MDM presentation

Version 06.01.03

Part 1

Standard Dry Mix Method
(Lime Cement columns)

Standard
Dry Mix columns
System overview

Applications

- Organic soils
- Soft clays
- Silty clay
- Clayey silt
- Sandy soils

Usage

- Road & Rail road embankments
- Slope stabilization
- Excavations
- Industrial buildings
- Remediation of contaminated soil

Standard Dry Mix columns

Installation parameters

- Column diameter: 20 – 32 inches
- Column depth: up to 82 feet
- Installation capacity: 190-240 lft/hour
- Amount of binder: 120 – 420 lbs/cu.yd
- Mixer rotation: 100 – 250 rpm
- Column strength: ~ 200 kpa (30 psi)
- Permeability: over $5 \times 10^{-7} cm/s$

- Requirements: Needs >20% water content.
- Works best in soft soils.

Standard Dry Mix columns

Hercules' tool & machine

Standard Dry Mix columns

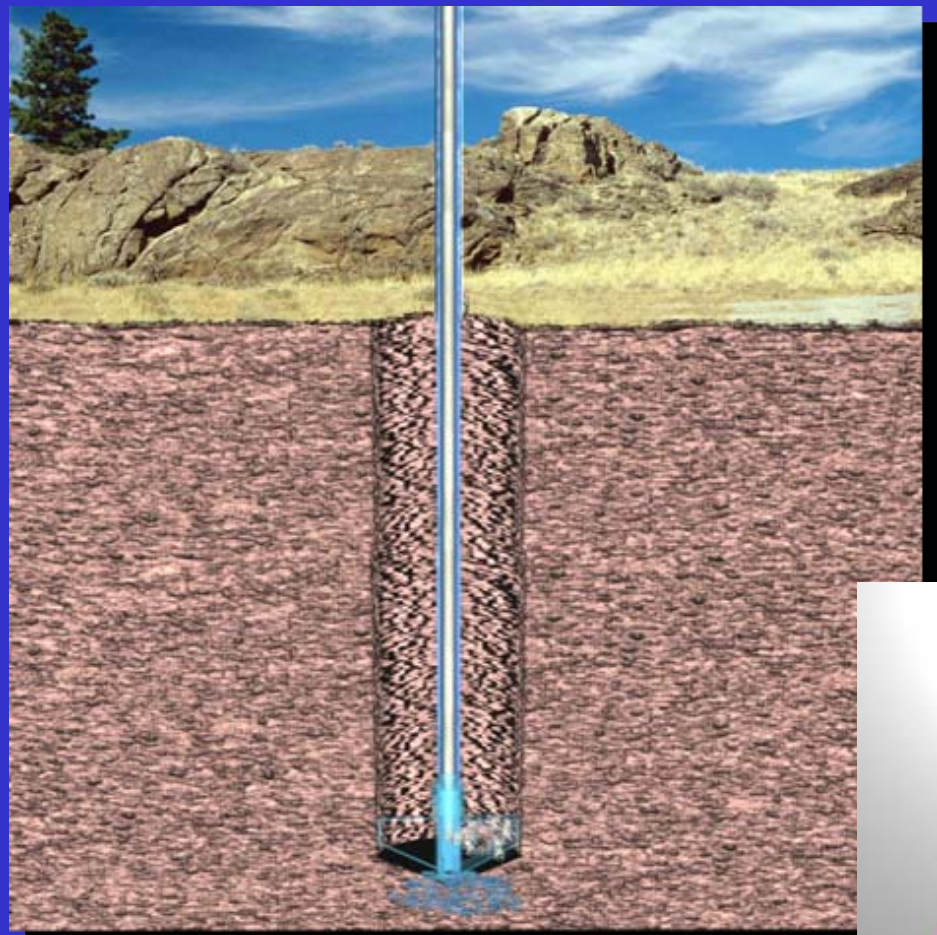
Skanska’s tool & machine

Part 2

Modified Dry Mixing™
MDM ™

Modified Dry Mixing™

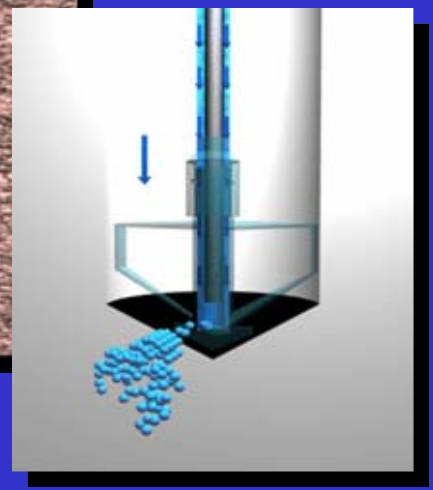
Patented process
U.S. Pat # 5.967.700



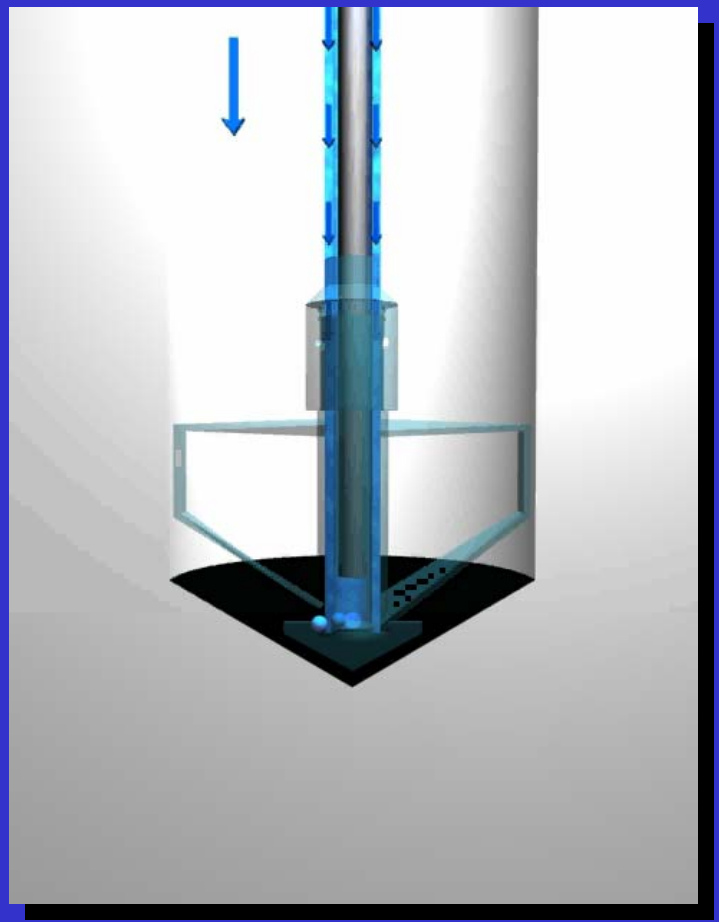
MDM™ Column installation, optimizing water content in soil

Process remains dry mix type.

The water is added separately during insertion of mixing tool.



