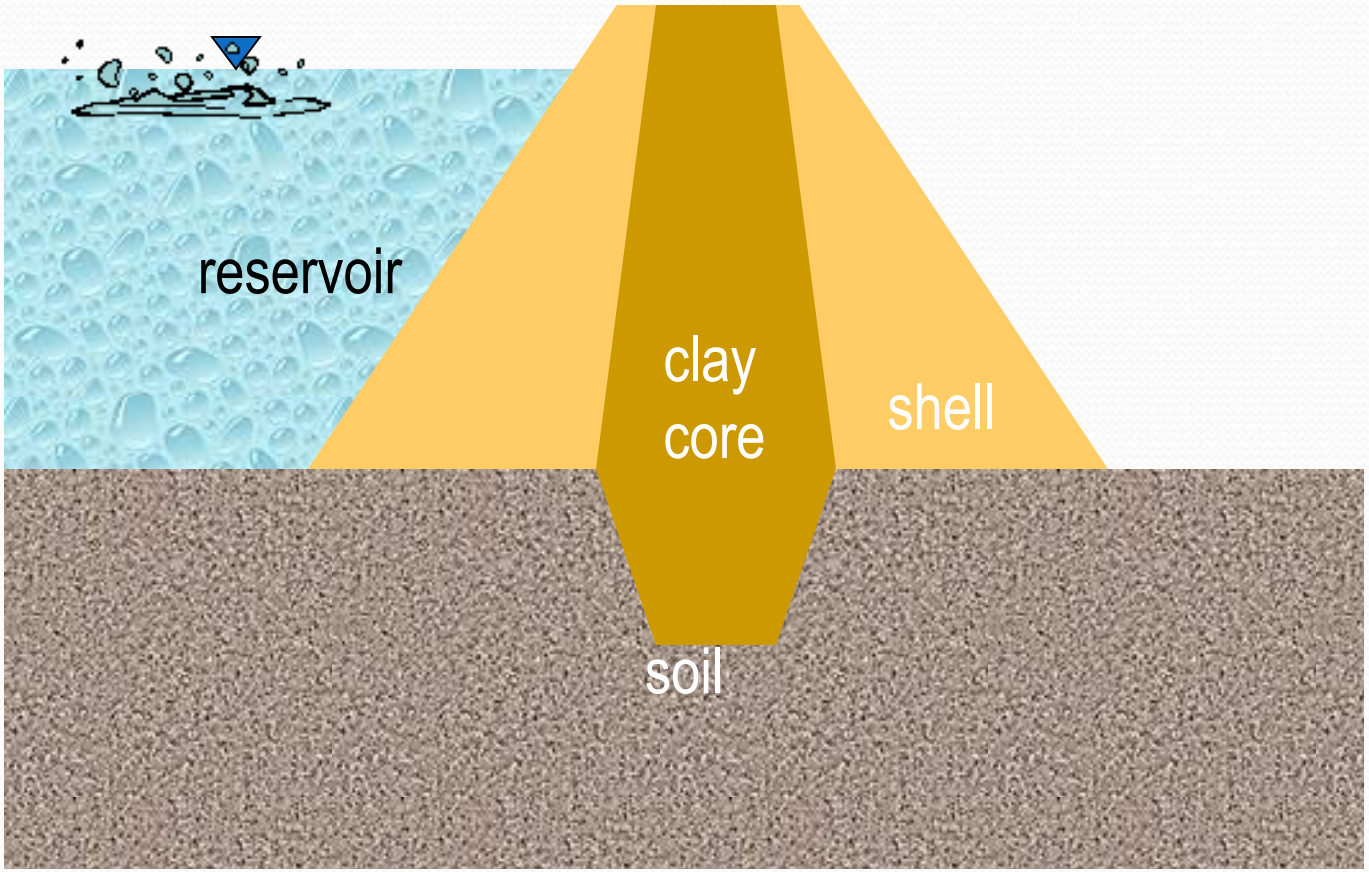
Cofferdam

~ sheet pile walls enclosing an area, to prevent water seeping in

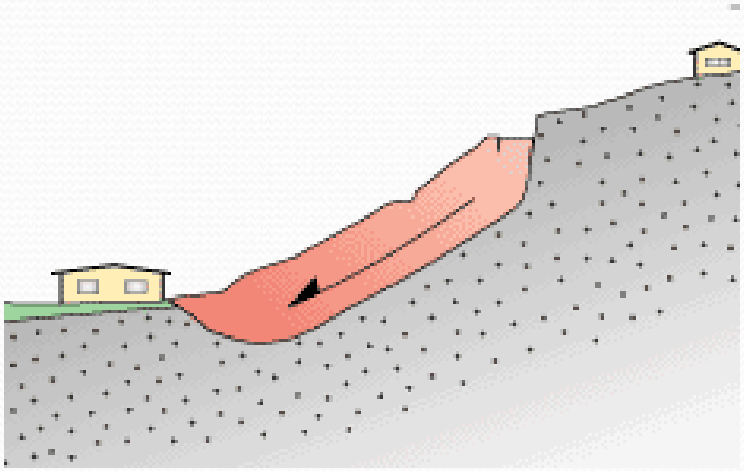
Tunneling



Earth Dams ~ for impounding water



Landslides



Earthworks

~ preparing the ground prior to construction

Roadwork, Pacific Highway

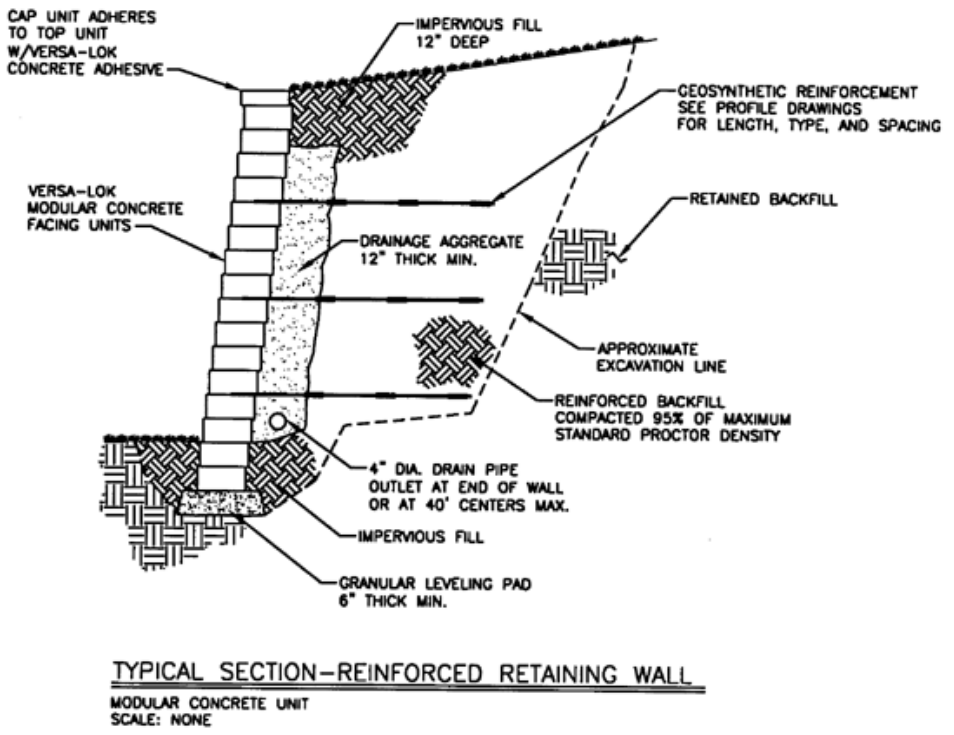
