14th Asian Regional Conference on Soil Mechanics and Geotechnical Engineering

QC Methods for Deep Vibro Techniques

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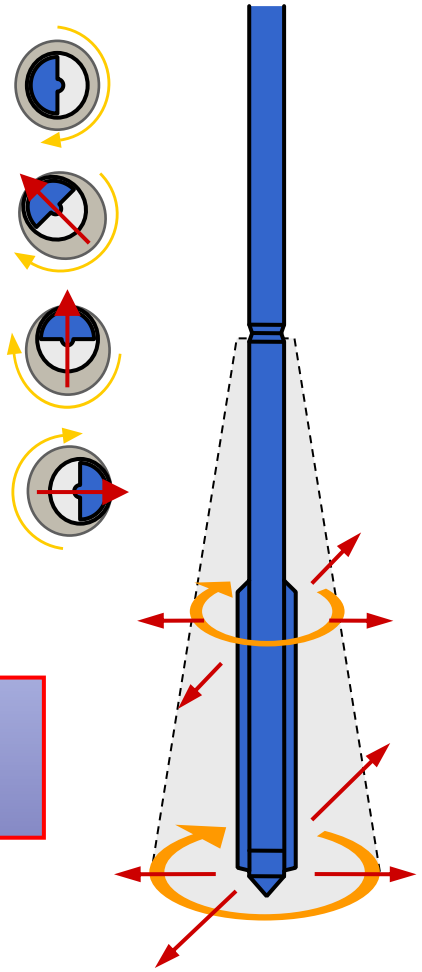
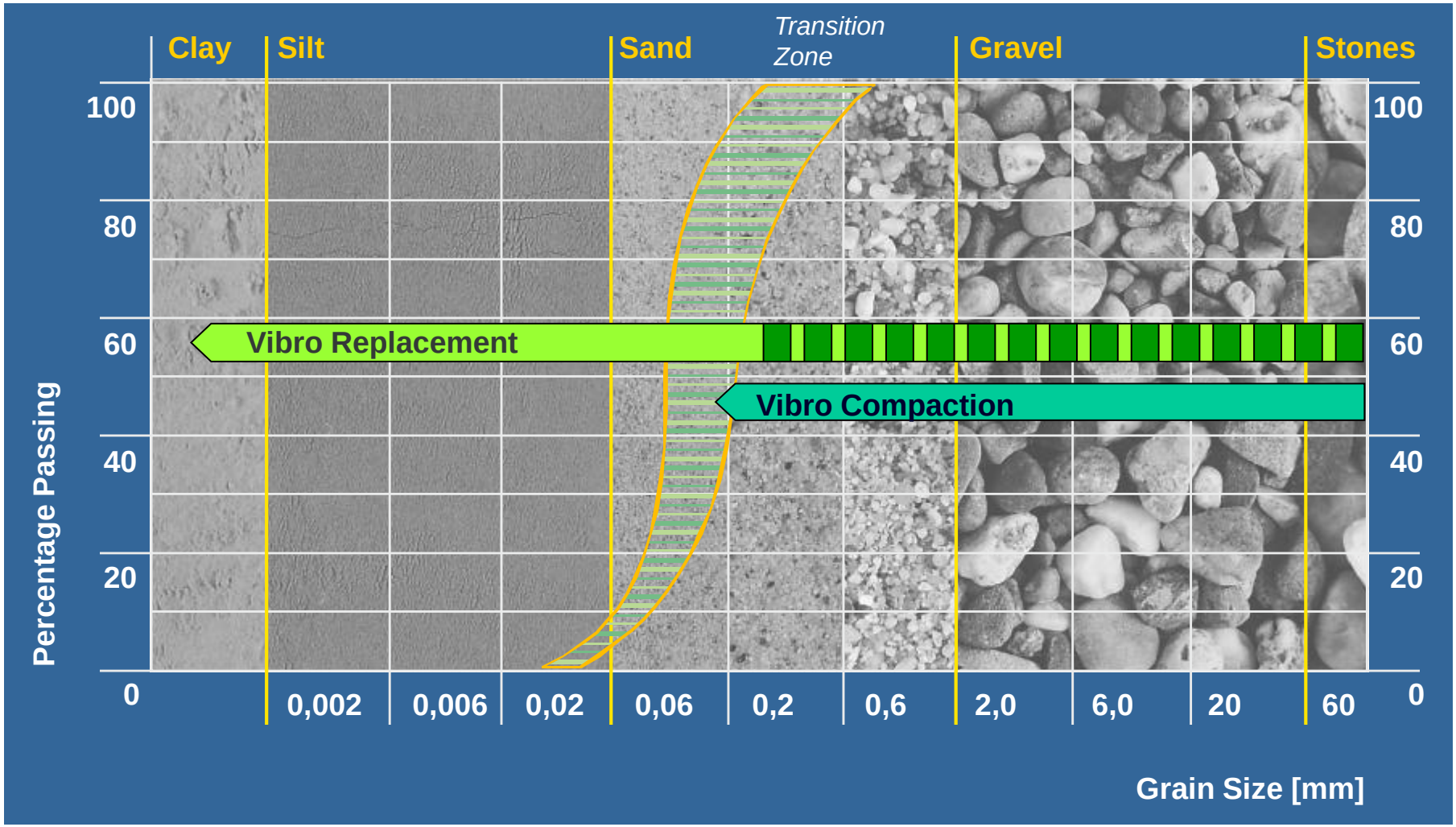
Deep Vibro Techniques

