GROUND IMPROVEMENT TECHNIQUES
(CE 408) CREDIT-3

Dr. Supia Khatun
Assistant Professor
Aliah University
Newtown Campus Kolkata

Need for Ground Improvement

Different types of problematic soils

Emerging trends in ground Improvement

Need for engineered ground improvement(Concerns)

- Mechanical properties are not adequate
- Swelling and shrinkage
- Collapsible soils
- Soft soils
- Organic soils and peaty soils
- Sands and gravelly deposits, sinkhole formations
- Foundations on dumps and sanitary landfills
- Handling dredged materials
- Handling hazardous materials in contact with soils
- Use of old mine pits

Leaning tower of Pisa

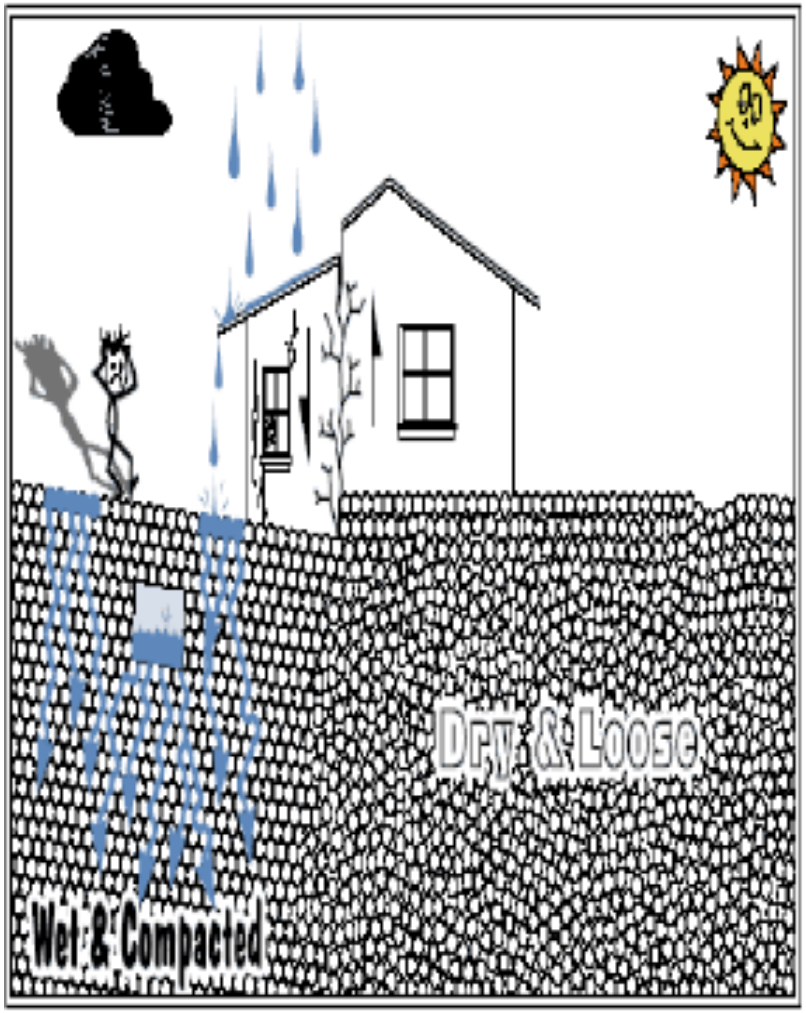
Kandla Port Building after 2001 earthquake