Geofabrics

~ used for reinforcement, separation, filtration and drainage in roads, retaining walls, embankments…

Geofabrics used on Pacific Highway

Geosynthetics

- Geosynthetic stabilized walls

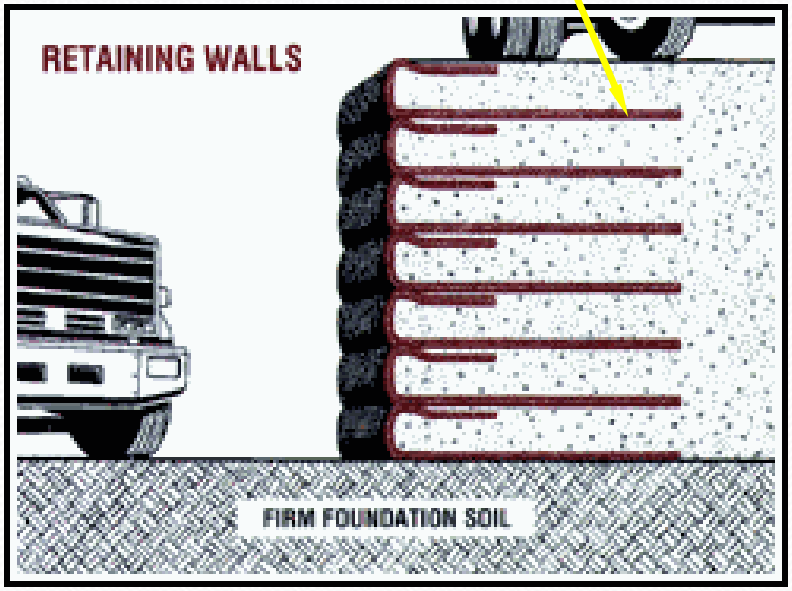


(kshitija.wordpress.com 2007)

(Environmental Science & Engineering 2007)