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



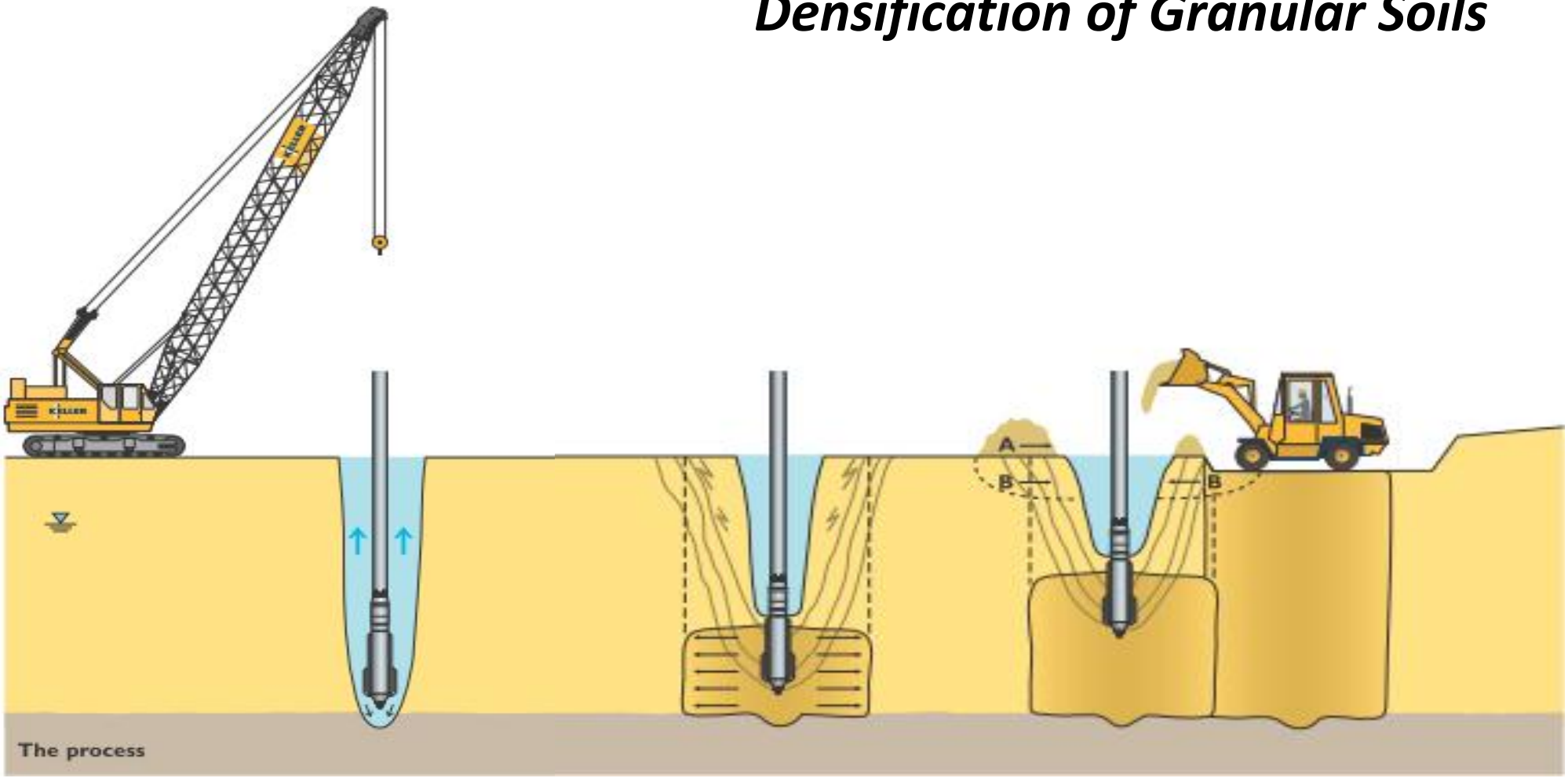
Applicable soils

Vibro Compaction & Vibro Replacement



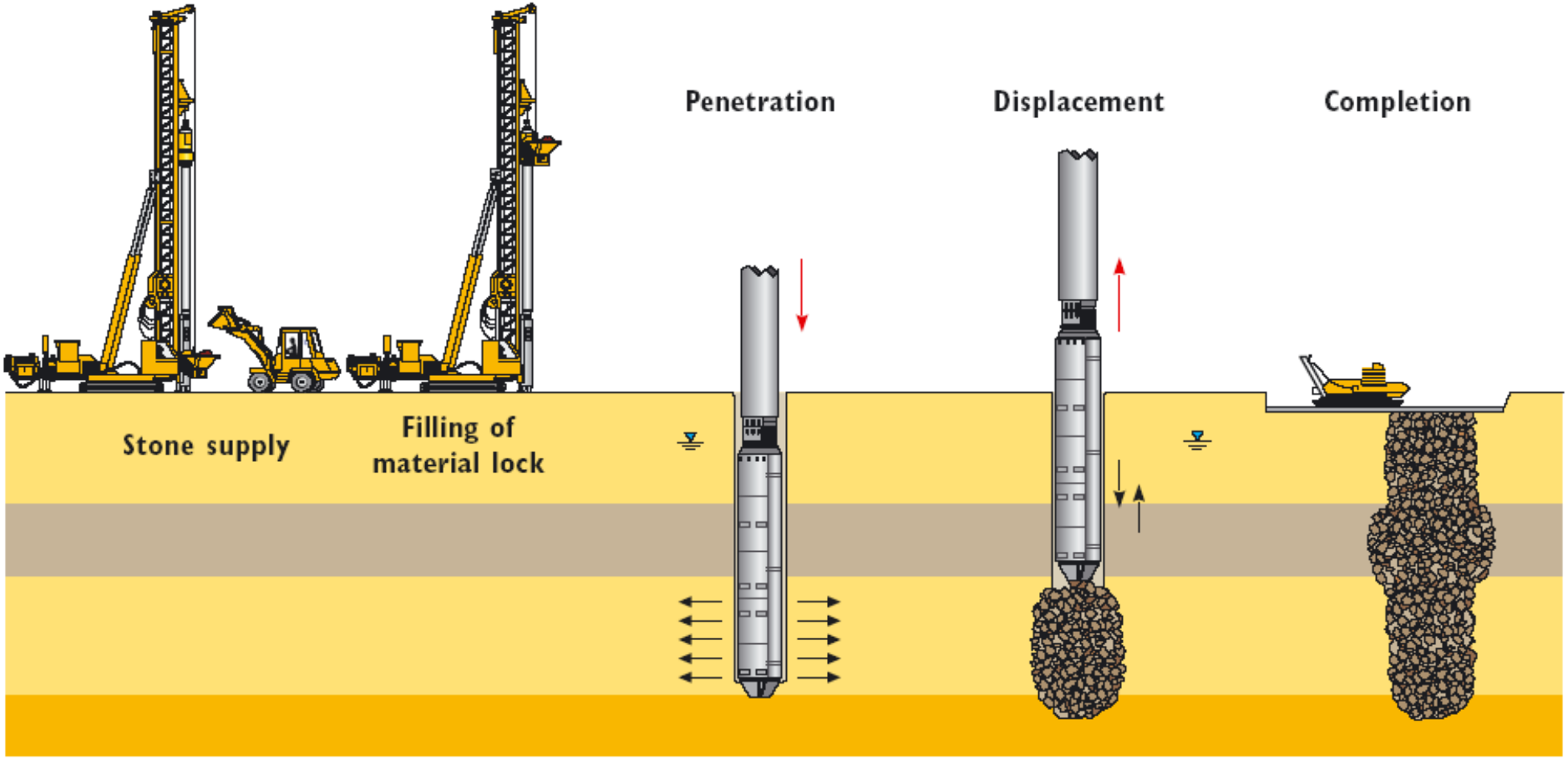
Vibro Compaction

Densification of Granular Soils



Vibro Replacement

