
Modified Dry Mixing (MDM)
a new possibility in Deep Mixing
LCTechnology
Hercules

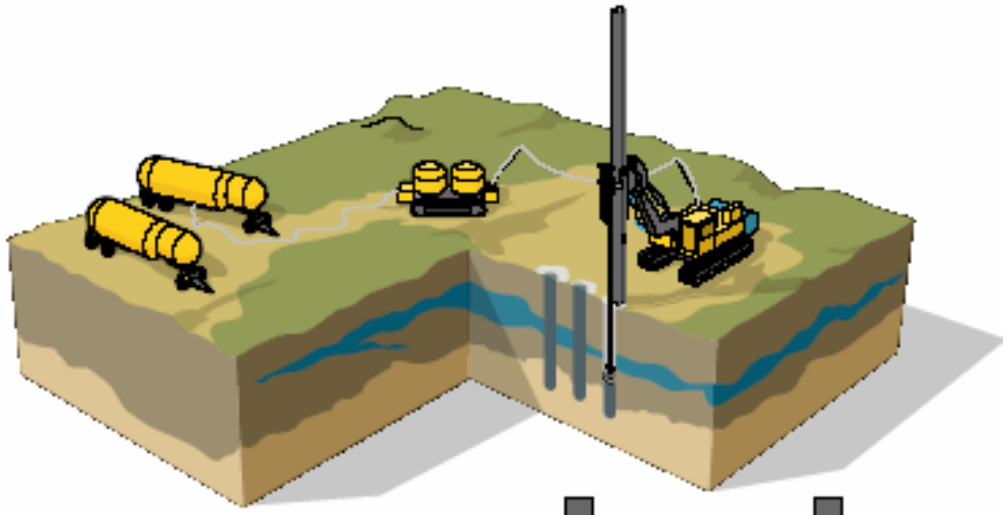
MDM Presentation

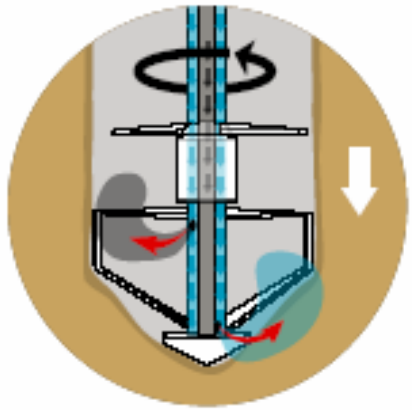
- Process
- Applications
- Case history
- Equipment
- Control, QA/QC
- General