Mechanically Stabilized Earth Walls

~ using geofabrics to strengthen the soil



Geoenvironmental Engineering

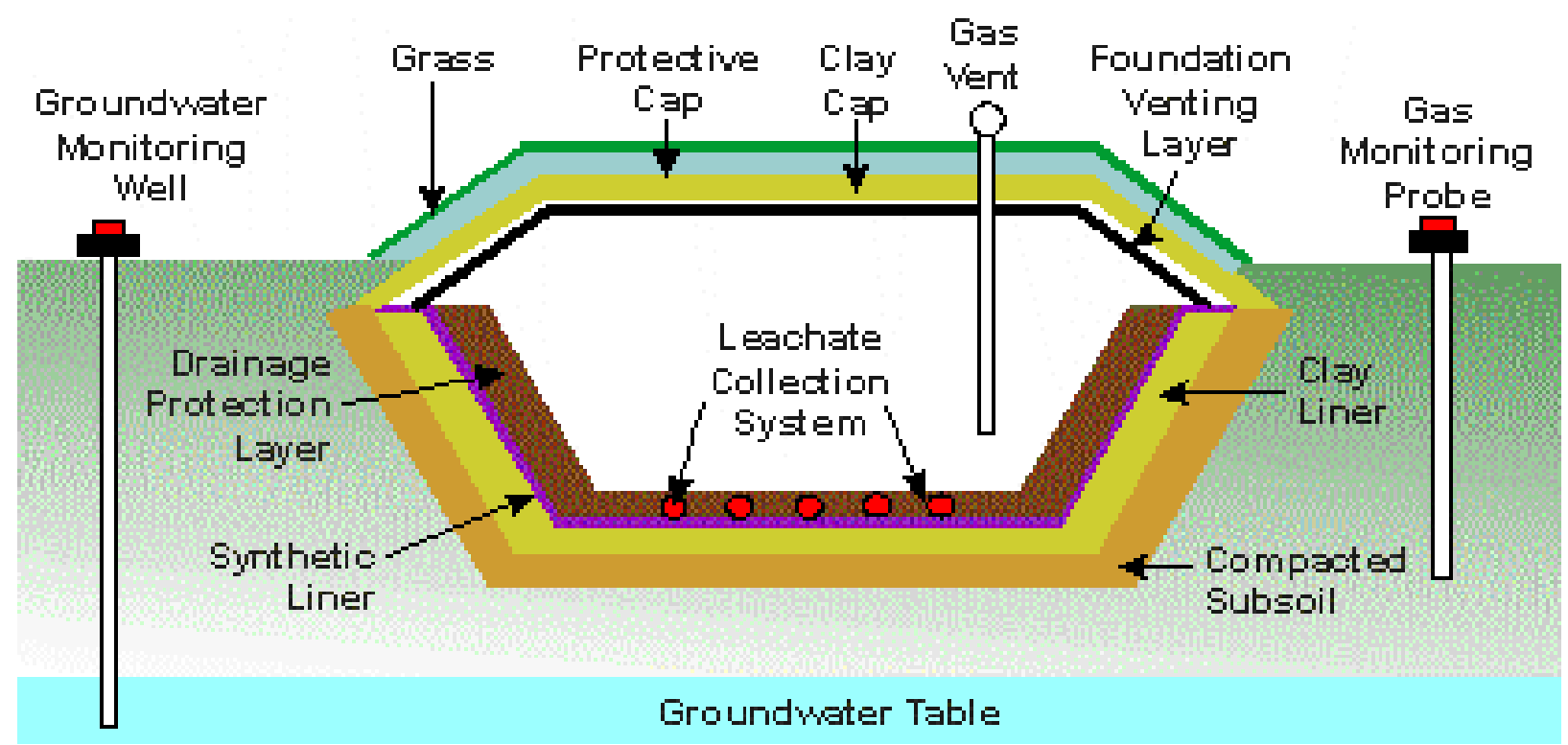
- Characterization and remediation of Geo-environmental hazards

MSW Landfill

(from Willmer 2001)

(from Norwegian Geotechnical Institute 2001)