Introduction of Material (Stone/Concrete) into the Ground



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*

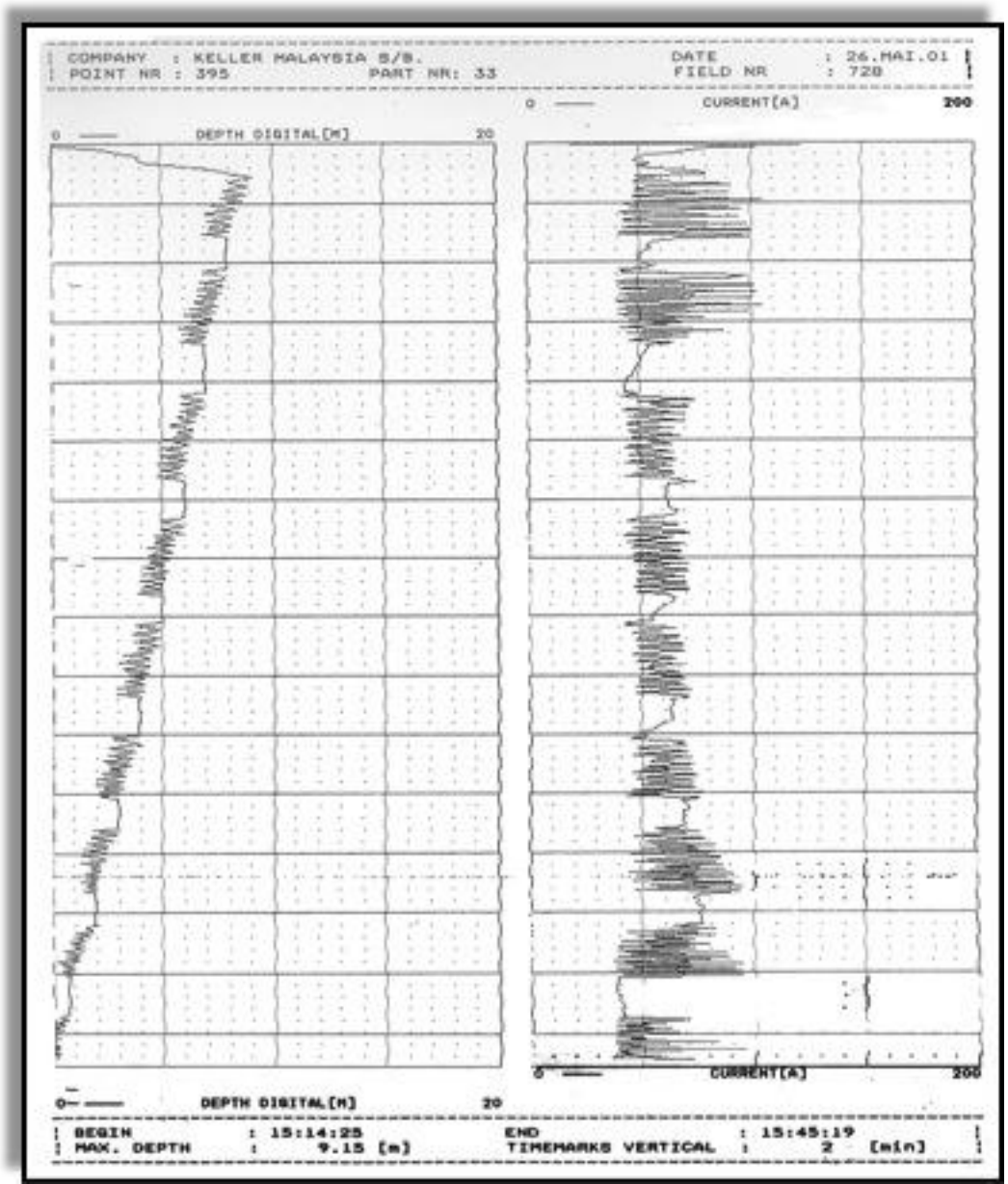
Treatment

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

M4 Device

Treatment

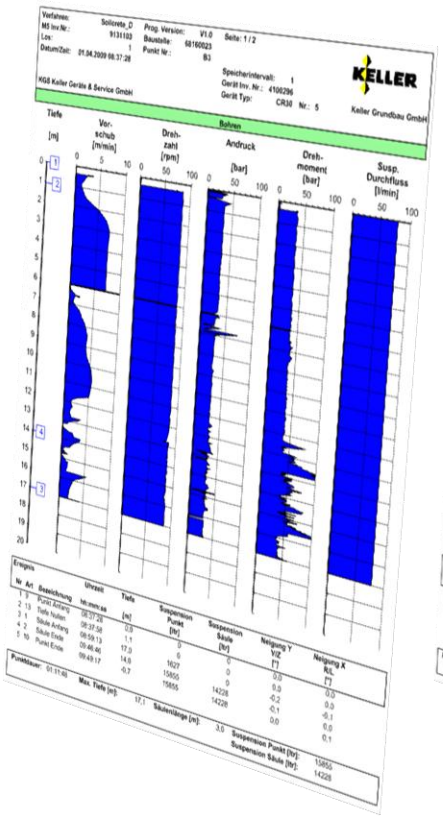
