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QC Methods for Deep Vibro Techniques
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Deep Vibro Techniques

- Deep Vibro Techniques
  - Vibro Compaction
  - Vibro Replacement
    - Stone Column
    - Concrete Column
Applicable soils

Vibro Compaction & Vibro Replacement

### Grain Size [mm]

- **Clay**
- **Silt**
- **Sand**
- **Transition Zone**
- **Gravel**
- **Stones**

### Percentage Passing

- **0**
- **20**
- **40**
- **60**
- **80**
- **100**

**Vibro Replacement**

**Vibro Compaction**
Vibro Compaction
Densification of Granular Soils
Vibro Replacement

Introduction of Material (Stone/Concrete) into the Ground

Stone supply  Filling of material lock

Penetration

Displacement

Completion
Quality Control in Deep Vibro Techniques
Stages of Work

Soil Investigation & Design

Execution

Verification (Post Testing)
Soil Investigation & Design

A. Planning Soil Investigation
B. In-situ tests
C. Laboratory Tests
D. Design
Soil Investigation

- Design and Execute an appropriate investigation
  - Soil type, fines content, liquefaction potential
  - Compressibility, shear strength, sensitivity
  - Carbon content (Peat), Carbonate content (shells)
  - Extent & depth to hard layer
  - Fill, boulders, obstructions
In-situ & Laboratory Tests

- Determine suitable tests
  - *DPT, CPT, Boreholes, Vane, etc*

- Experienced Operator
  - *Trained, Certificates, etc*

- Proper Equipment
  - *Calibration certificates, Service records, etc*

- Fully Supervised
  - *Experienced supervisor*
Design

- Determine suitability of ground for treatment
  - Objective of treatment, Soil engineering properties, Performance criteria

- Surroundings
  - Adjacent structures, Availability of water, etc

- Selection of treatment type
  - Previous similar experience, Geotechnical considerations, mixed / hybrid solutions

- Engineering Design
  - Extent, location, depth (full depth or partial depth), obstruction, construction sequencing (stages)
Execution
Execution

A. Construction Drawings and Method Statement
B. Site Preparation
C. Treatment
D. Supervision
Construction Drawings and Method Statement

- Approved drawings
  - Latest information, design intent, extent, depth, sequencing

- Approved Method Statement
  - Trials, site calibration, methodology, verification, monitoring
Site Preparation

- Platform Stability
  - Removal of top soil & obstruction,
  - thickness of fill & sand blanket

- Drainage Blanket
  - Suitable draining material,
  - thickness, drains, maintenance
Treatment

- Use suitable tool
  - Required compaction effort, water assisted or “dry”

- Machinery
  - Depth dependent (power and weight), water assisted or “dry”

- Column Material
  - Type, Grading curve, Hardness, Durability
Treatment

- Real Time Monitoring
  - Ref nr, date, time, depth, duration
    at each stage, vibrator power
  - consumption, stone consumption
Treatment

- Real Time Monitoring
Treatment

- Real Time Monitoring

Keller System M5
Treatment

- Real Time Monitoring

Keller System M5

Touch Panel Computer
Treatment

- M5 with Rig Controller
Vibro Scan

VISUALISATION OF VIBRO COMPACTION

With the new invented program VibroScan the soil conditions can be visualized in the whole working area during execution. This enables Keller to realize and to react in case of deviation of the existing soil conditions.

VISUALISATION OF OTHER VIBRO METHODS

VibroScan can be used also for other Vibro methods and makes the relief of the of the bearing soil layer or the improved soil in the working area visible.

GRAPHIC OUTPUT IN 2D AND 3D

COLOURED VISUALISATION OF INSTALLED COLUMN LENGTHS
Supervision

- Suitably qualified and experience personnel
- Follow approved drawings and method statement
- Review departure from design basis or unforeseen ground
- Review Real Time Monitoring data
Verification
(Post Testing)
Verification

A. Post-treatment Soil tests

B. Load tests

C. Full scale simulation (surcharge, zone tests)
Post-treatment Soil Tests

- Determine changes in soil properties after treatment
  - *In situ tests e.g. CPT*

Typical Specification

- RD 65% + Cut-off 12 MPa
- RD 75% + Cut-off 13 MPa
- RD 85% + Cut-off 14 MPa
Load Tests

- **Plate Bearing Tests**
  - Useful for shallow treatment, general quality of column head
  - Number of tests depending on extent of treatment

- **Single or Group Tests**
  - Group tests more representative of mass treatment to deeper depths
Full Scale Simulation

- **Zone Tests**
  - *Surcharge over a fairly large area representing future structure*
  - *Normally carried out prior to treatment for uncertain ground or settlement sensitive structure*
Full Scale Simulation (contd.)

- **Structural Load**
  - *Actual structure loaded e.g.*
    - oil tank loaded with water
  - *Besides design verification,*
    - can serve as pre-loading to
    - *reduce long term*
    - *settlement*
Conclusions

- Quality awareness and control should be present at all stages of Ground Improvement work – SI, Design, Execution, Post Testing
- Online monitoring of improvement work is essential
- Presentation and review of measured data on a daily basis is important
- Post improvement penetration testing and/or load testing essential for verification of success of ground improvement
Thank you ...