Geoenvironmental Engineering

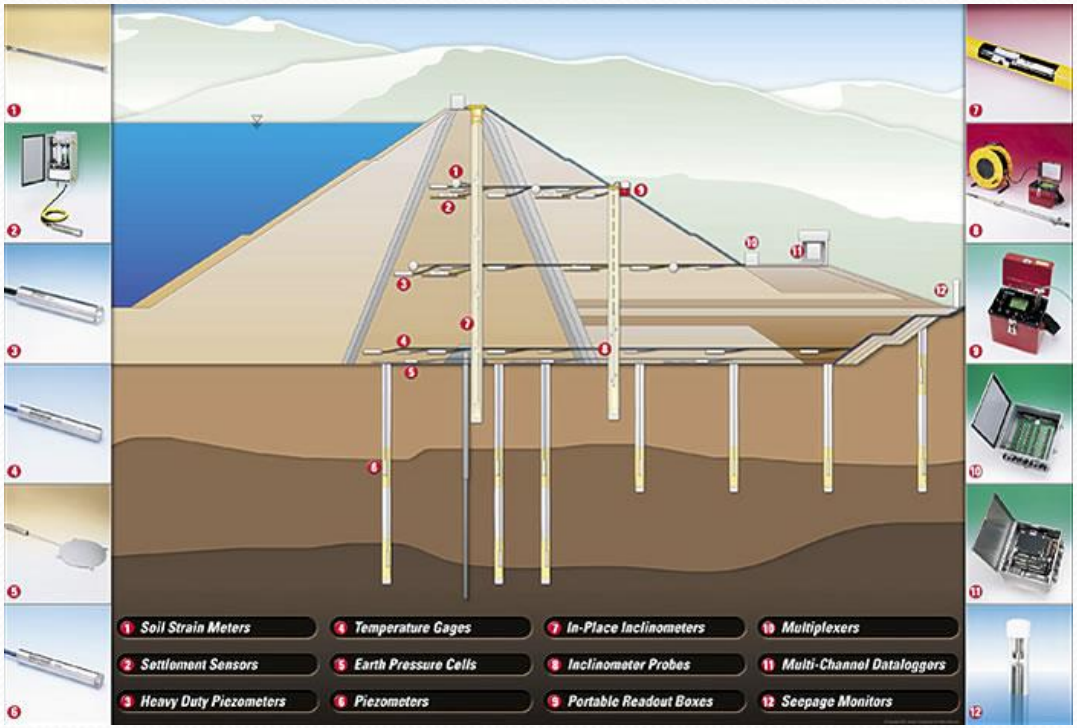


Waste Disposal in Landfills

Instrumentation

~ to monitor the performances of earth and earth supported structures

~ to measure loads, pressures, deformations, strains



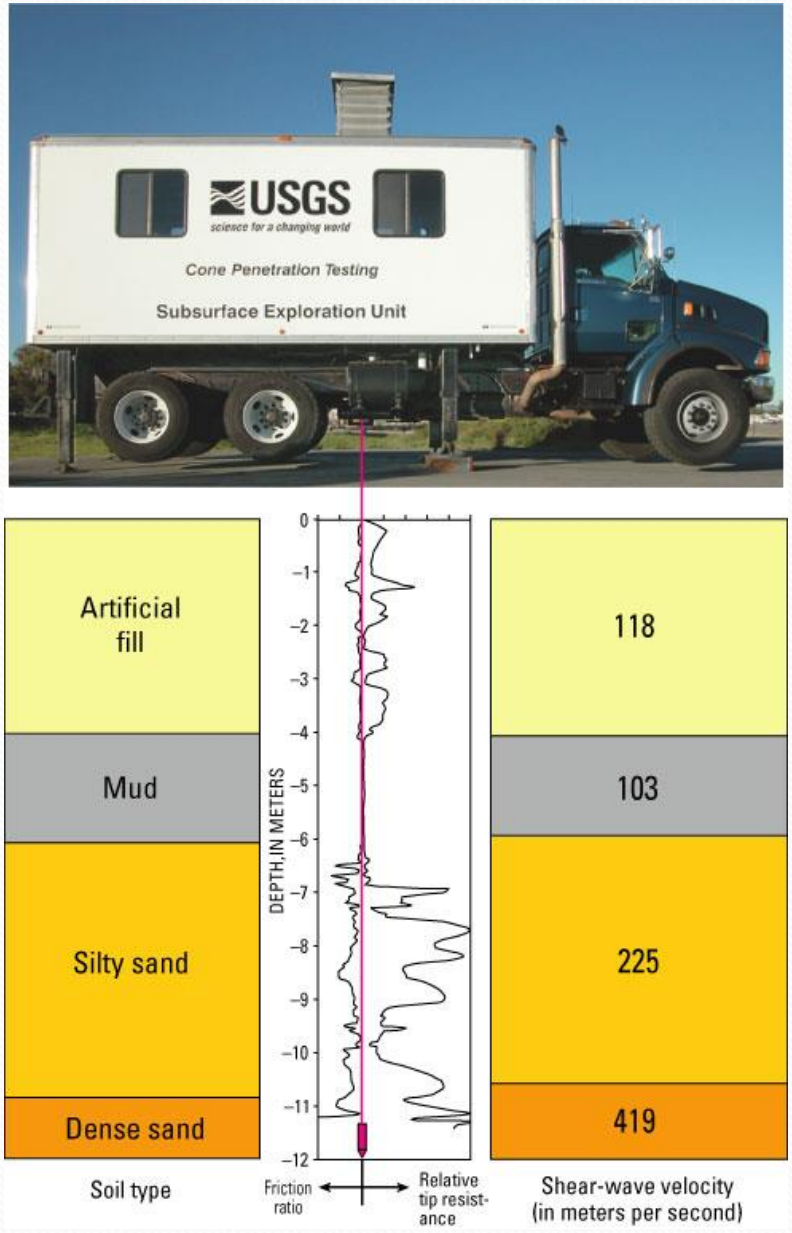
Soil Testing

Vane Shear Test

Standard Penetration Test

Soil Testing

Cone Penetration Testing



Soil Testing

Triaxial Test on Soil Sample in Laboratory