- Real Time Monitoring

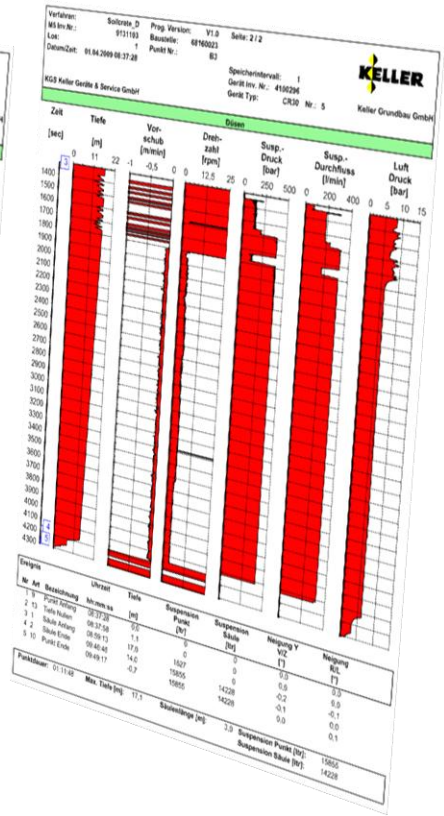


Treatment

- Real Time Monitoring

Keller System M5





Treatment

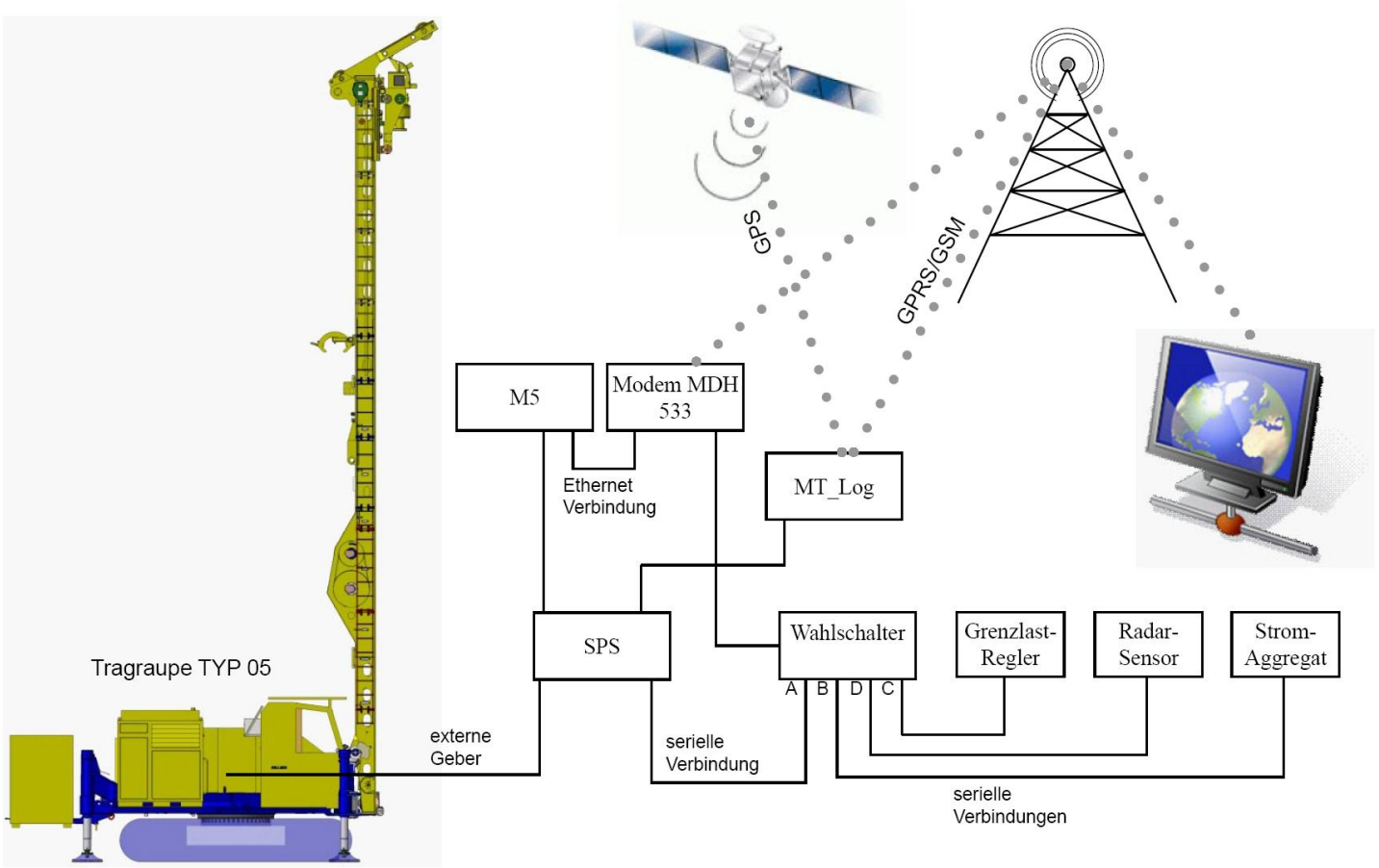
- Real Time Monitoring

Keller System M5

Touch Panel Computer

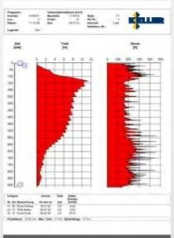
Treatment

❑ M5 with Rig Controller

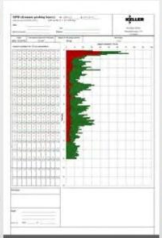


Vibro Scan

VISUALISATION OF VIBRO COMPACTION



RECORDING PROTOCOL



DPH - TEST
(BEFORE & AFTER)

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.