Effect of Swelling

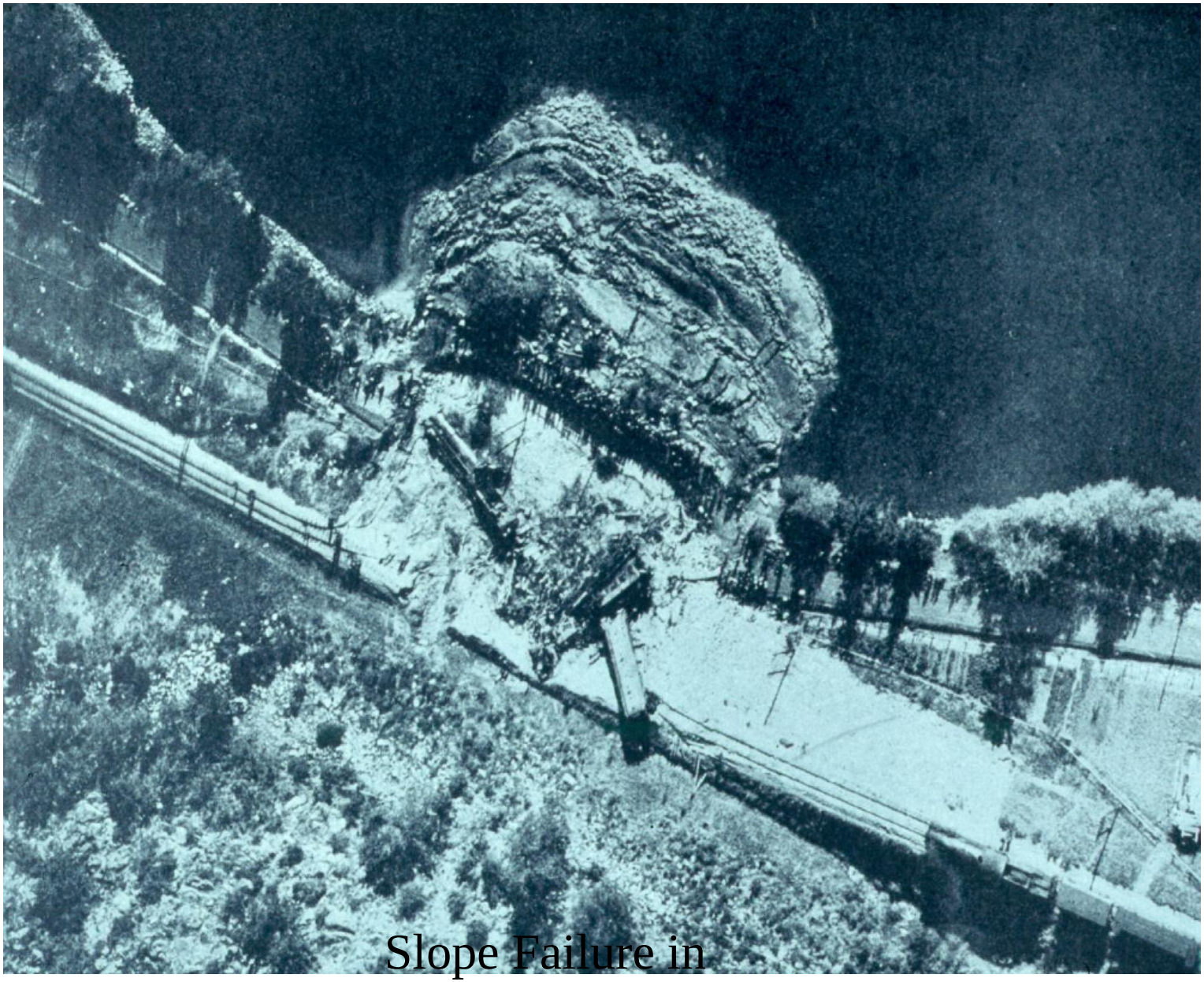
Effect of shrinkage

Swelling and shrinking soils exist in many areas in India, Large tracts of Maharashtra, Andhra, Deccan plateau, Chennai

Collapsible soils



Collapse occurs due to saturation, loss of cementation bonds, specific clay structure and areas in some areas in Rajasthan and in some counties abroad this is prevalent.



Slope Failure in Sweden

Failure of slope

Effects of liquefaction

Need for engineered ground improvement(Strategies)

When a project encounters difficult foundation conditions, possible alternative solutions are-

- Avoid the particular site
- Design the planned structure (flexible/rigid) accordingly
- Remove and replace unsuitable soils
- Attempt to modify existing ground
- Enable cost effective foundation design
- Reduce the effects of contaminated soils
- Ensure sustainability in construction projects using ground improvement techniques

Ground Improvement Techniques for different soil types

Ground improvement can be done through various mechanisms

- Compaction
- Dewatering
- Reinforcement
- Admixtures or grouting

Reinforcement

•This method improves the soil response by interaction between soil and inclusion.