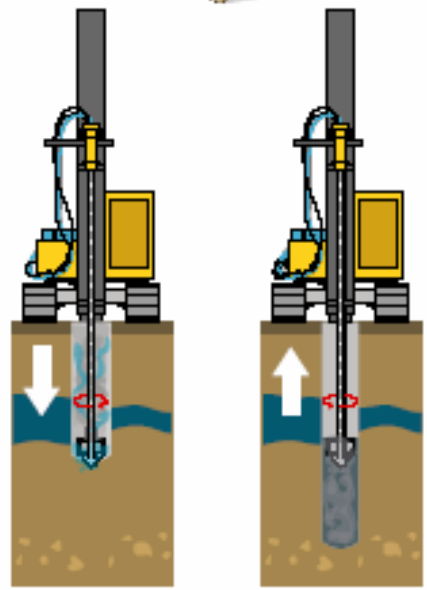
Process

MDM™
Modified Dry Method

Logistics and Execution Principles

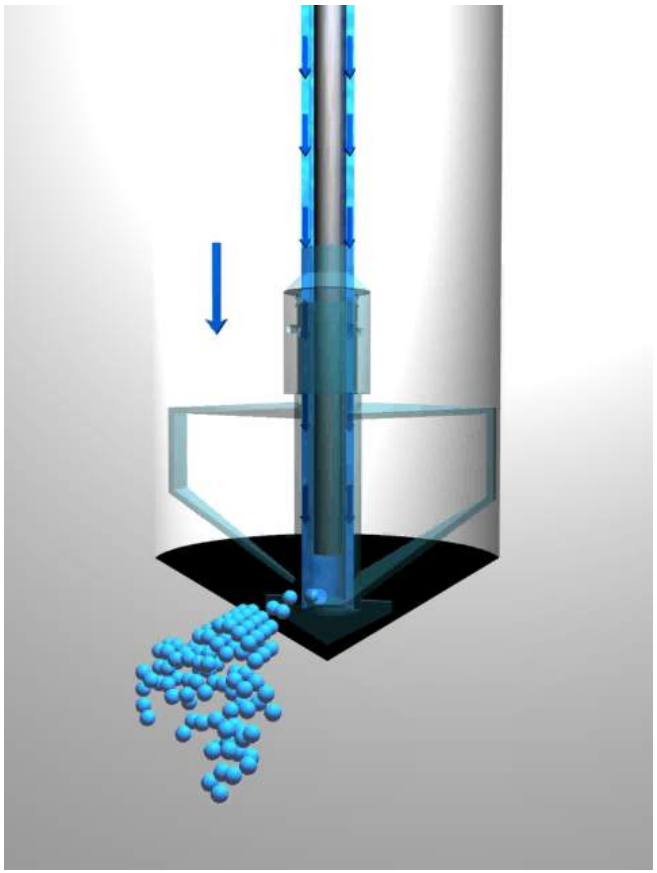






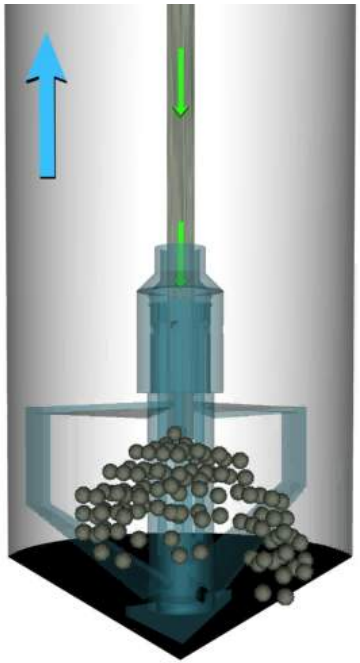
- Improves dry soils
- Penetrates stiff soils
- Optimizes mixability
- Activates the binder
- Minimizes spoil

The MDM Process - Penetration



- Purpose
  - Improved mixing capabilities
  - Improved penetration capabilities
- Increased water content
  - Increased sensitivity
  - Increased liquidity index
- Fluidisation of the soil
  - Mechanical
  - Hydraulic
- Computer controlled Zone program
  - Water flow/pressure
  - Penetration speed
  - Binder delivery, part of total