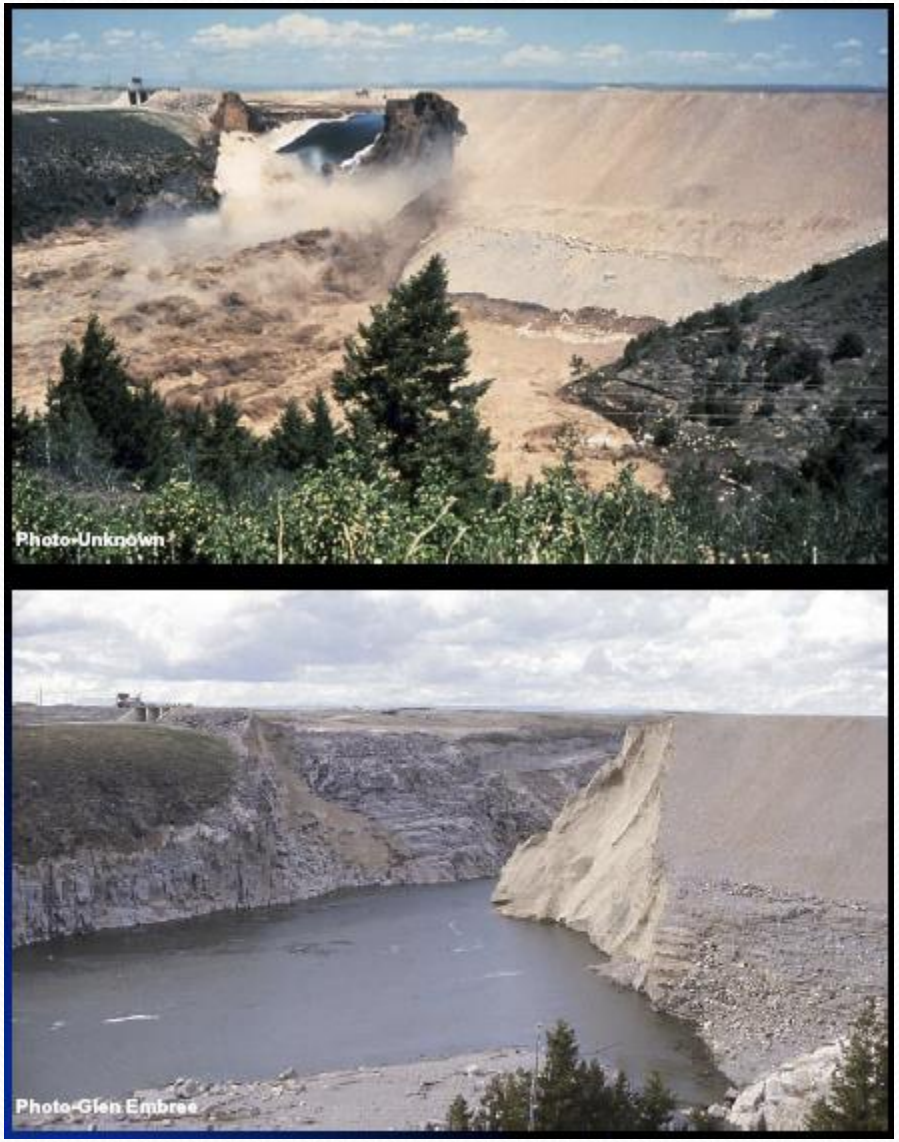
Challenges

GeoHazards

Geotechnical Engineering Problems

- How will the groundwater conditions impact the engineering project?

Teton Dam Failure (1975)



Geotechnical Engineering Problems

- What will be the impact of excavations, grading, or filling?

- Collapse of Nicoll Highway,Singapore, 2004

Geotechnical Engineering Problems

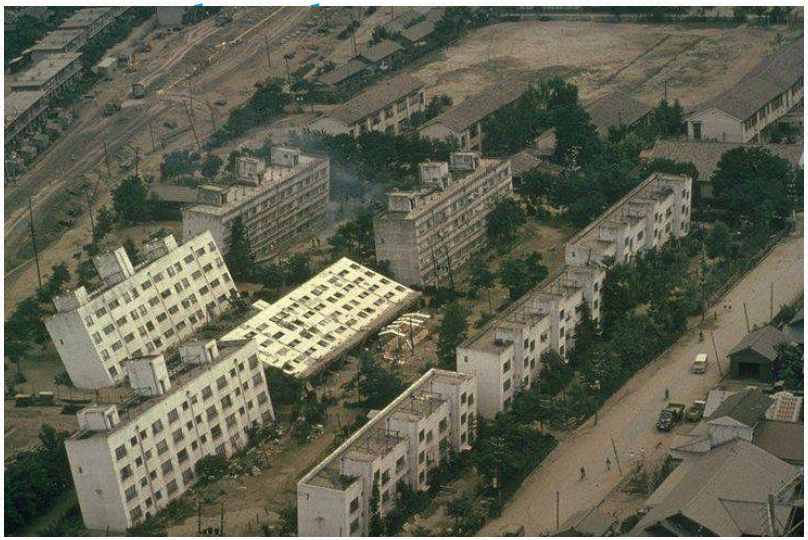
- Are natural or proposed earth slope stable?