• The improving period depends on the life of inclusion.

• In this technique there is no change in the state of soil.

•It is a widely used technique as it can be done for many types of soils.

Admixtures or Grouting

•Cementation plays a major role in improving the soil response.

• Short term/long term improvement techniques are possible.

•There is a change in soil state after adopting it.

Compaction

- The state of soil is improved in this technique due to high densification.
- This is a long term improvement technique.
- There is a change in soil state after adopting it.
- This technique can be adopted for silty , sandy and gravely soils.

Dewatering

- This is a technique similar to compaction.
- It is mostly adopted to clayey soils.

SNo	Type of soil	Reinforcement	Admixtures	Compaction	Dewatering
1	Organic soil				
2	Volcanic clay soil				
3	Highly plastic clay				
4	Lowly plastic clay				
5	Silty soil				
6	Sandy soil				
7	Gravel soil				

Soils for which the technique is not applicable

Soils for which the technique is applicable

Classification of ground modification techniques

- Mechanical modification
- Hydraulic modification
- Physical and chemical modification
- Modification by inclusion and confinement
- Combination of the above

Methods for Soil Improvement

Ground Reinforcement	Ground Improvement	Ground Treatment
• Stone Columns	• Surface Compaction	• Soil Cement
• Soil Nails	• Drainage/Surcharge	• Lime Admixtures
• Micropiles	• Electro-osmosis	• Flyash
• Jet Grouting	• Compaction grouting	• Dewatering
• Ground Anchors	• Blasting	• Heating/Freezing
• Geosynthetics	• Dynamic Compaction	• Vitrification
• Fibers		
• Lime Columns		
• Vibro-Concrete Column		
• Mechanically Stabilized Earth		
• Biotechnical		

Factors affecting the selection of ground improvement technique

- **Type and degree of improvement required**

- Bearing capacity improvement, settlement reduction, permeability enhancement/decrease, long term/short term, liquefaction resistance.

- **Type of soil, geological structure, seepage conditions**

- Type of clay/sand and foundation, role of pore pressure and seepage, presence of diffcult geological condition.

❑ **Costs, equipment, specifications**

• Size of the project, availability of equipment, transportation costs, experienced contractors, Specification of work, guidance documents.

❑ **Construction time**

• Construction time available, use of accelerated construction techniques

- **Possible damage to adjacent structure or pollution of ground water resources**
- Tolerable levels of loading and deformation, pore water contamination
- **Durability of the materials involved**
- Short term and long term, corrosion, aggressive soil condition.

❑ **Toxicity and corrosivity of any chemical additives**

• Government regulations may restrict the choice of additives

• Using Vitrification of soils to limit radio active or hazardous wastes,

• Ex: Remediation of chromium-contaminated soil through ex situ vitrification (ASCE journal paper)