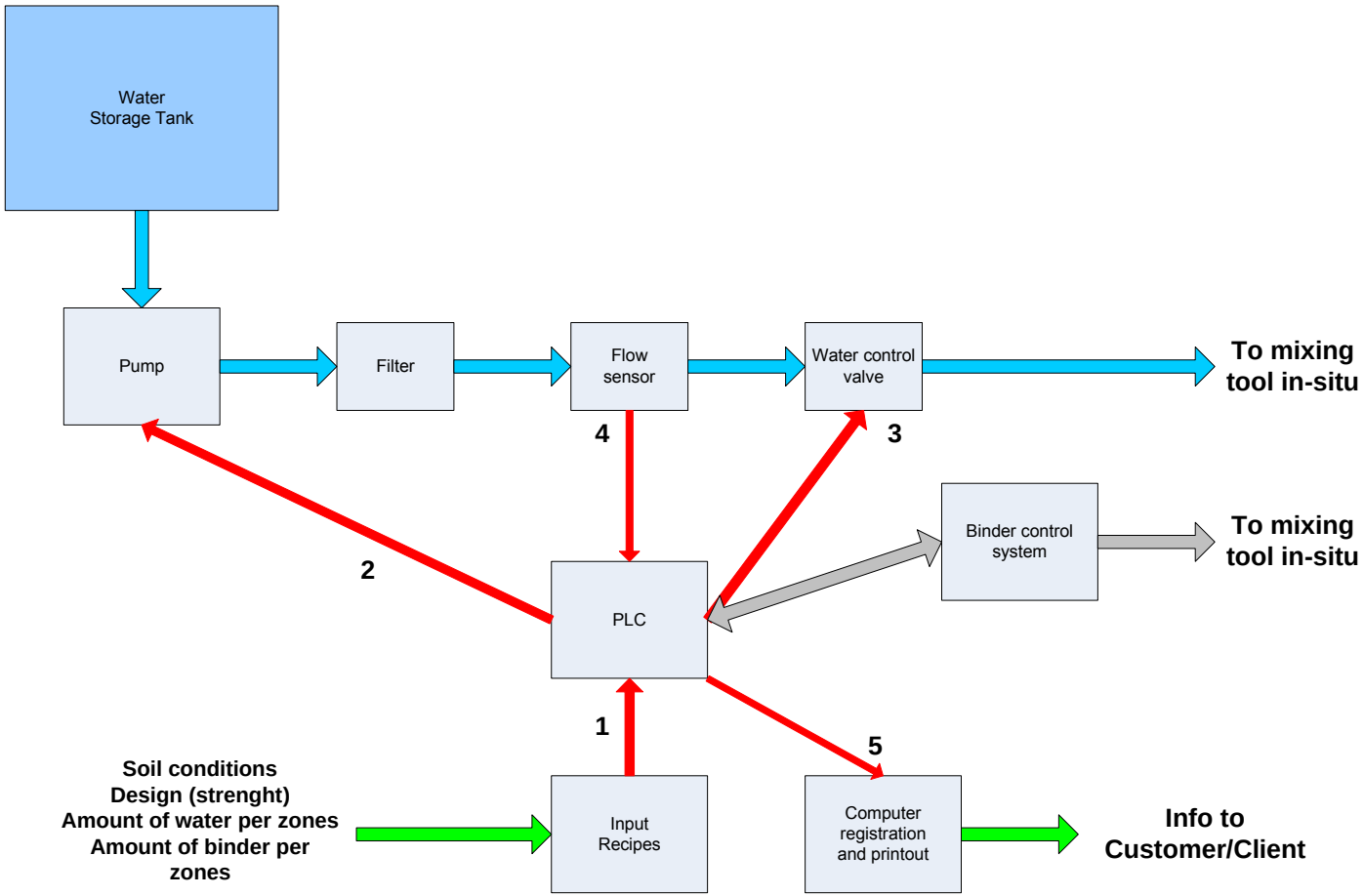
The MDM Process - Retrieval



- **Purpose**
  - Optimize final mixing of binder and in-situ material
- **Introduction of dry binder**
  - Balance of binder total
  - Additional water if needed
- **Computer controlled Zone program**
  - Binder delivery
  - Mixing energy
  - Retrieval speed

