

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

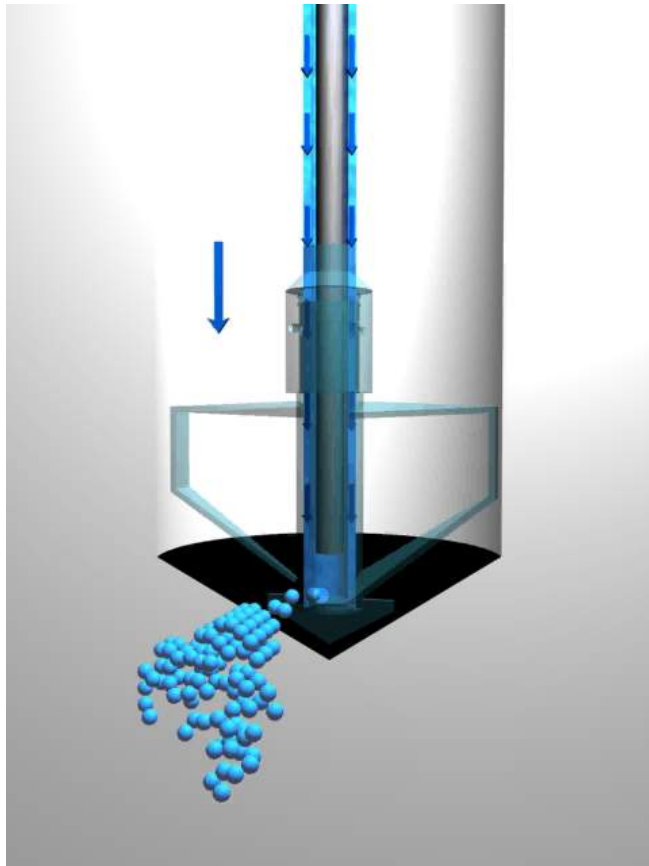


**LCTechnology
Hercules**

Structure of presentation

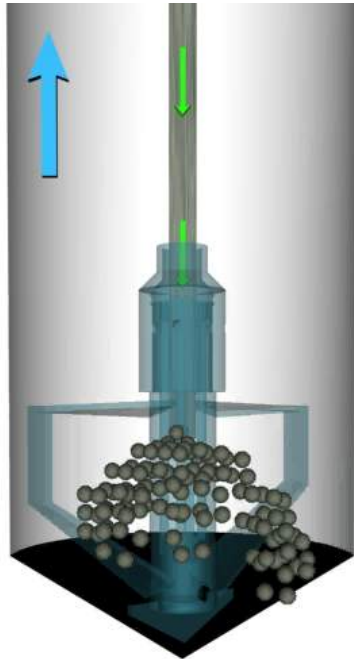
1. The MDM process
2. The MDM system – new possibilities
3. Major advantages
4. Field tests
5. QC of MDM columns
6. Applications
7. Summary of main points

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
- Zone program
- Computer controlled
 - Water flow/pressure
 - Penetration speed