❑ **Reversibility or irreversibility of the process**

• Ex: Lime added to expensive soil reacts in presence of sulphate

Reusability of components such as steel, plastics, concrete etc

❑ **Reliability of methods of testing, analysis and design**

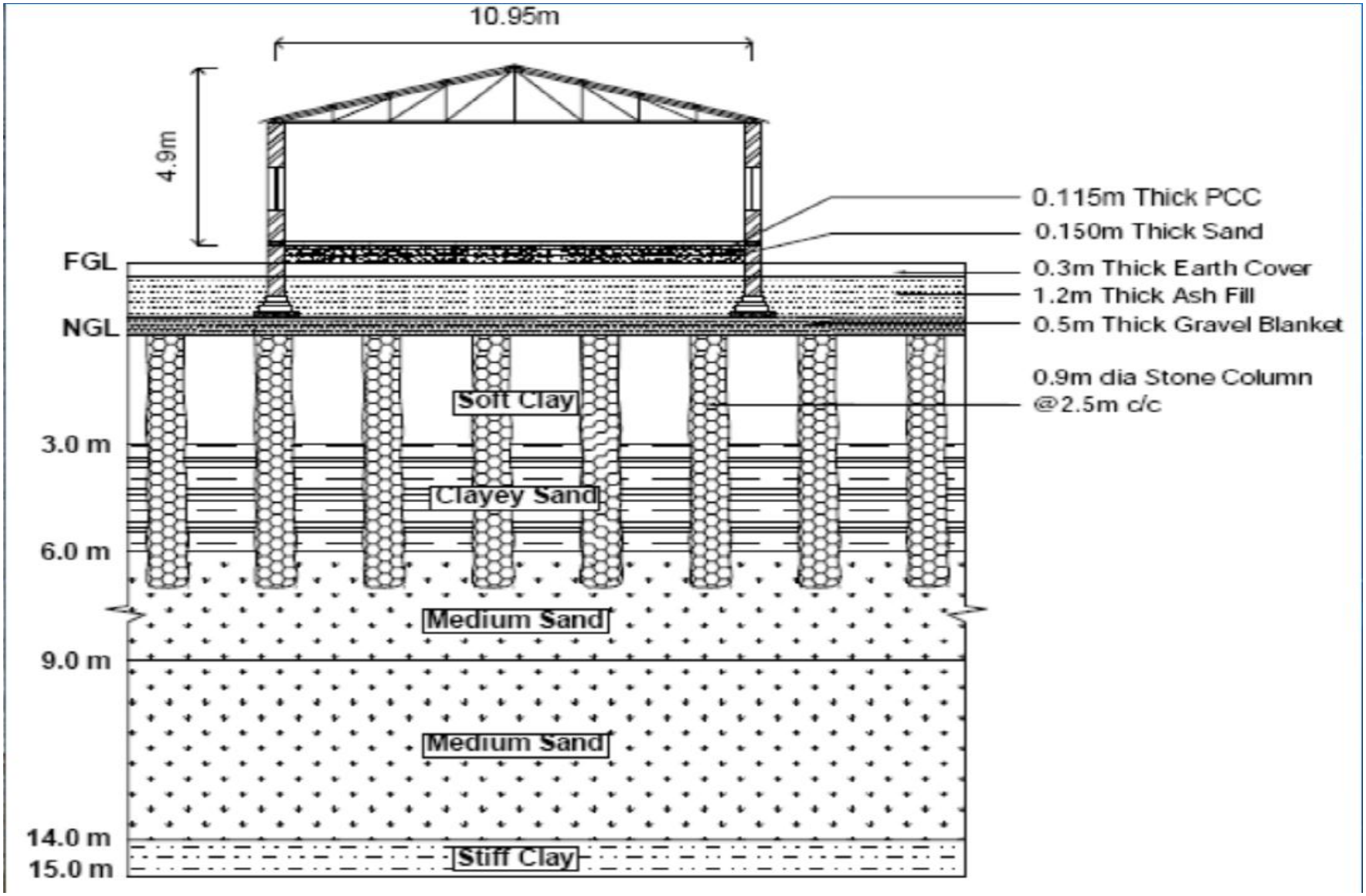
• Good methods of testing, proven methods of design and analysis should be used and empirical approaches need to be avoided

❑ **Feasibility of construction control and performance measurements**

• Documents of quality control and performance are required in major ground improvement projects