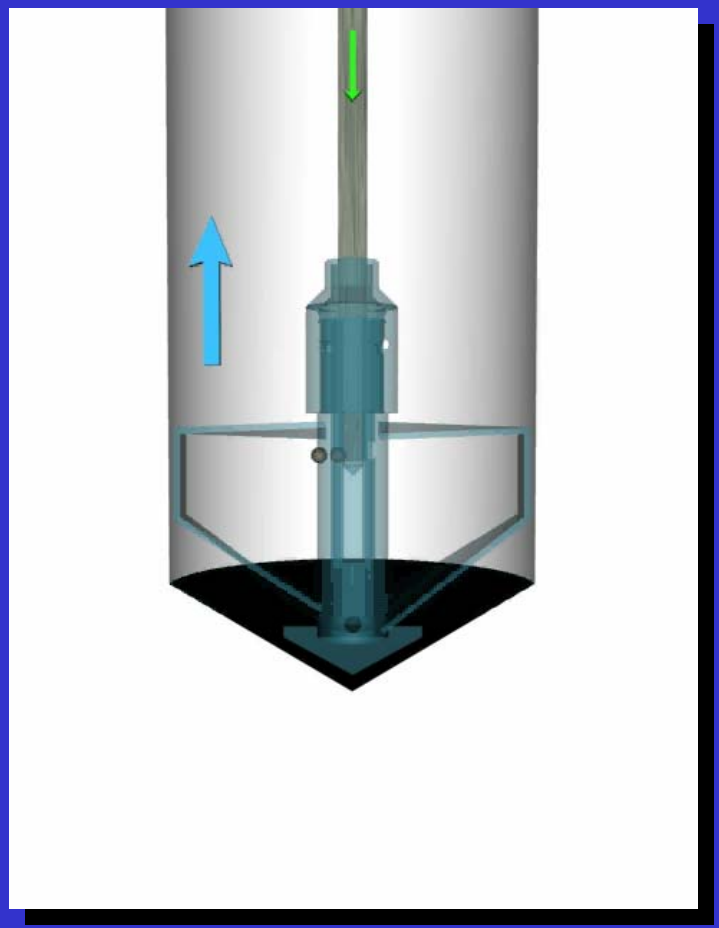
How Modified Dry Mixing works:



Insert tool and add water to desired levels

Mixing speed approx. 100 rpm

At required depth change rotation and…



withdraw tool,
inject dry binder,
mix and create
a uniform column

Mixing speed:
150 – 250 rpm

Modified Dry Mixing™
Advanced Dry Mix columns

- MDM™ = Water + dry binder
- Remains dry mixed process (ease of use)
- Additional water is injected into soil when mixing tool is inserted
- Amount of water is determined by Aqua Soil Sensor™ and/or at a predetermined rate
- Result = Optimum water conditions

cont.:

- Lime and cement is added at rate reflecting the modified water content while retracting tool
- More efficient use of binder (better hydration)
- Produces columns with a high degree of uniformity
- Produces columns with uniform shear strengths to a high degree of efficiency
- One rig can install columns with shear strengths ranging from 20 – 200+ psi from column to column (or from station to station in the same column)

Optimizing water content in soil

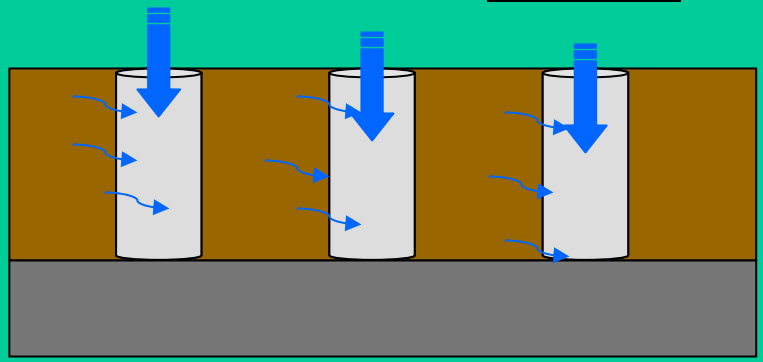
Amount of additional water can be determined by the following methods:

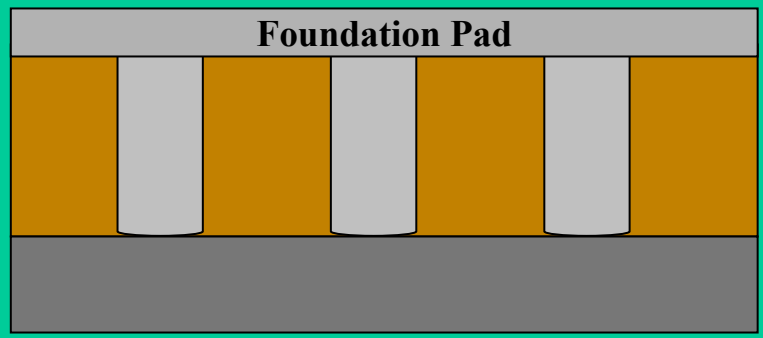
- According to previous geo-technical survey determining water content
- By use of moisture sensors on tool head in combination with geo-tech survey
- By use of Aqua Soil Sensor™ with geo-tech survey as reference point

Modified Dry Mixing™

Example:

- **Optimize water content in column hole, e.g. ~ 60 %**
- **Add binder/cement for 60 % wc + absorption**
- **Additional water is absorbed from clay (drains the clay/soil = higher shear)**
- **Total water content in column hole: ~ 70-75%**





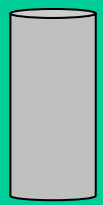
= Clay, 25 % wc

= Solid base

= Absorbed water

= Dry clay, 5-10 % wc

Resulting Product:



= **MDM™ Column. More binder/cement can be injected due to higher water content in column hole.**

MDM™ columns can achieve higher strengths/load capacities than standard dry mixing in the same soil conditions.

Soil Mix column installation

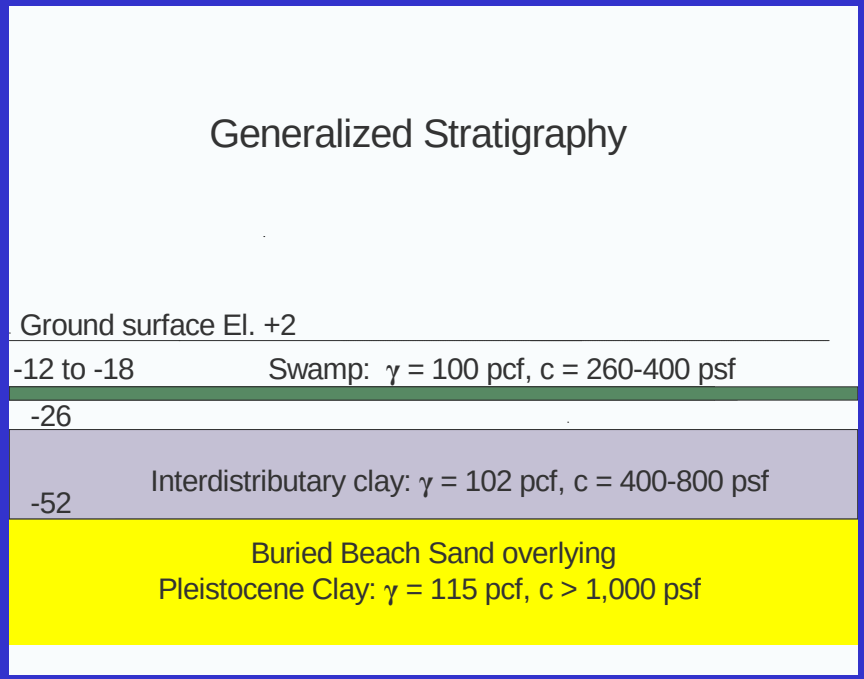
Case study: New Orleans water lock 2002/03