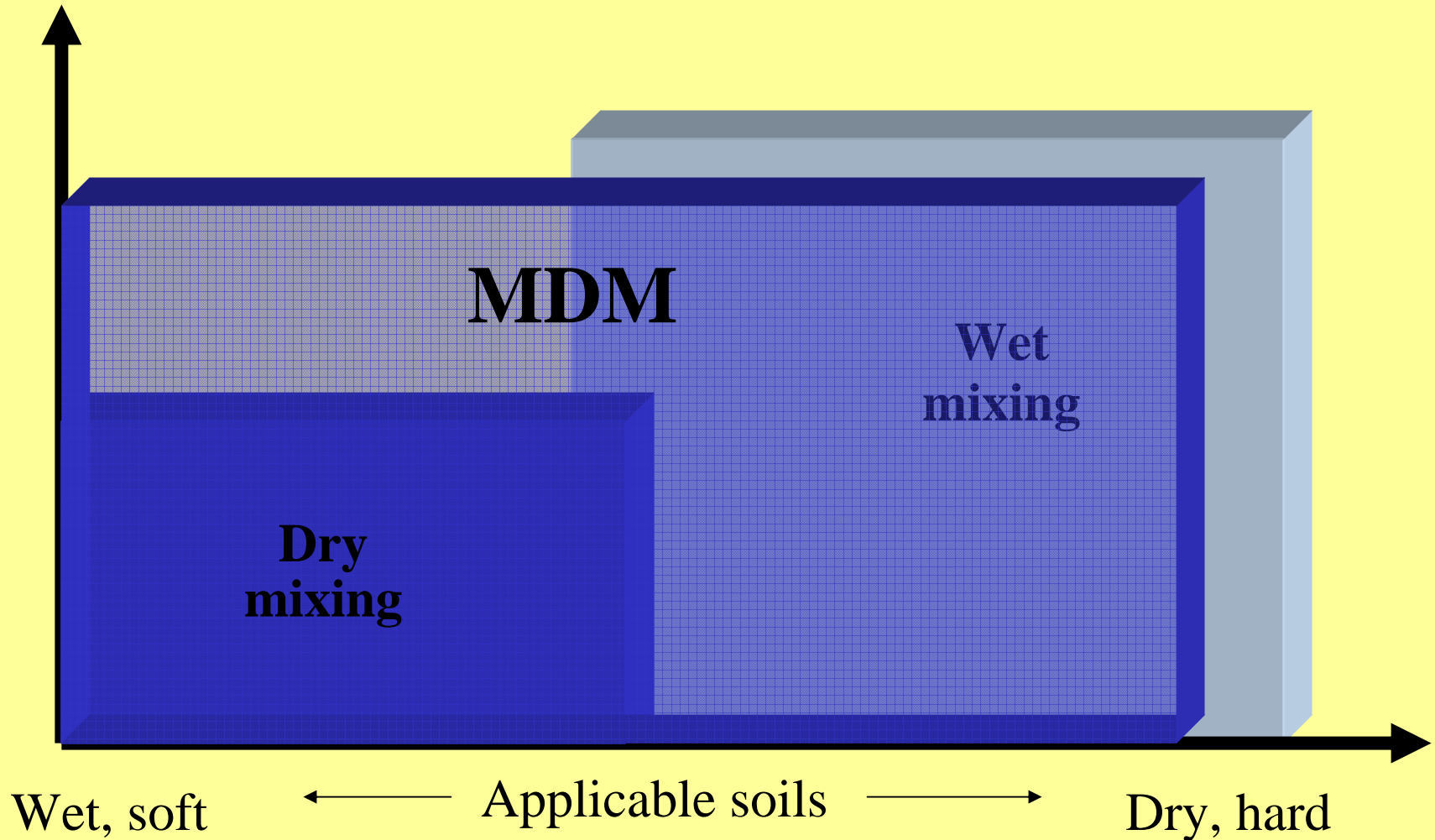
The MDM Process - Retrieval



- Purpose
 - Optimize mixing of binder
- Introduction of dry binder
- Zone program
- Computer controlled
 - Binder content
 - Mixing energy