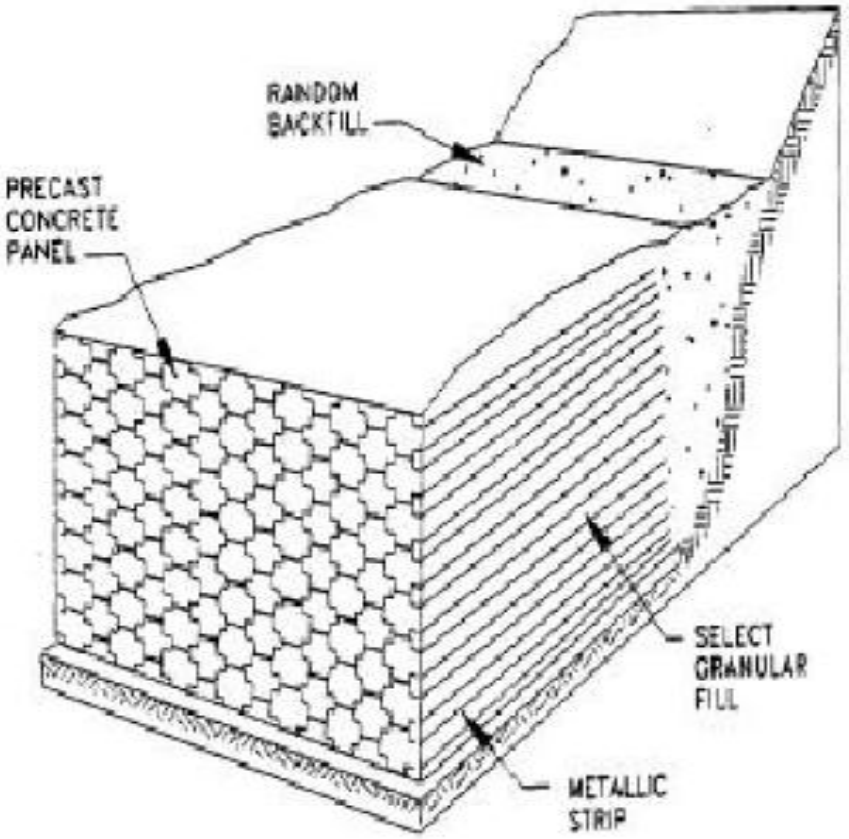
Benefits of ground improvement techniques

- Increase of strength
- Reduce distortion under stress (Increases stress-strain modulus)
- Reduce compressibility (volume decreases due to a reduction in air voids or water content under loads)
- Prevent detrimental physical or chemical changes due to environmental conditions (freezing / thawing, wetting / drying)
- Reduce susceptibility to liquefaction



