NPTEL Course

GROUND IMPROVEMENT

Prof. G L Sivakumar Babu
Department of Civil Engineering
Indian Institute of Science
Bangalore 560012
Email: gls@civil.iisc.ernet.in
Module I

- Need for Ground Improvement
- Different types of problematic soils
- Emerging trends in ground Improvement
Introduction

- Scarcity of suitable construction sites

- Problem soils
  - Collapsible soils
  - Liquefiable soils
  - Waste materials
  - Expansive and shrinkage
  - Marshy and soft soils
  - Karst deposits

- Wide application

- Economy
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

<table>
<thead>
<tr>
<th>Ground Reinforcement</th>
<th>Ground Improvement</th>
<th>Ground Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Stone Columns</td>
<td>• Surface Compaction</td>
<td>• Soil Cement</td>
</tr>
<tr>
<td>• Soil Nails</td>
<td>• Drainage/Surchage</td>
<td>• Lime Admixtures</td>
</tr>
<tr>
<td>• Micropiles</td>
<td>• Electro-osmosis</td>
<td>• Flyash</td>
</tr>
<tr>
<td>• Jet Grouting</td>
<td>• Compaction grouting</td>
<td>• Dewatering</td>
</tr>
<tr>
<td>• Ground Anchors</td>
<td>• Blasting</td>
<td>• Heating/Freezing</td>
</tr>
<tr>
<td>• Geosynthetics</td>
<td>• Dynamic Compaction</td>
<td>• Vitrification</td>
</tr>
<tr>
<td>• Fibers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Lime Columns</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Vibro-Concrete Column</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Mechanically Stabilized Earth</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Biotechnical</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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 difficult 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.
Continued… :

- **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
Objectives of ground improvement techniques

- Increase 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)
- Ex: Additives, fibers, reinforcement