

# **GROUND IMPROVEMENT TECHNIQUES FOR GEOTECHNICAL & GEOTECHNICAL EARTHQUAKE ENGINEERING**

## **Background**

The soil at a construction site is not always totally suitable for supporting structures such as buildings, bridges, highways and dams. In granular soils, in-situ soil may be very loose and indicate large elastic settlement. Under these conditions, soil needs to be densified to increase its unit weight and shear strength. If top layers of soil are undesirable, it must be removed and replaced with better soil on which structural foundation can be built. The fill soil should be well compacted to sustain desirable structural load. In low-lying areas also, fill may be required to raise the ground elevation for construction of foundation.

Sometimes soft saturated clay layers are encountered at shallow depths below foundations. Such soils usually undergo large consolidation settlement depending on the structural load and the depth of the layers. Special ground improvement techniques are required to minimize settlement under these conditions. Similarly specific type of soil improvement techniques are required in the case of expansive soils.

Objectives of ground improvement is to:

- (i) Reduce settlement of structures.
- (ii) Improve shear strength and bearing capacity of shallow foundations.
- (iii) Increase factor of safety against possible slope failure of embankments and dams.
- (iv) Reduce shrinkage and swelling of soils.

In both seismically active and inactive areas, soil improvement techniques are commonly used, if existing soil is expected to lead to unsatisfactory performance. Usually it is in the form of unacceptably large horizontal or vertical (or both) movements. Consequently, soil improvement techniques are directed towards increasing strength and stiffness of soil deposits under earthquake conditions. For earthquake conditions, ground improvement technique is also directed towards reduction in excess pore pressure generation during ground shaking.

## **About the Workshop**

With the above background, the proposed one day workshop is designed to provide the participants with the fundamentals of following ground improvement techniques:

- In-situ densification of soils.
- Ground improvement and modification.
- Reinforced soil.
- Grouting.
- Grading and other soil improvement methods to mitigate earthquake effects.

Above mentioned topics will be covered in detail in the form of power point slides. First four topics are ground improvement techniques in geotechnical engineering, whereas the fifth topic is in the context of geotechnical earthquake engineering. Concepts will be explained with solved numerical examples at appropriate places.

### **Who would benefit from this Workshop?**

- Young faculty members teaching geotechnical as well as geotechnical earthquake engineering.
- Young research scholars working in the area of geotechnicals.
- Young engineers working in the area of geotechnicals.
- Civil engineering undergraduate and graduate students.

### **About the Presenter**



**Dr. Kamalesh Kumar, B. Tech., M.S., Ph. D.** is Assistant Professor at Birla Institute of Technology & Science, Pilani. Dr. Kumar obtained his B. Tech. degree from Indian Institute of Technology, Kanpur and M. S. degree from Lehigh University, Pennsylvania, USA. He completed his Ph. D. from BITS Pilani, Rajasthan in 2002. He has research publications in one international conference, four national conferences and two national journals. He has contributed chapter on geotechnical earthquake engineering for the lecture notes developed by civil engineering group, BITS Pilani for earthquake risk management. He has also written book entitled “Basic Geotechnical Earthquake Engineering”. He took theory classes on the topic of ground improvement engineering during training programme for engineers of Engineers India limited at Engineers India limited, New Delhi and attended DST sponsored short term course on application of centrifuge modeling to geotechnical engineering practice as nominated participant at Indian Institute of Technology, Bombay. His area of specialization is geotechnical engineering. He is member of Phi-Beta-Delta, honour society for international scholars.

## Course Content

### **1. In-situ densification of soils**

- Introduction
- Response of sand & clay to external stress
- Compaction piles in sands
- Impact compaction of sands
- Vibratory compaction in sands (vibroflotation, vibro compaction piles)
- Explosions in sands
- Comparison of in-situ densification methods in sand
- Vibroflotation in clays
- Accelerated pre-consolidation of clays (types of drains, vertical & radial consolidation, methodology)
- Illustrative examples

### **2. Ground improvement & modification**

- Introduction
- Improving by excavating & replacing (mixing additives, applications)
- In-situ ground improvement (compaction piles, compaction with dynamic loads, pre-loading using sand drains, grouting, replacing existing soil with better soil in bore holes, deep mixing, inserting reinforcing elements, freezing soil, applications)
- Illustrative examples

### **3. Soil reinforcement**

- Introduction
- Mechanism
- Reinforcement
- Reinforcement – soil interaction
- Applications
- Reinforced soil structures with vertical faces
- Reinforced soil embankments
- Open excavation using soil nails
- Slope stabilization using soil nails
- Reinforced soil below unpaved road
- Reinforced soil beneath foundations
- Illustrative examples

### **4. Grouting**

- Introduction
- Grout types
- Desirable grout characteristics (groutability, stability, setting time, permanence, toxicity)
- Grouting methods
- Permeation grouting (grouting pressure, grouting technology, single stage grouting, descending & ascending stage grouting, sleeved pipe grouting, grouting arrangements)
- Displacement – compaction grouting
- Displacement soil fracture grouting
- Jet grouting (grouting technology, grouted columns)
- Illustrative examples

### **5. Grading and other soil improvement methods to mitigate earthquake effects**

- Introduction (avoid liquefaction susceptible soils, remove or improve soil, build liquefaction resistant structures)
- Grading
- Other site improvement methods (soil replacement methods, water removal methods, site strengthening methods, grouting, thermal methods, geosynthetics)
- Ground water control (introduction, sump pumping, well point system with suction pump, deep well with submersible electric pump, jetting system, sheet piling cut off wall, slurry trench cut off wall, freezing, diaphragm structural wall)
- Ground water control for slopes (natural earth slopes above developed land, natural earth slopes within developed areas, reservoir slopes, highway or railway slopes, earth dams, excavations)