Levee Stability Application for Deep Soil Mixing - Test Section

Mark L. Woodward, PE
Peter R. Cali, PhD, PE
Renee S. Scholl, EI

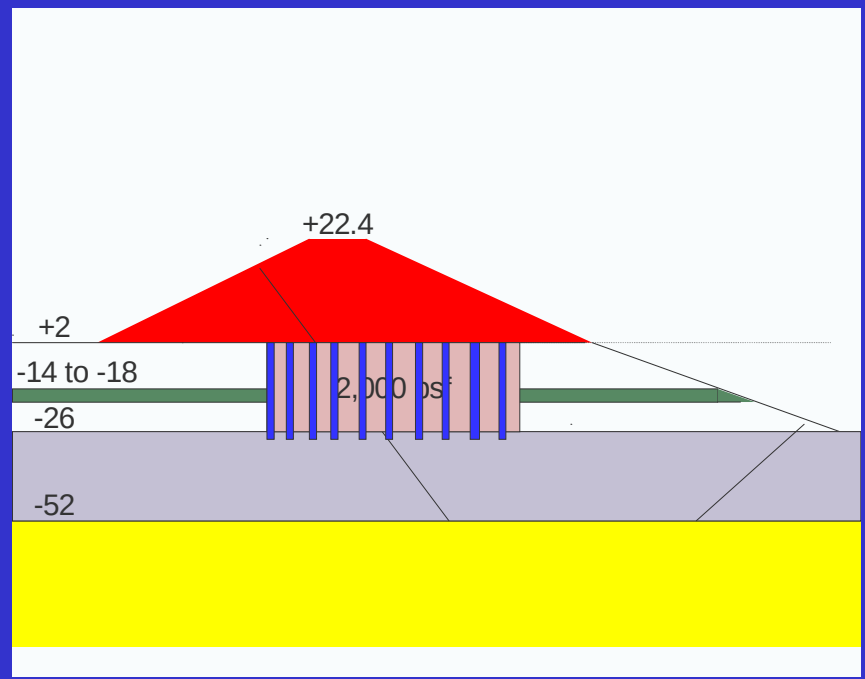
New Orleans District

Site conditions and design criteria



New levee wall.

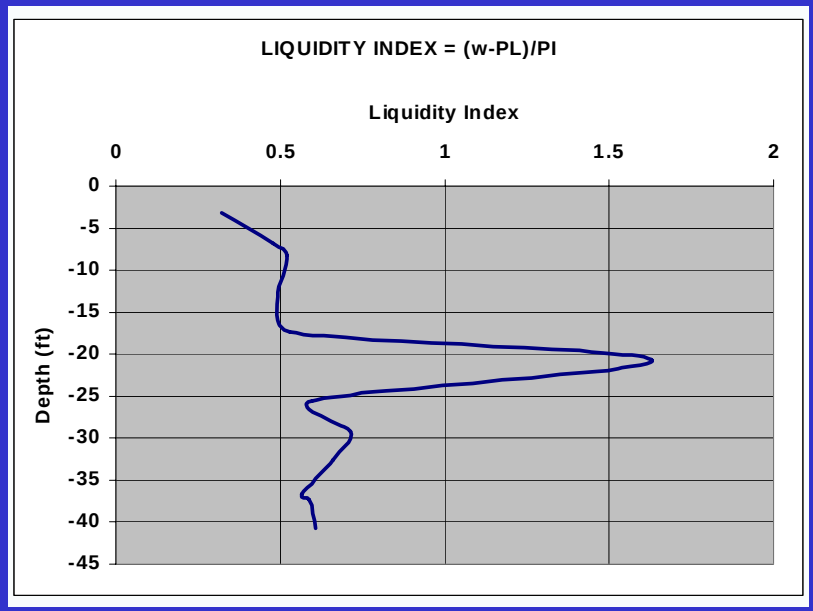
Target design strength of soil/column matrix = 2000 psf