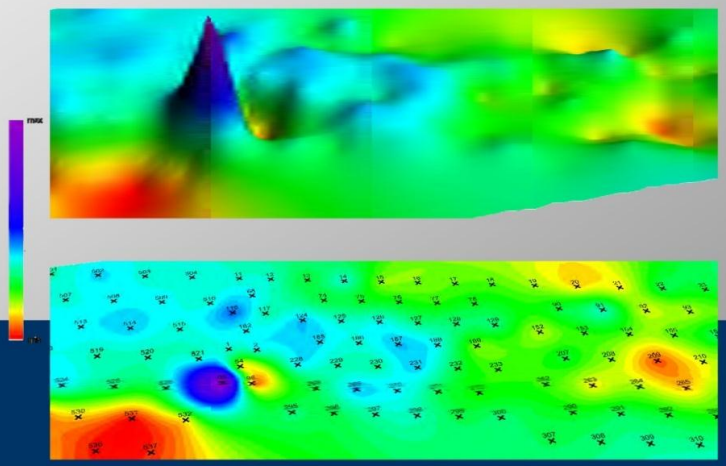
1. DESIGN
2. EXECUTION
3. VISUALISATION
4. MODIFICATION

VISUALISATION OF OTHER VIBRO METHODS

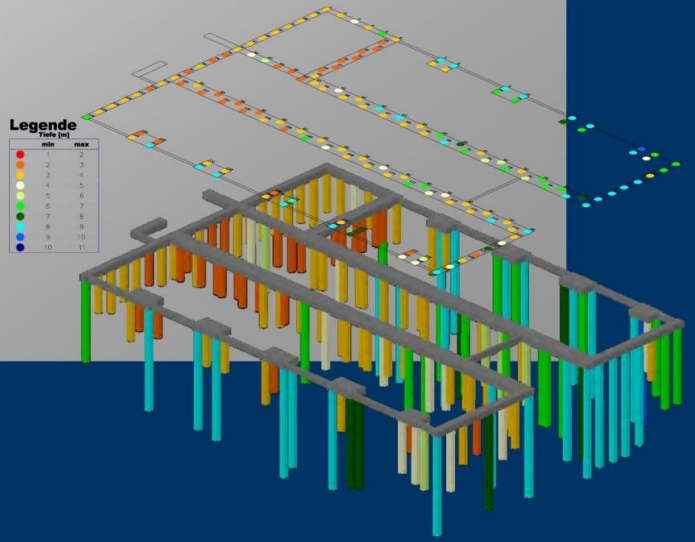
VibroScan can be used also for other Vibro methods and makes the relief of the of the bearing soil layer or the improved soil in the working area visible.