Column
Strength

Versatility of MDM



Deep Mixing Equipment

Wet MDM Dry



Major advantages



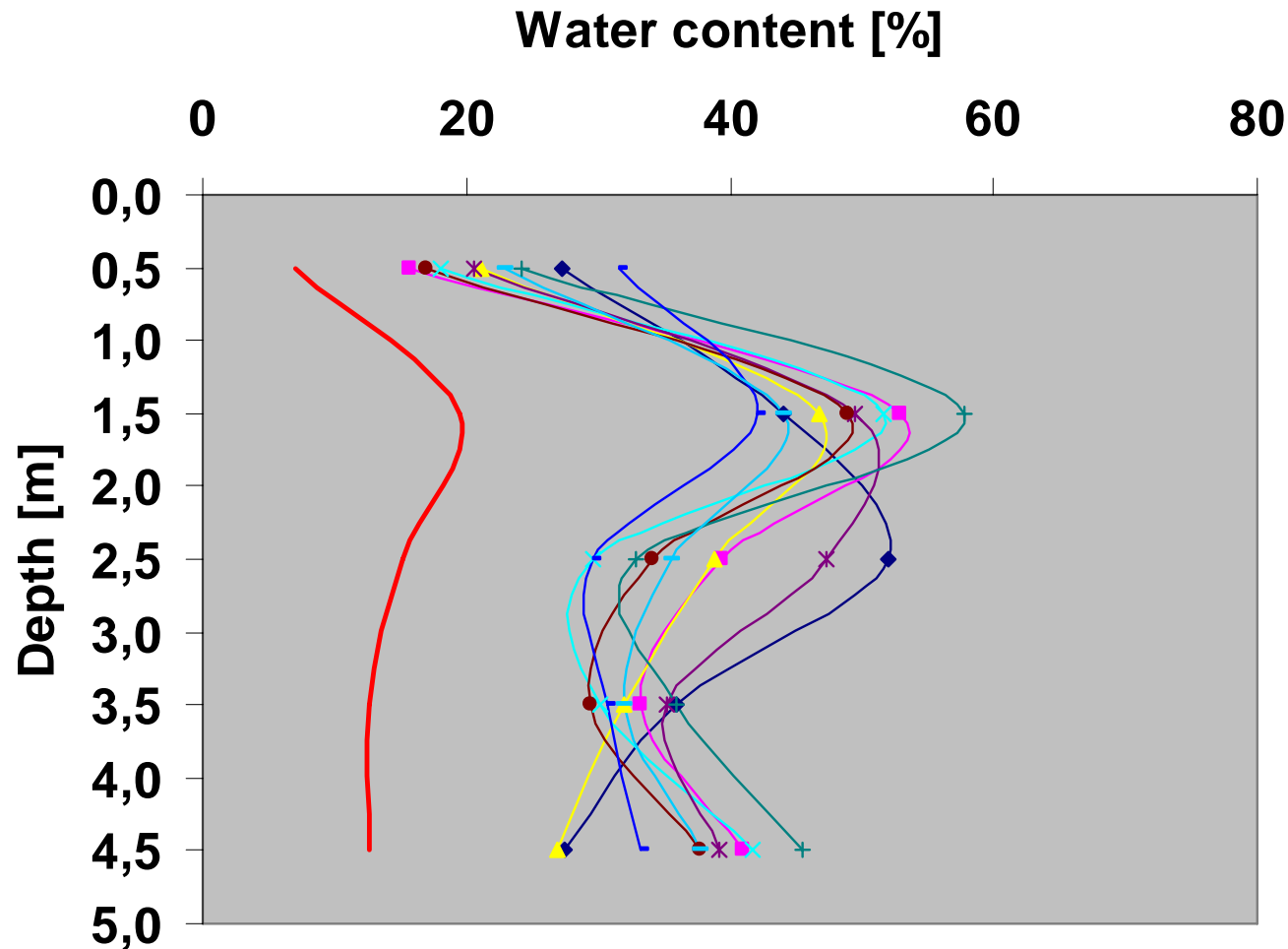
- Wide spectrum of soils
 - dry/wet
 - soft/stiff
- Tailor-made columns
 - Optimized water content
 - Optimized binder content
- No surface spoil
- Computerised process control
- Same equipment for wet & dry mixing