(from Norwegian Geotechnical Institute, 2001)

Geotechnical Earthquake Engineering

- Effects of earthquakes

1964 Niigata Earthquake



(from Kramer – www.ce.washington.edu 1996)

1967 Caracas

(from Alshibli 2001)

Geotechnical Earthquake Engineering

- Effects of earthquakes

1995 Kobe Earthquake

1999 Chi Chi Earthquake

(Boulanger and Duncan 2006)

GeoSolutions

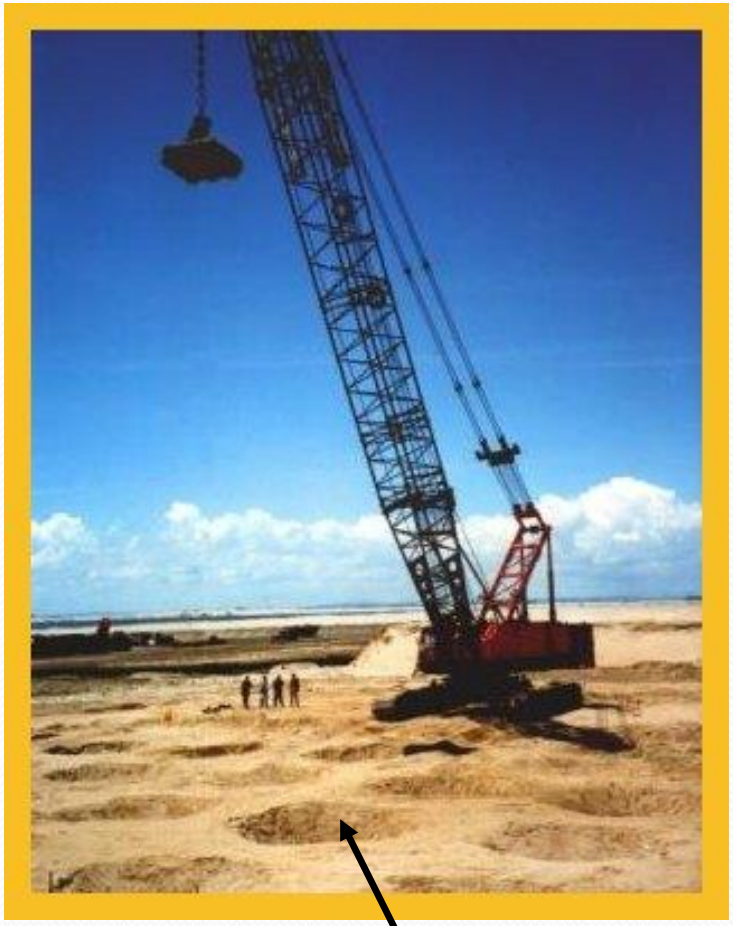