DATA LOGGING DURING EXECUTION

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

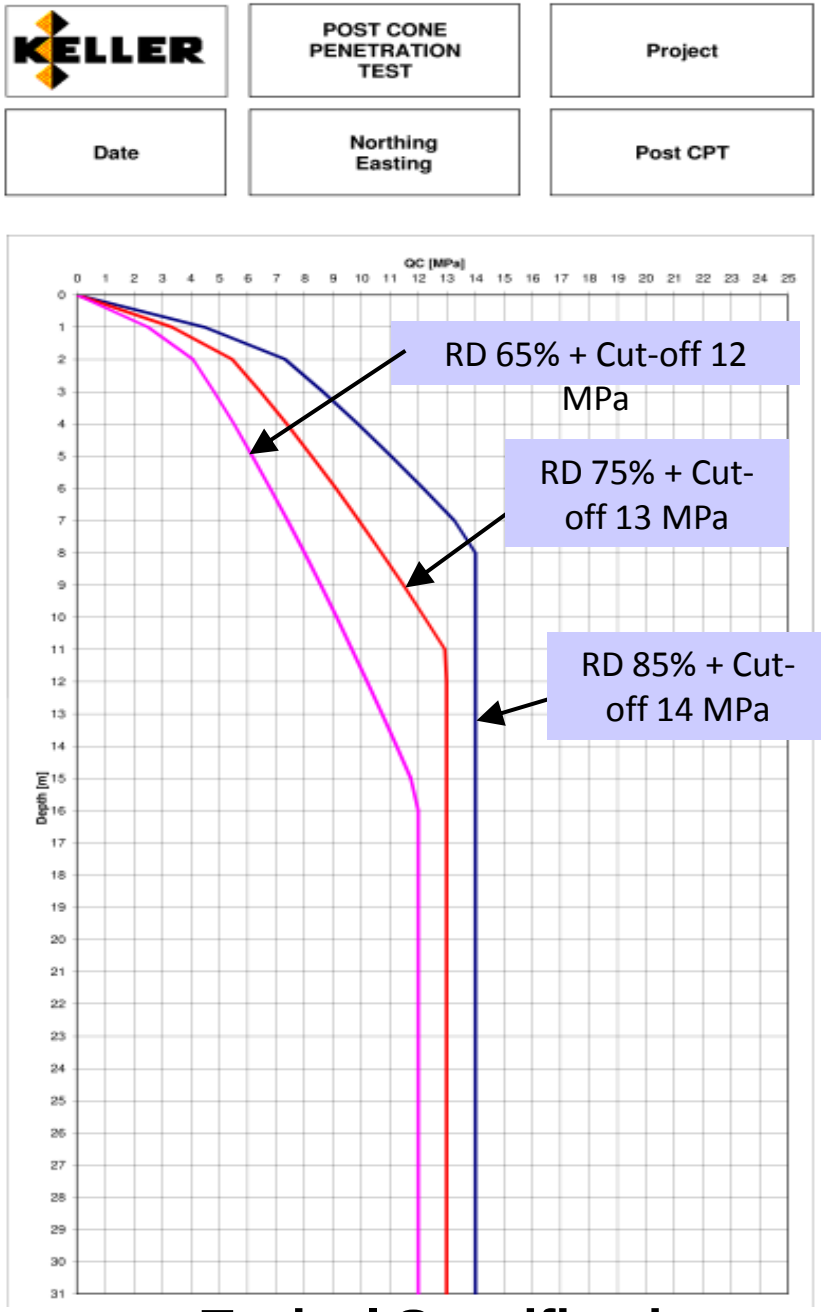
A. Post-treatment Soil tests

B. Load tests

C. Full scale simulation (surcharge, zone tests)

Post-treatment Soil Tests

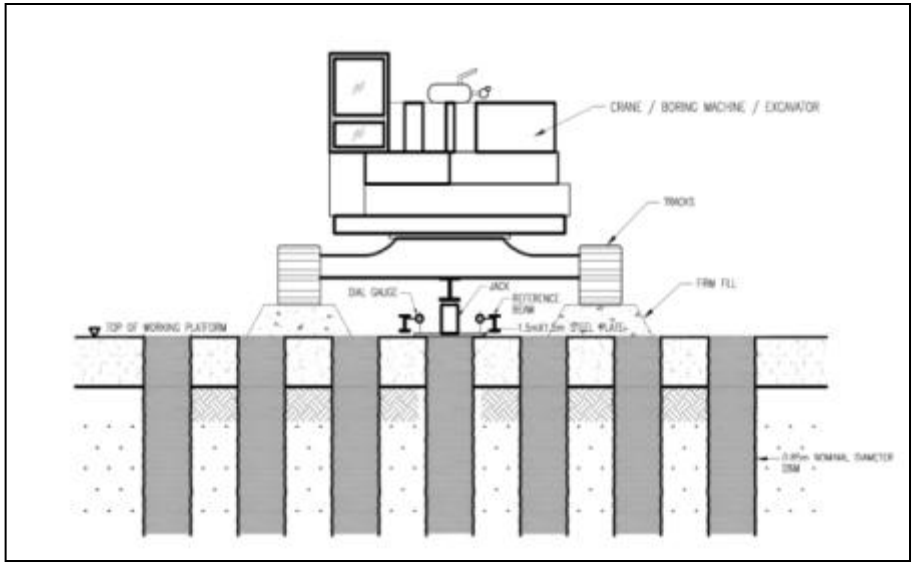
- **Determine changes in soil properties after treatment**
  - *In situ tests e.g. CPT*