Field test in stiff “dry” sand, Sweden

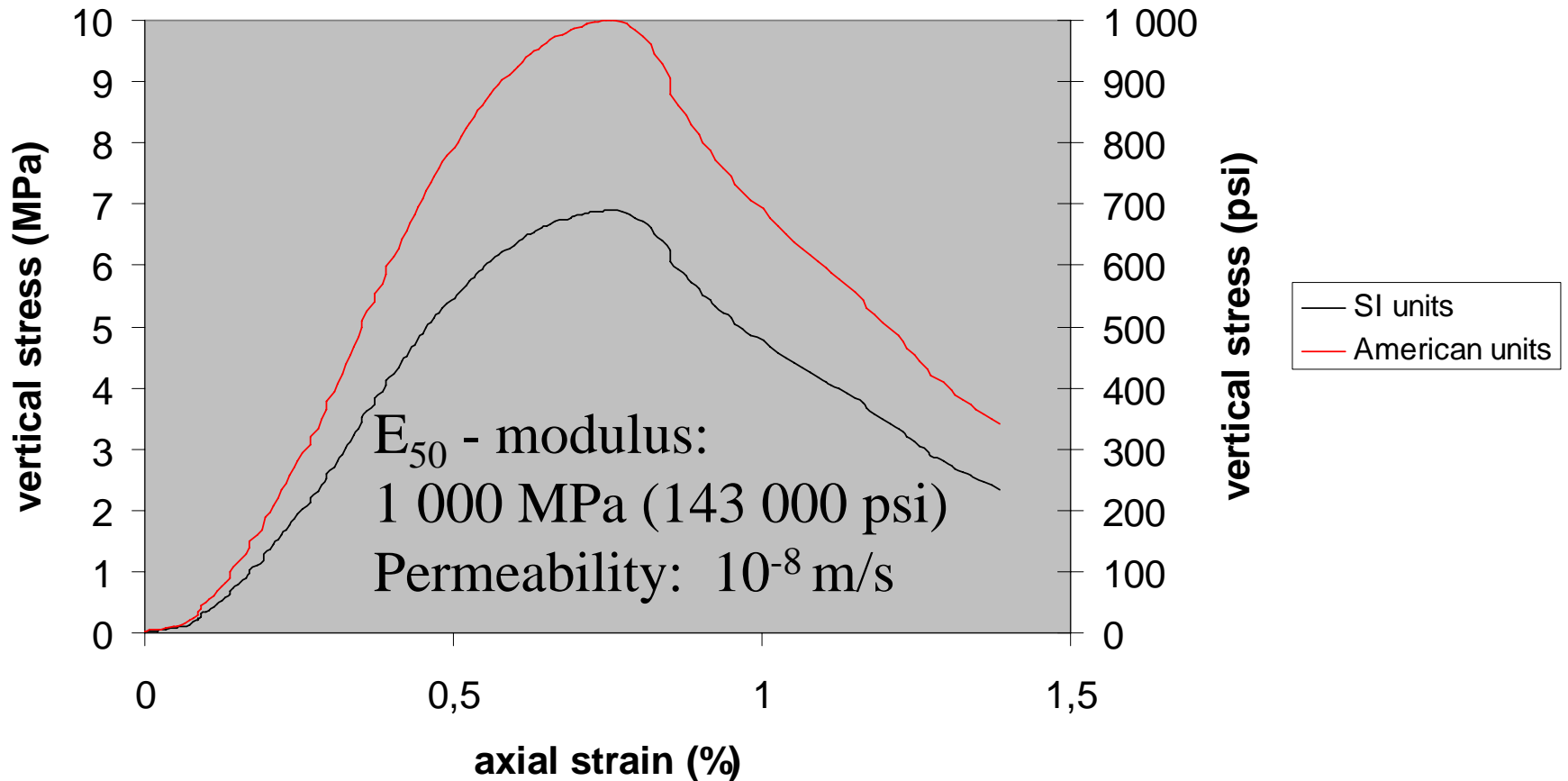


- Existing soil parameters
 - Fine to medium sand
 - q_c -value 200 – 300 tsf
 - water content 5 – 15%
- Column parameters
 - Diameter 31.5 in
 - Length 33 ft
 - Binder content 28 lb/ft³

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/ft³

Achieved results



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

Field test in September 2004 – very soft clay

- Purpose
 - Behaviour of two test embankments
 - Design column strength
 - Comparison between Dry mixing & MDM regarding behaviour & cost efficiency
 - Mixing tool evaluations
- Performed in conjunction with Swedish Road Authority
- Control objectives
 - Settlement
 - Strength
 - UCS
 - CD Triaxial
 - CU Triaxial
 - Variation of strength
 - Pore pressure
 - Chemical analysis (Ca)
 - Behaviour of geogrid (load transfer platform)

QC of MDM – columns



- Core sampling
- Load testing
- Pressure meter
- ICT[®] (Instant Core Testing, under development)
- Detailed recording of column properties