Ground Improvement

Impact Roller to Compact the Ground

Ground Improvement

Sheepsfoot Roller to Compact Clay Soils

Ground Improvement

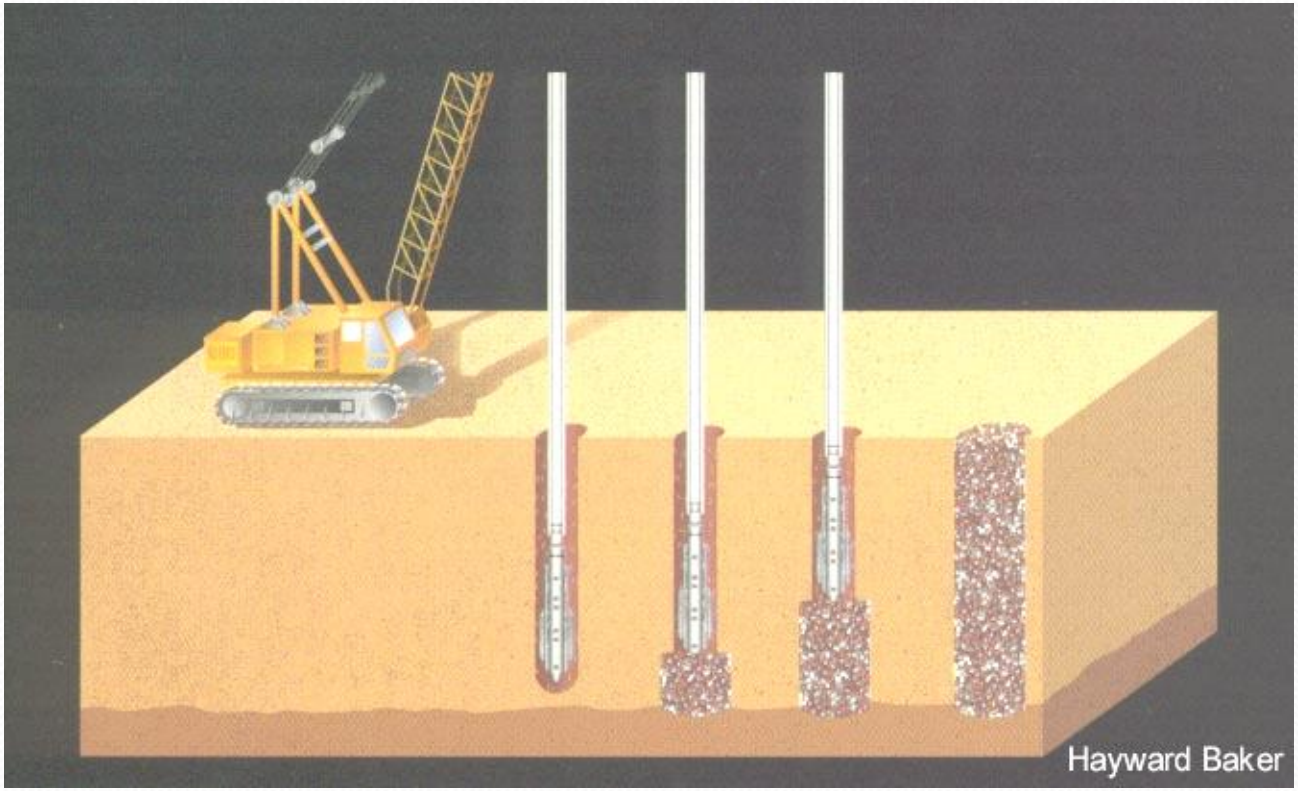


Big weights dropped from 25 m, compacting the ground.

Craters formed in compaction

Soil Improvement

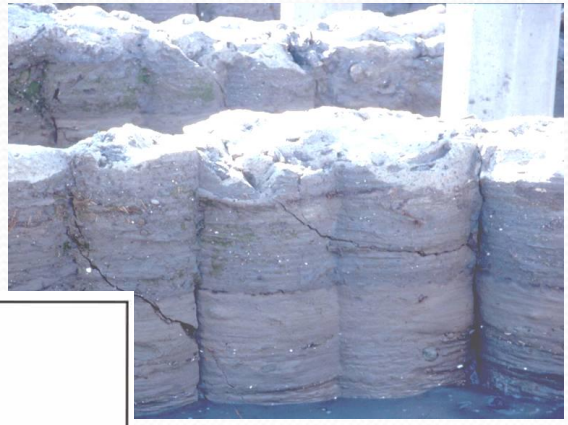
- Stone Columns

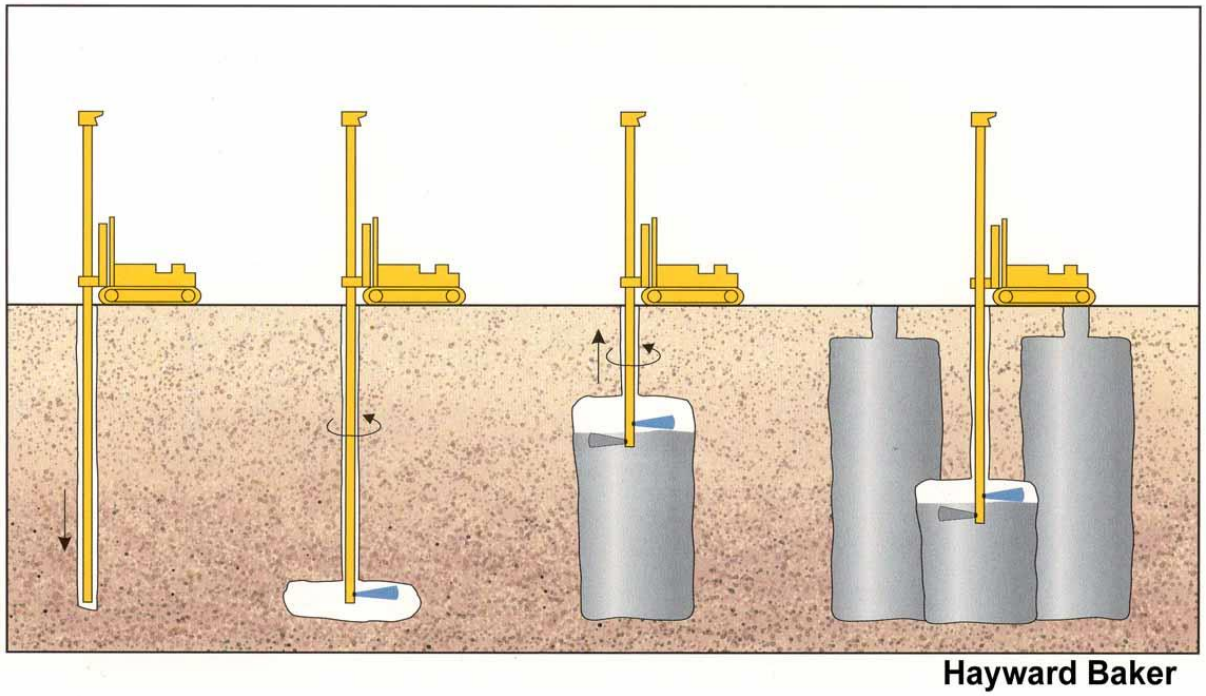


(Boulanger and Duncan 2003)