MDM schematic overview

Water control



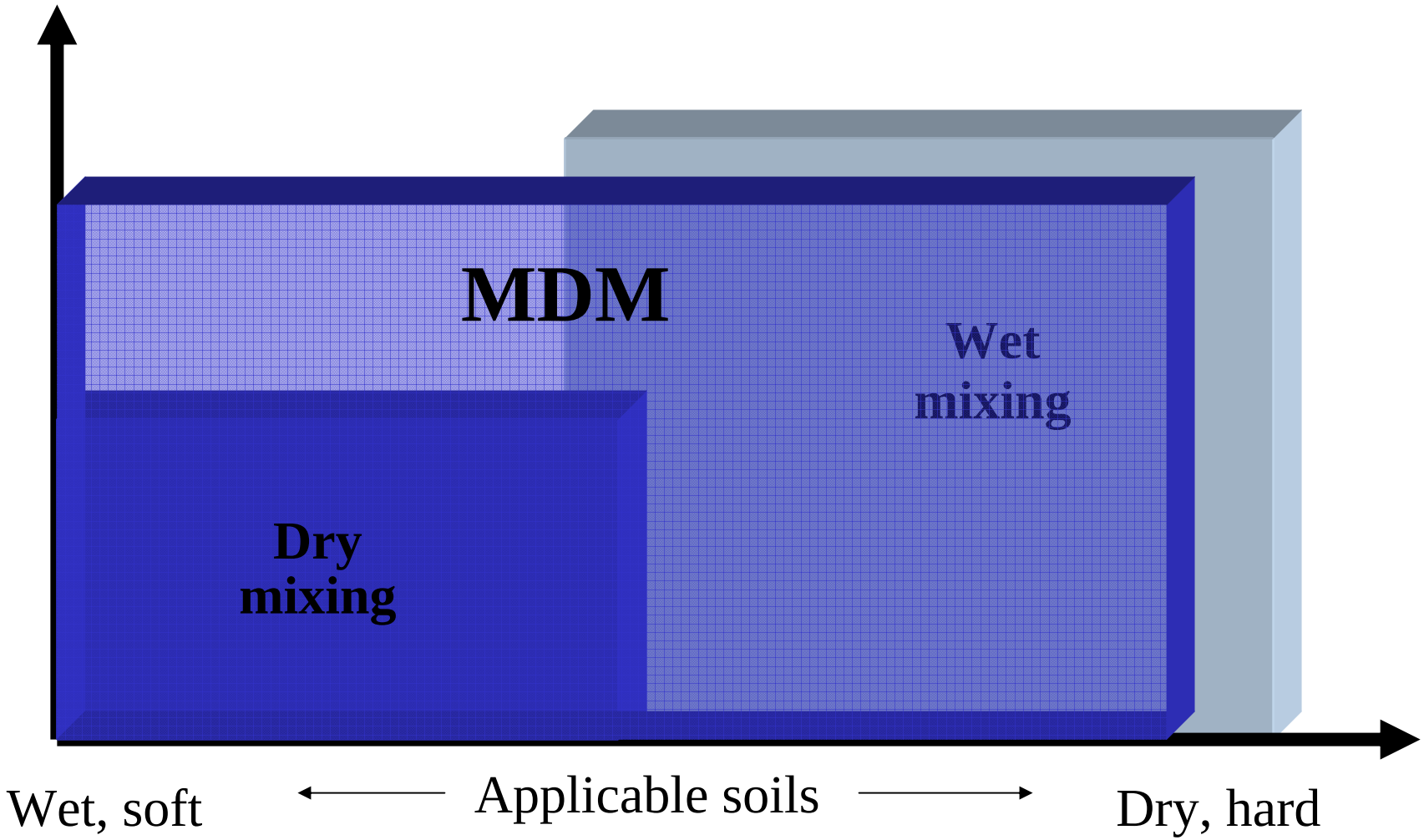
Applications

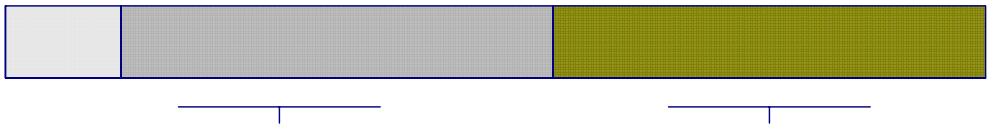
Applications

- Embankments
- Levee walls
- Foundations
- Retaining walls
- Cut – off walls
- Soil remediation

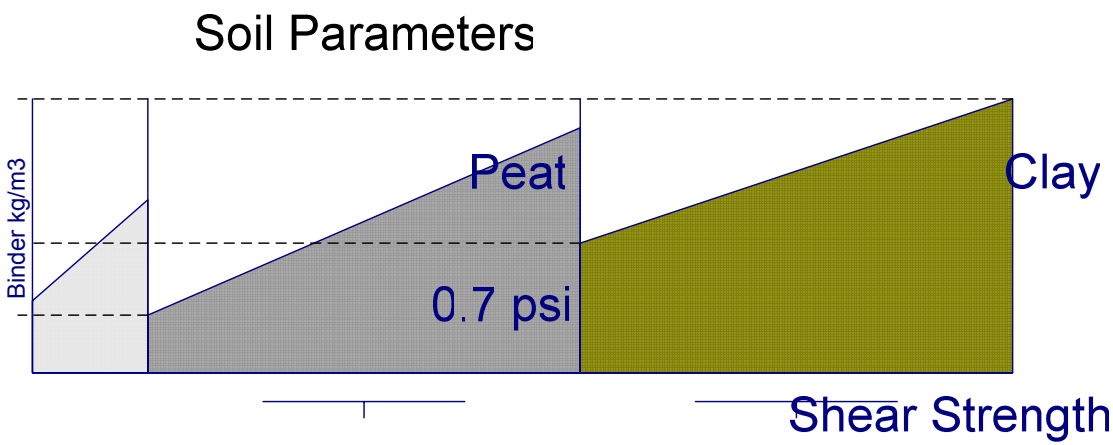
Column Strength

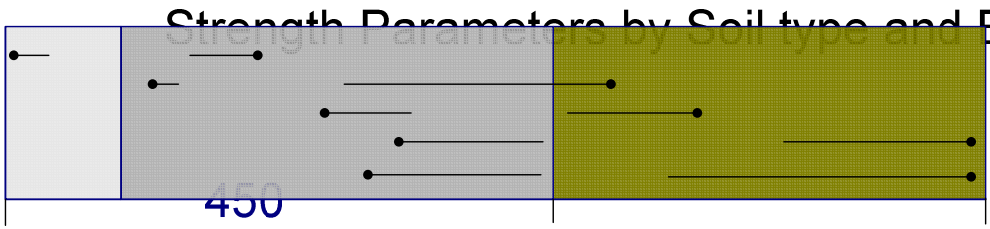
Versatility of MDM





Quick Guide to Applications





Major advantages MDM

- Combines the advantages from the wet and dry mixing
- Widens the range of applications using the same equipment
- Amount binder can be varied in zones (different strengths)