Applications

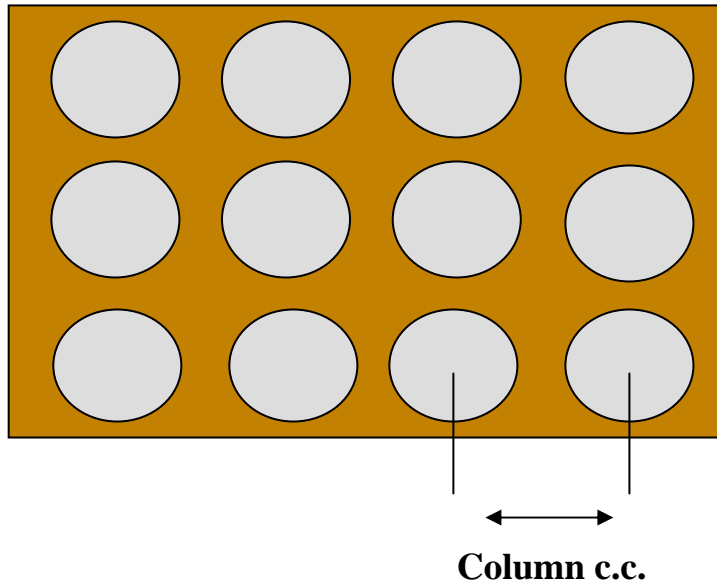


- Embankments
- **Levee walls**
- **Foundation**
- **Retaining walls**
- **Cut – off walls**

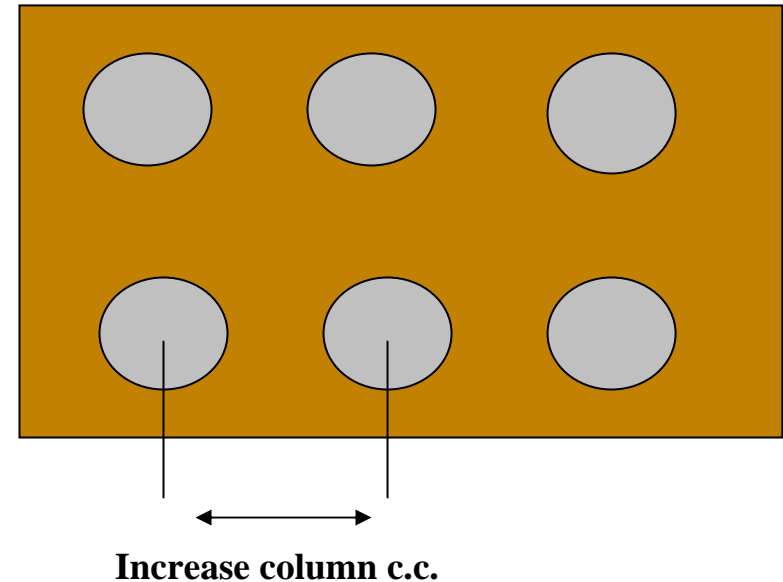
Modified Dry Mixing™

Differences in design compared to dry mixing for embankments:

Standard Dry Mix

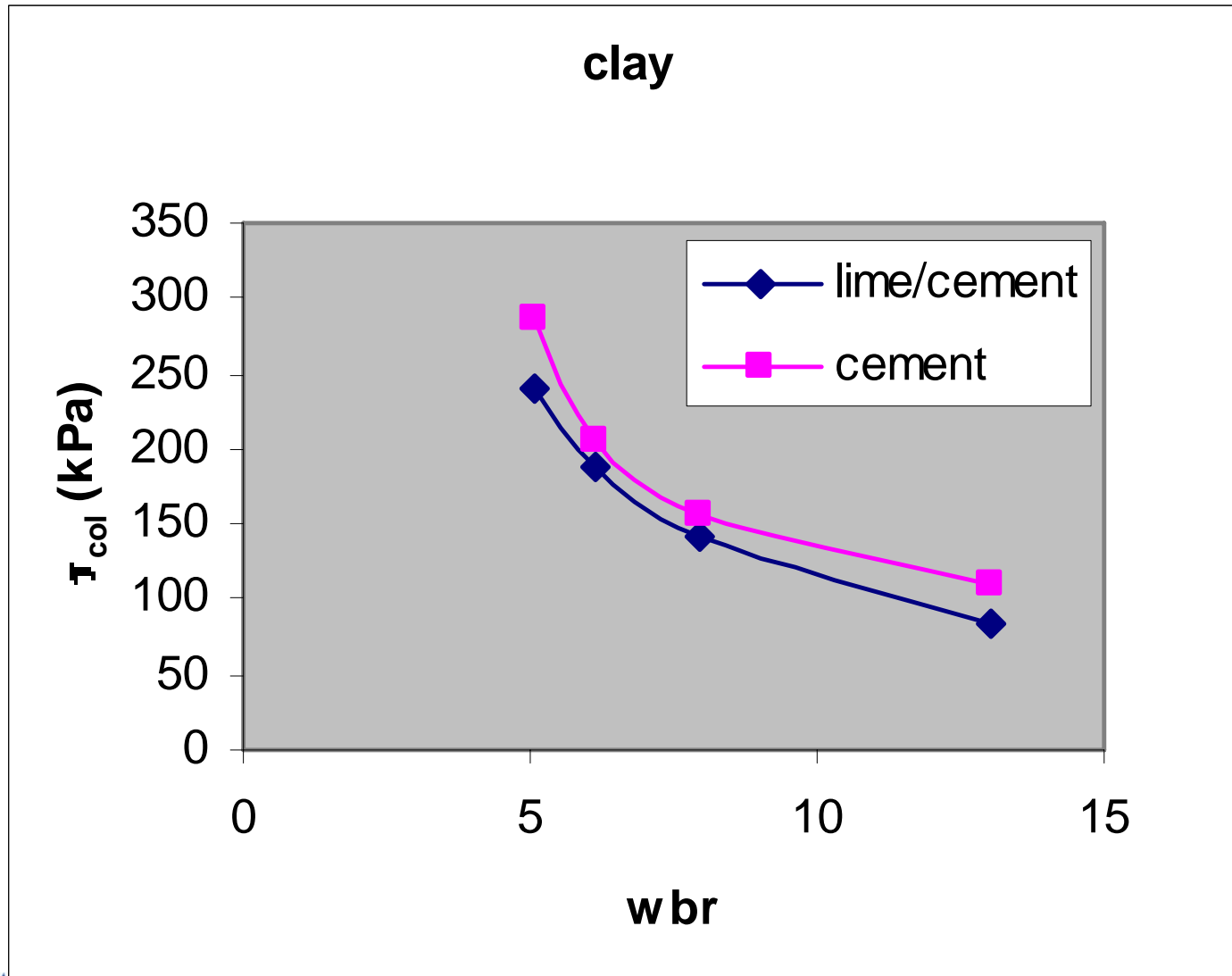


Modified Dry Method™

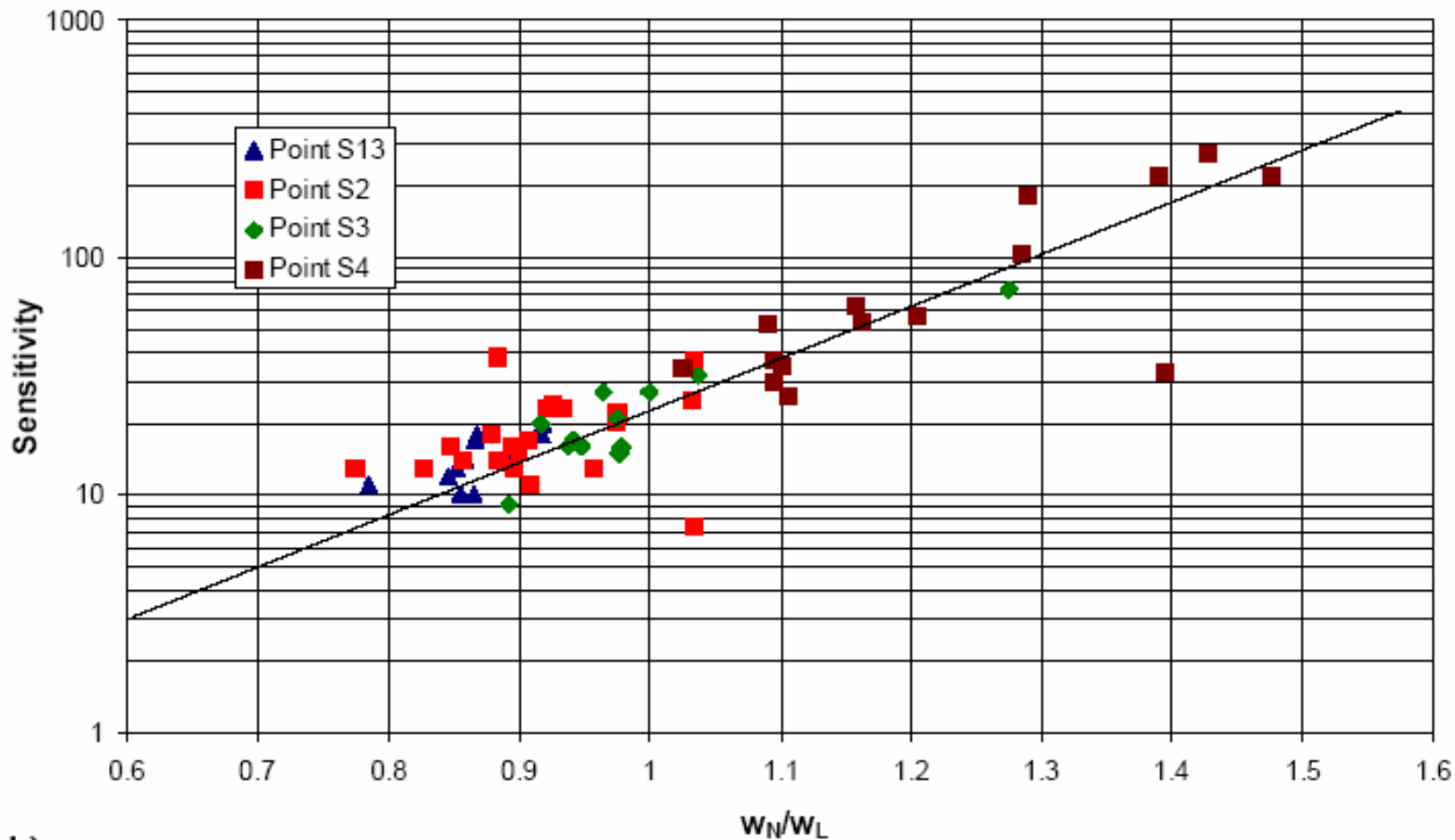


- **Increase column c.c. with MDM™ and reduce # of columns needed for a given load.**
- **Reduces installation time and overall project cost.**