Soil Improvement

- Jet Grouting

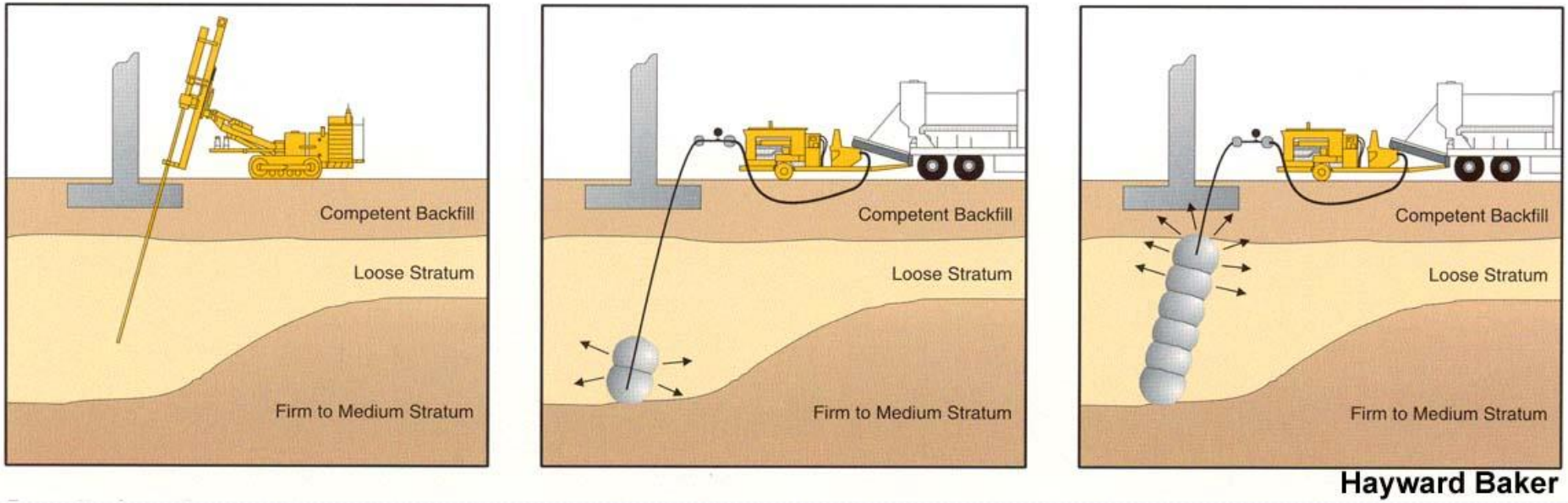




(Boulanger and Duncan 2003)

Soil Improvement

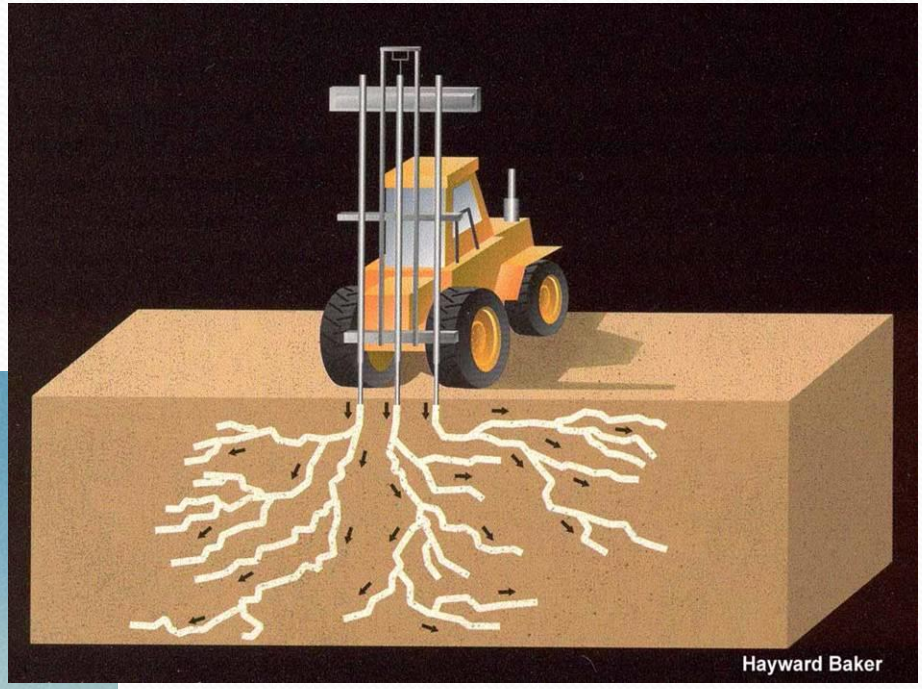
- Compaction Grouting



(Boulanger and Duncan 2003)

Soil Improvement

- Chemical Injection



(Boulanger and Duncan 2003)