- Applicable in a wide spectrum of soils
  - dry/wet
  - soft/stiff
- Tailor-made columns
  - Optimized water content
  - Optimized binder content
- No surface spoil
- Computerized process control
- Light, mobile equipment 5-8 psi ground pressure

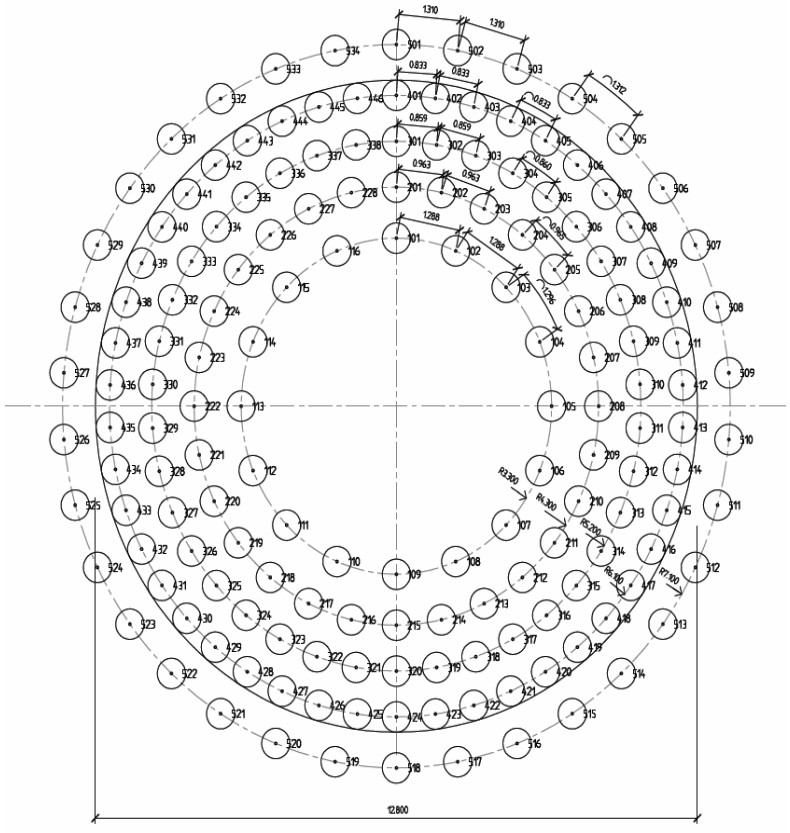
Case histories

- Wind power plant
- Foundation parking garage (more on cd)
- Field test sand, single mixed (more on cd)
- Field test clay, single mixed (more on cd)
- Technical papers on cd, soil mixing and liquefaction

MDM™ – Foundation of wind power plant

- Client: Enercon/Eolus vind
- L_{col} = 6 m
- D_{col} = 600 mm
- 162 columns
- Load: 180 – 280 kN

Odensbacken - Specification



- Allowable ground pressure 312 kPa
- Dynamic modulus 346 MPa
- Differential settlement ≤ 3 mm/m