Strength vs water cement ratio

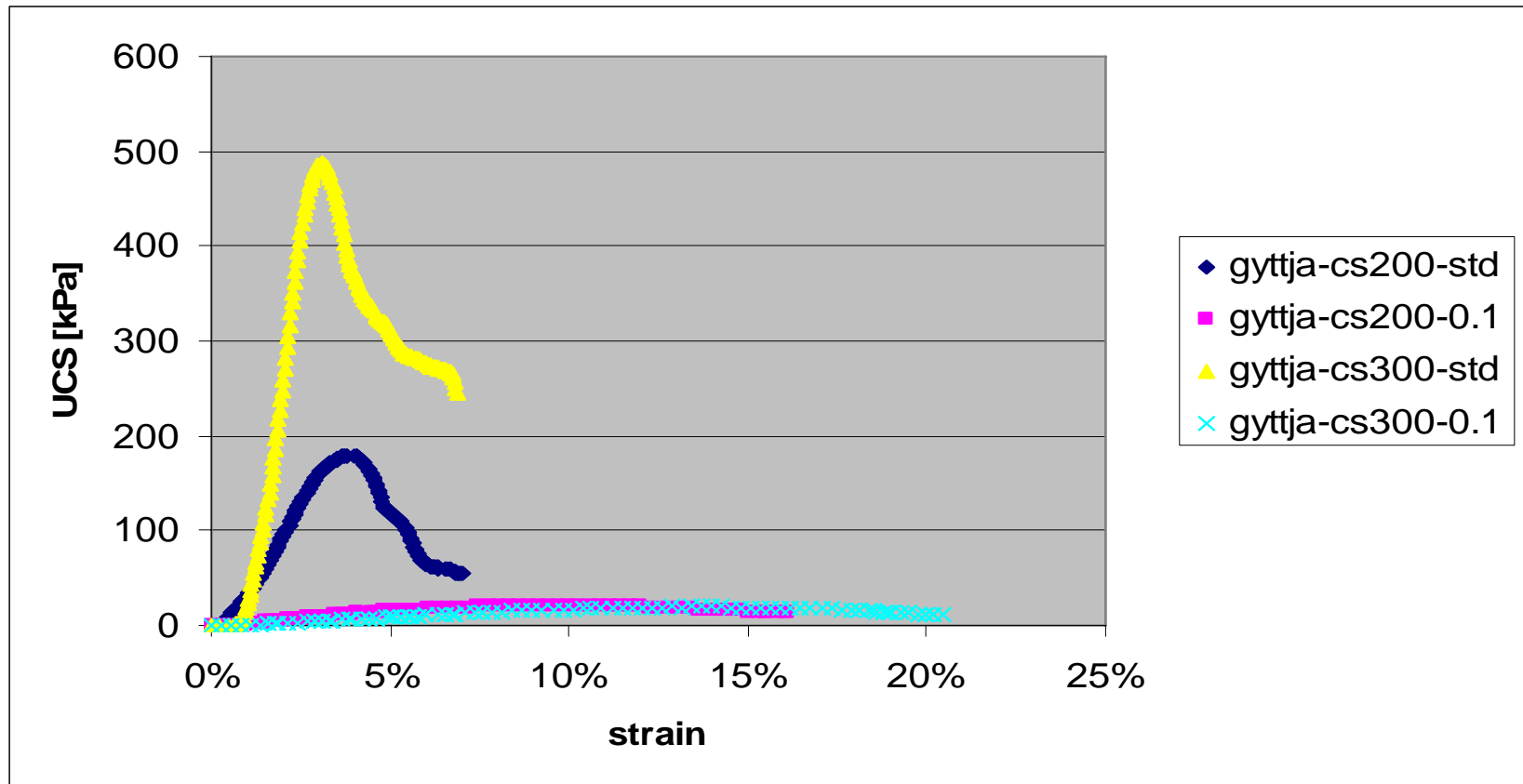


Sensitivity vs “liquidity index”



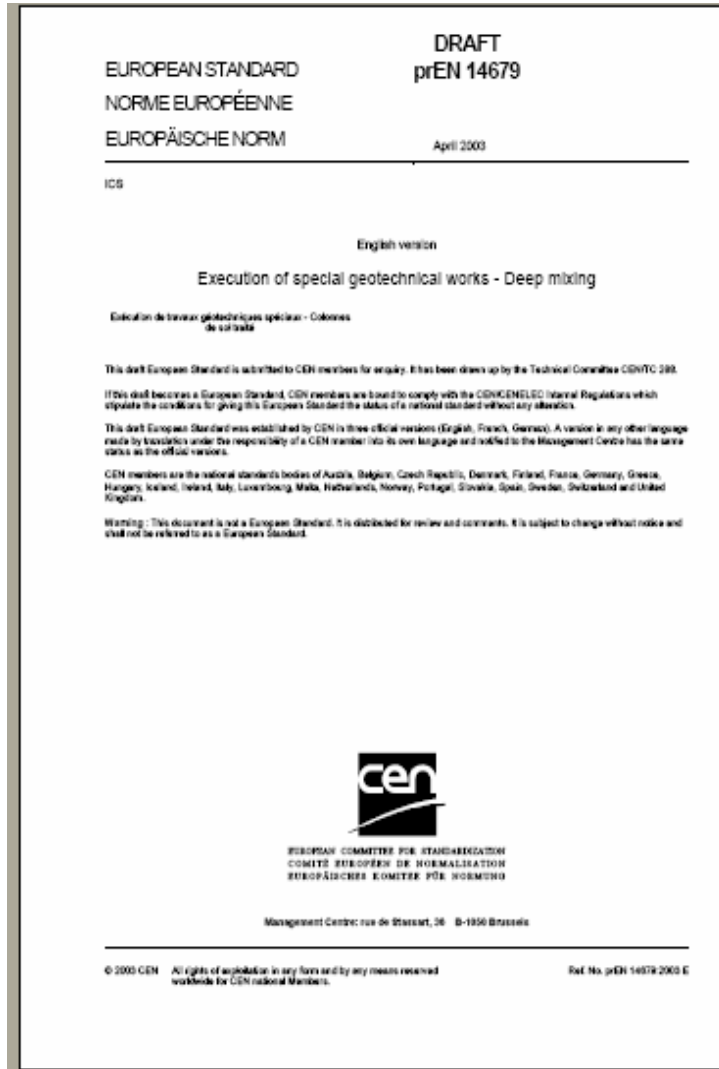
b)

Effect of mixing energy





Eurocode – Deep Mixing



- Deep Mixing
 - Dry Mixing
 - Wet mixing
- Unified definitions
- MDM included