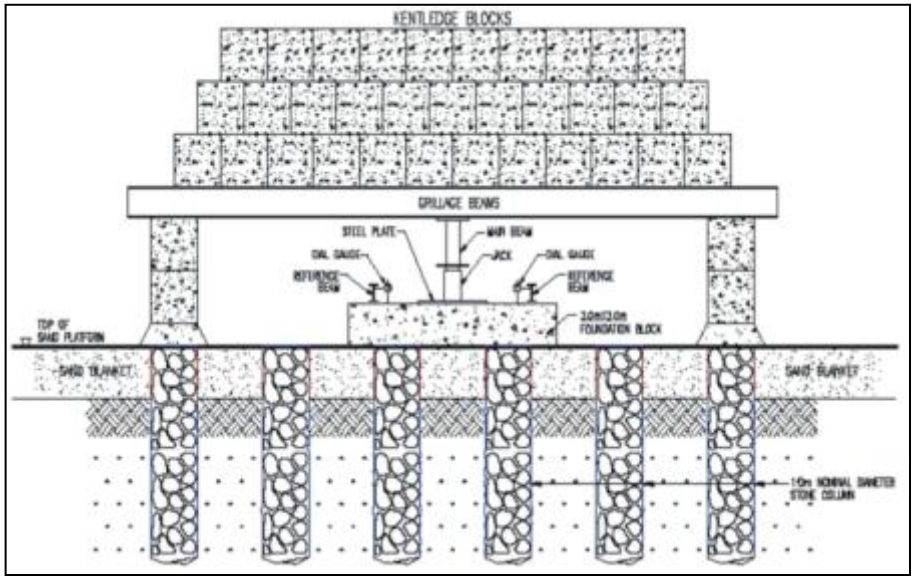


Typical Specification

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*

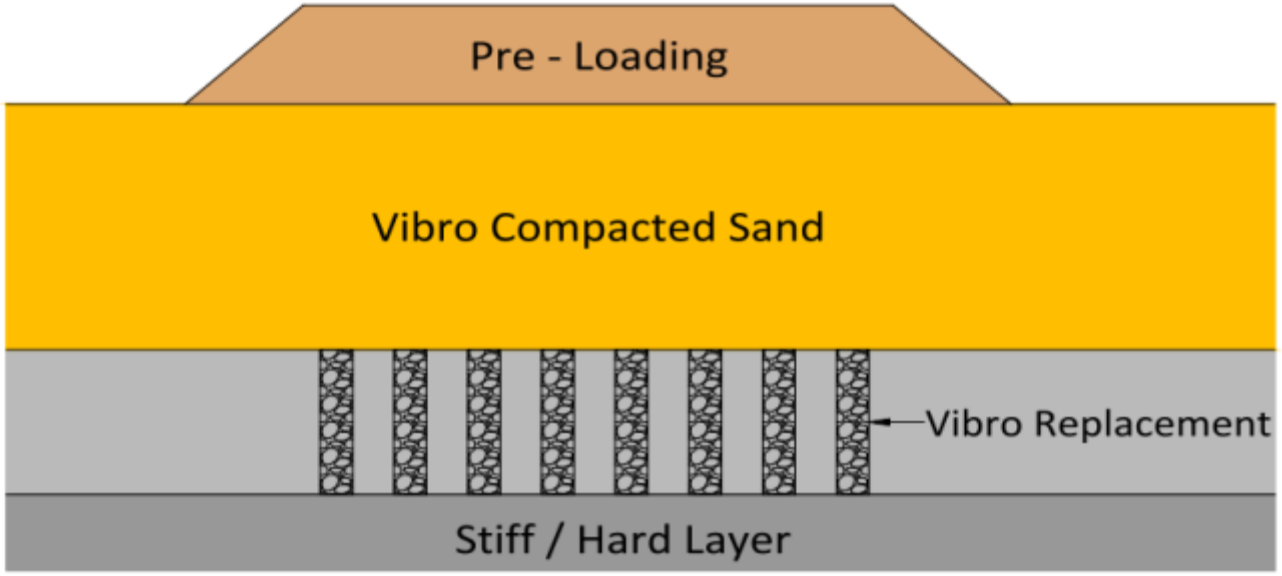




Full Scale Simulation

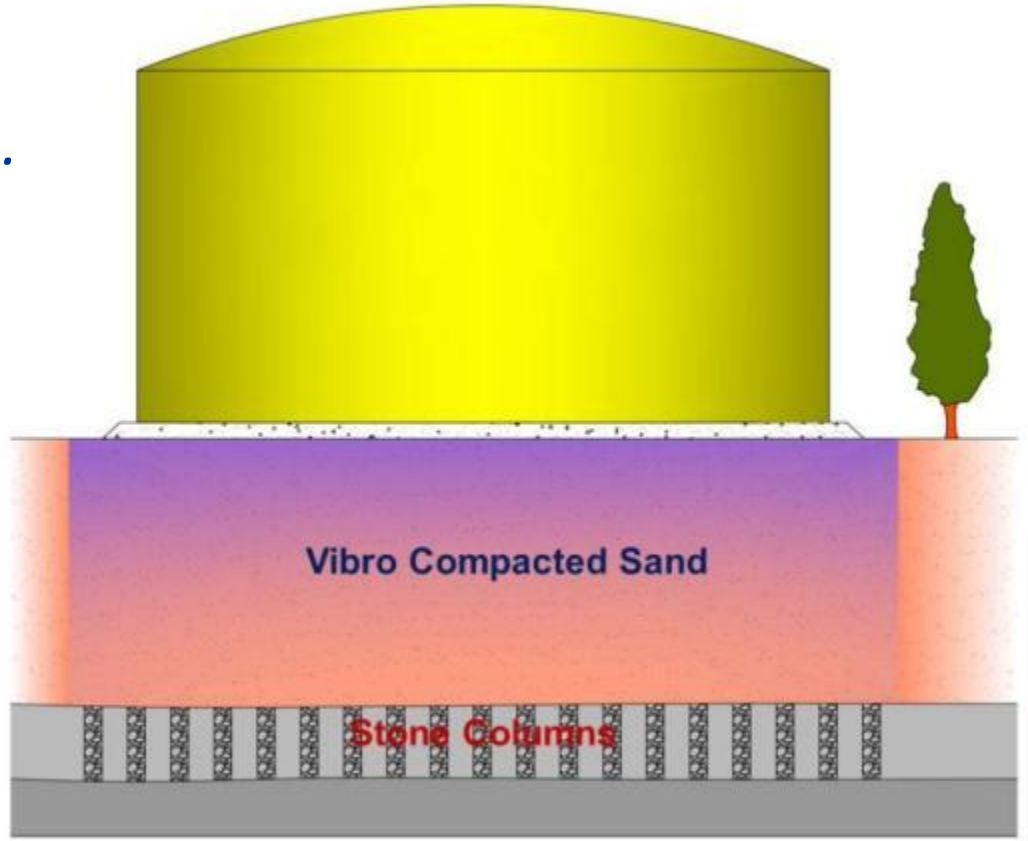
❑ Zone Tests

- *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 ...