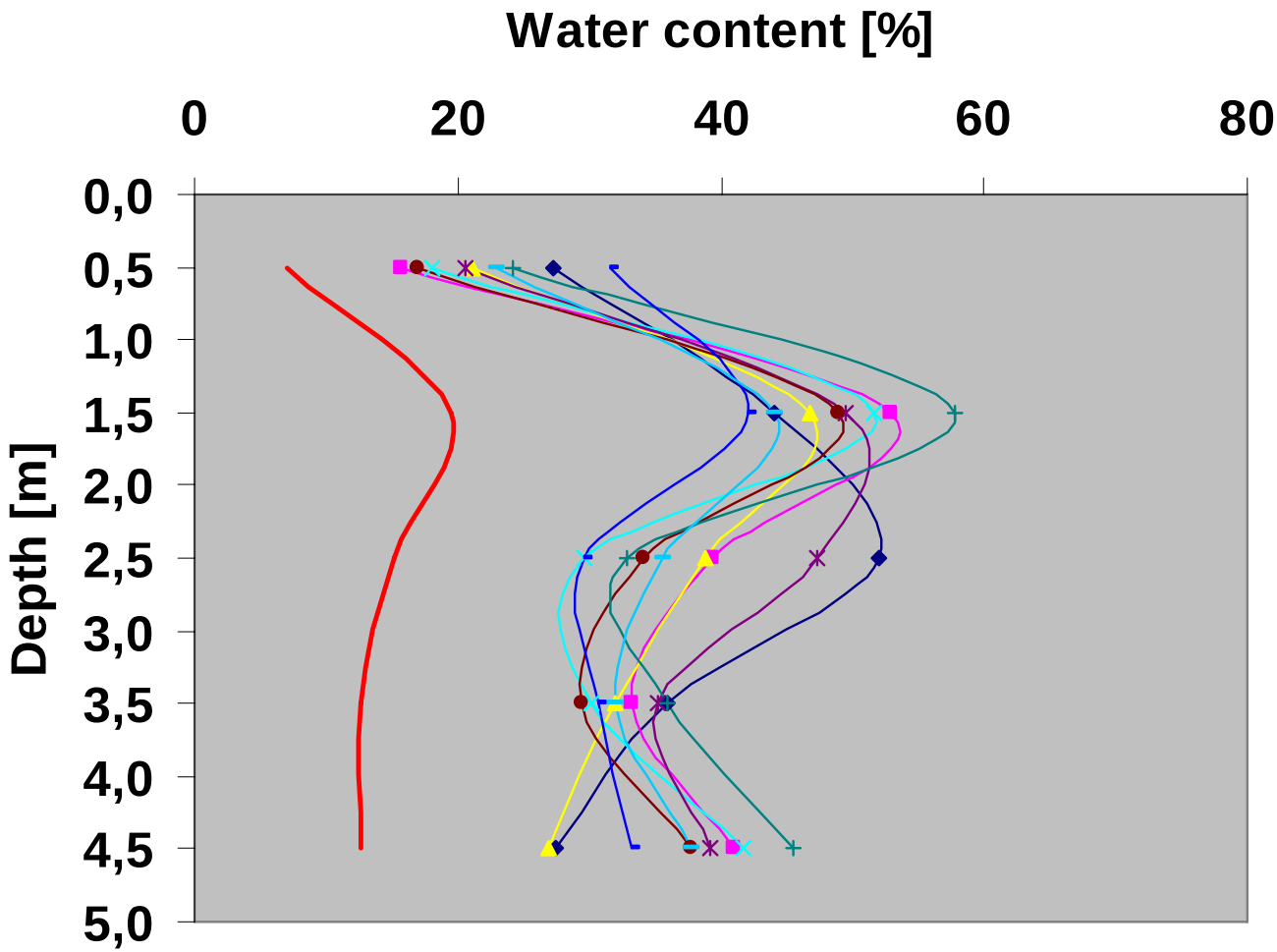
Parking House founded on MDM™ - columns

- Columns installed in blocks
  - 3 to 16 columns/block
  - 600 mm columns
  - 14 to 16 m length
- Column strength
  - Average 9 MPa
  - 3 to 17 MPa
- Column load
  - 250 to 300 kN