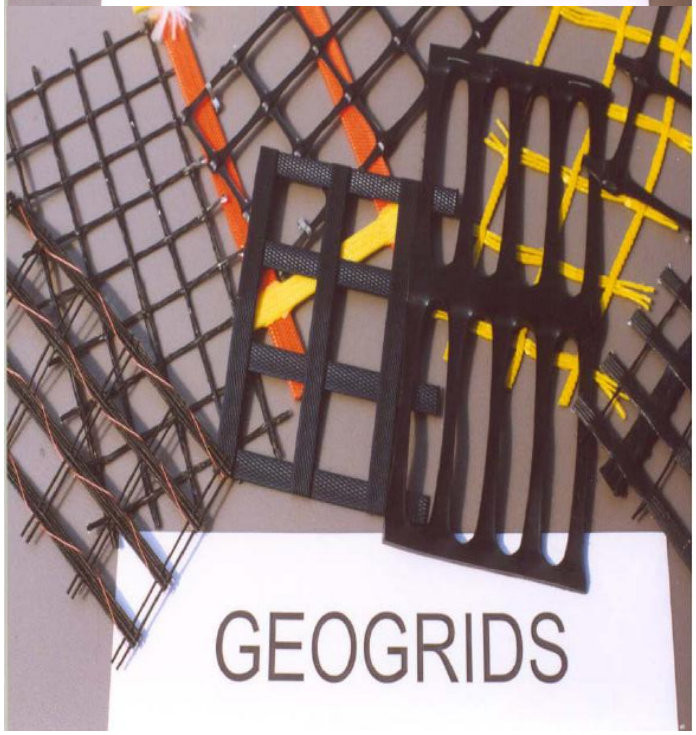
Stone columns

Nailing and Reinforced soil




GEOTEXTILES

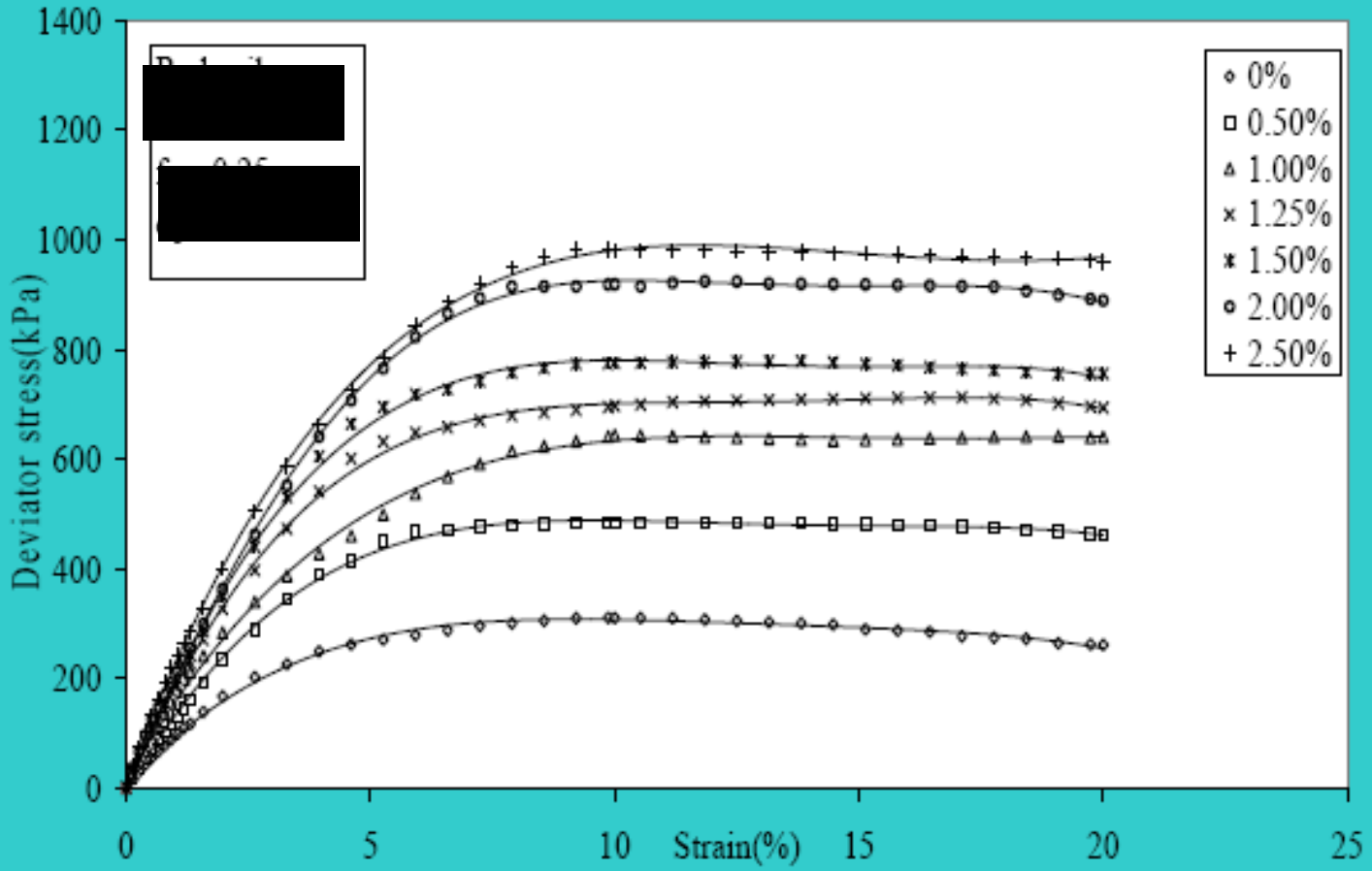

GEOMEMBRANES


GEOGRIDS


GEOCOMPOSITES

Fibers and reinforced earth

Effect of fibers on strength response



Effect of fibers on swell response