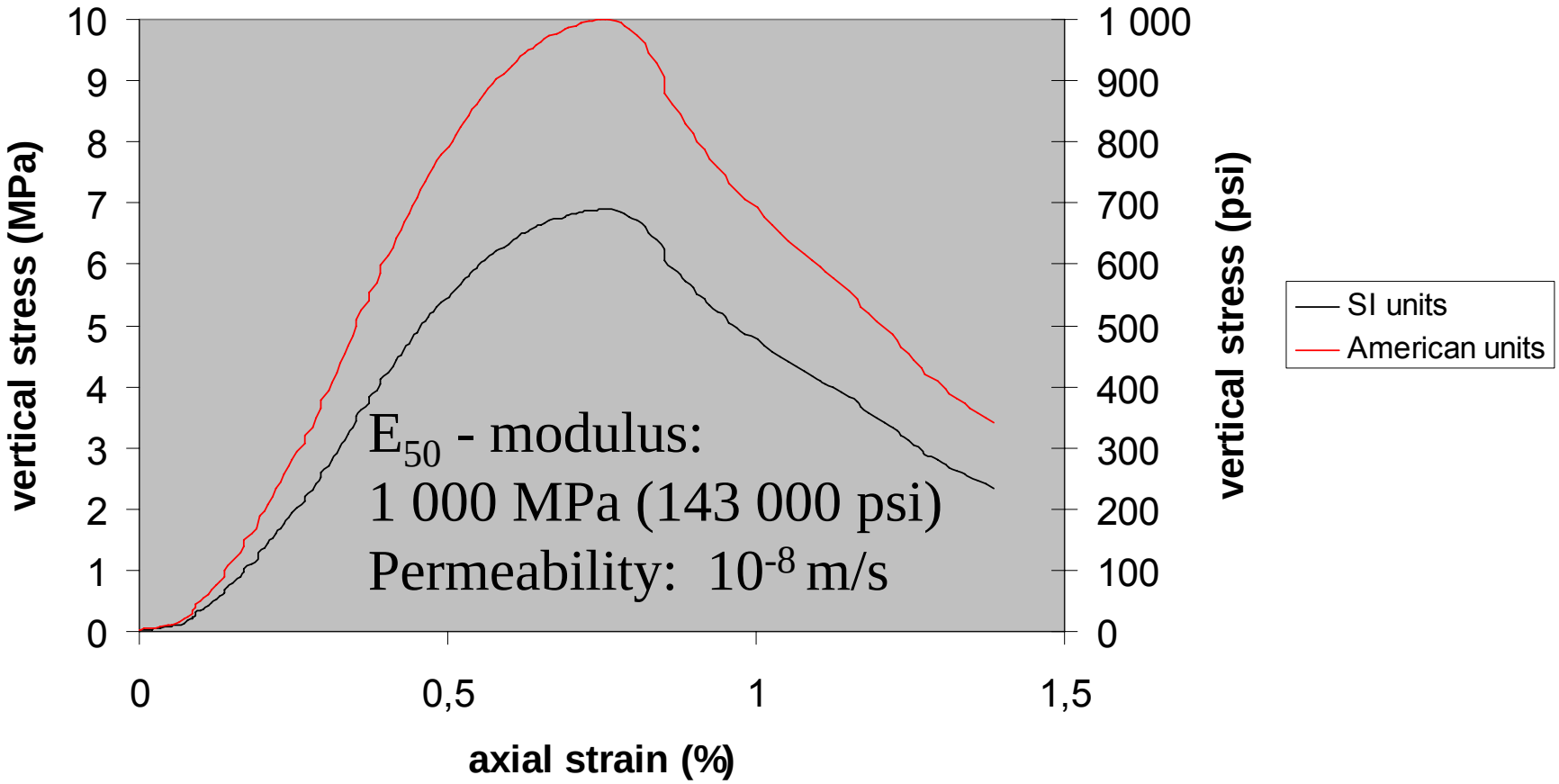
Field test in stiff “dry” sand, Sweden

- Existing soil parameters
  - Fine to medium sand
  - q_c-value 200 – 300 tsf
  - water content 5 – 15%
- Column parameters
  - Diameter 31.5 in
  - Length 33 ft
  - Binder content 28 lb/ft^3

Water content; before & after installation



Unconfined compression strength



Field test in very soft clay, Sweden

- Soil parameters
  - Very soft clay
  - Shear strength: 3–5 psi
  - Water content: 60–80%
  - Liquidity index: 0.6–1.1
- Column parameters
  - Diameter 24 in
  - Length 33 ft
  - Binder content 28 lb/ft^3

Achieved results

- Improved homogeneity
  - Compared to dry mixing
- Coefficient of variation
  - 15 to 30%
- Compressive strength:
  - q=834 psi

Equipment

Deep Mixing Equipment

MDM

Wet **Dry**

MDM
Deep Mixing Equipment

Wet and Dry
Deep Mixing Equipment

QA/QC

QA/QC.

In-Situ processes inherently suffers from a delay in QC answers and lack of predictable quality. With MDM we can:

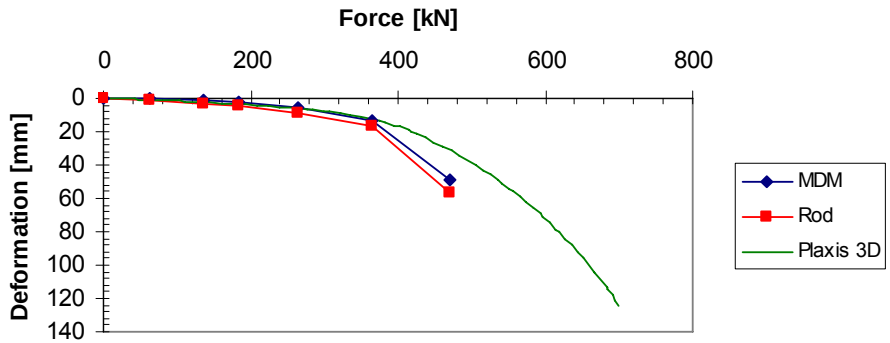
- Minimize variability of soil parameters by “normalizing” soil conditions
- Reduce unpredictability by refining the installation process
- Achieve a high degree of repeatability from column to column

QA/QC of MDM – columns

- Wet grab sampling
- Core drilling with UCT's
- Pressure meter testing
- Extraction of complete columns (pull up)
- Live load testing
- Detailed recording of column installation properties

Extraction of columns – Static load test

- Pullout force 510 – 610 kN (114-137 kipf)
- Age 2 weeks
- Weight 45 kN (10kipf) density 2.27 ton/m^3
- Cohesion 39 – 46 kPa



Product quality

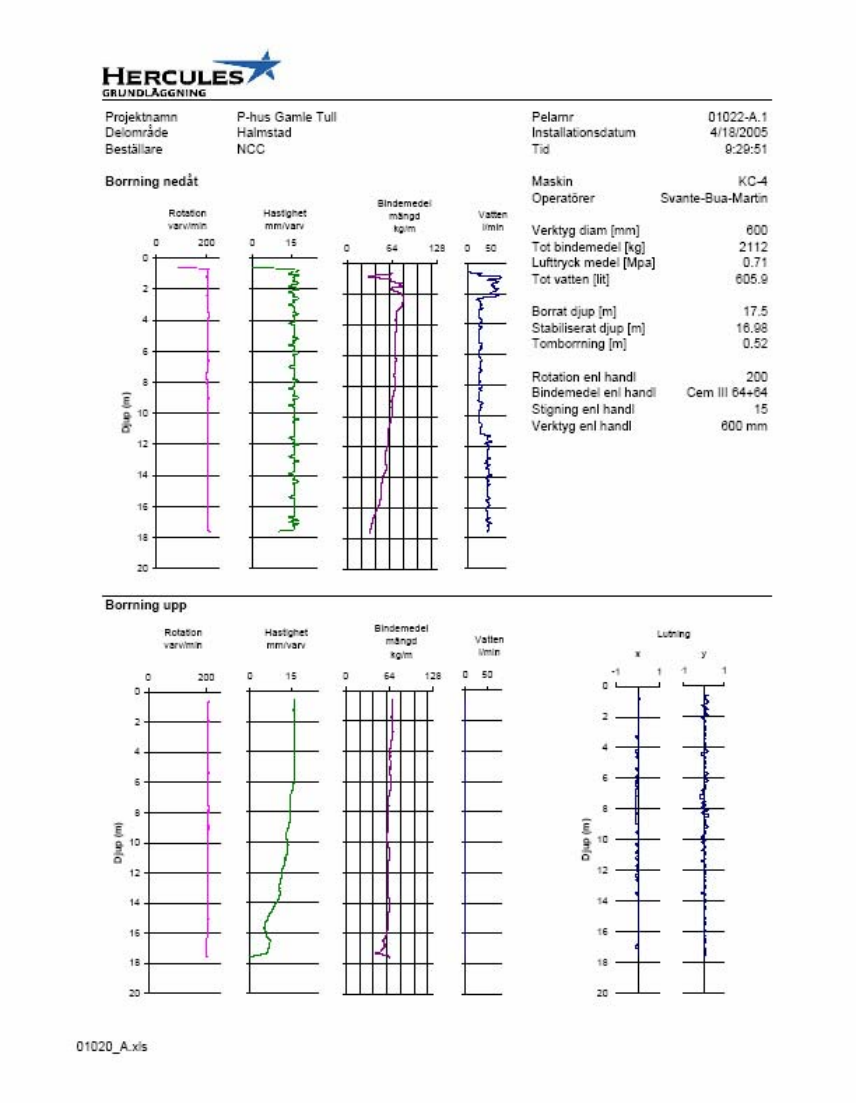
Columns in block

Mid section cut off

Product quality

Core samples

Computer Controlled Installation



Visual control during installation

Visual Inspection of Extracted Columns

General

MDM patents

- 4 Issued US patents
- 2 Pending US patents
- Trademarks

Conclusions:

- Sufficient available water is needed for proper hydration of the binder as well as for uniform mixing to take place.
- To produce a uniform column the amount of available water needs to be uniform.
- Low L.I. (0.5) is suitable only for strengths of <20 psi. Over 30 psi the L.I. needs to be 0.75 or higher.

Summary:

- By optimizing the water content with MDM™ the binder is utilized more efficiently.
- By adding water to the process, stronger and more uniform columns can be created. (more binder req. more water)
- Optimized utilization of the binder, can be varied in zones
- With an MDM™ high quality column the replacement ratio, or number of columns, can be reduced.
- Homogenous columns allow for good uniform core sampling
- Q/A is achieved by consistently producing a column with a high degree of efficiency.

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