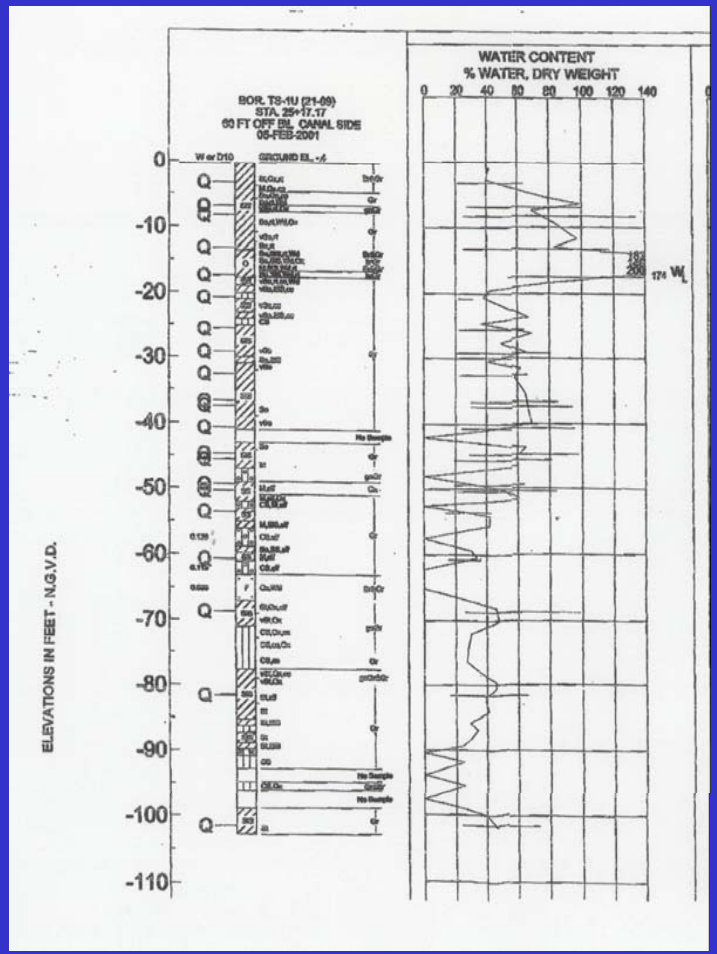
Column shear strength required=40 psi

cont.:

Liquidity Index



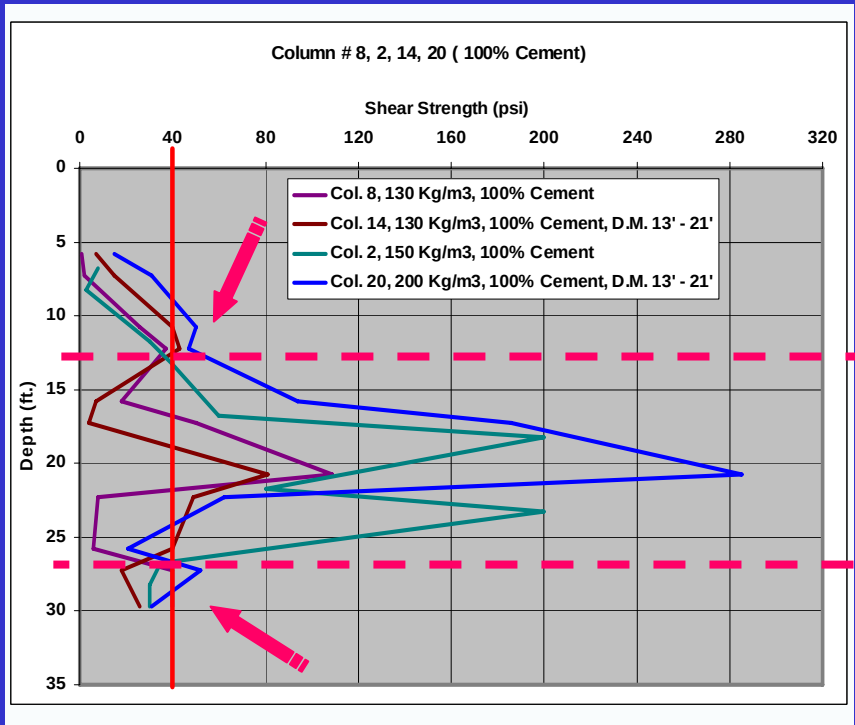
Water Content



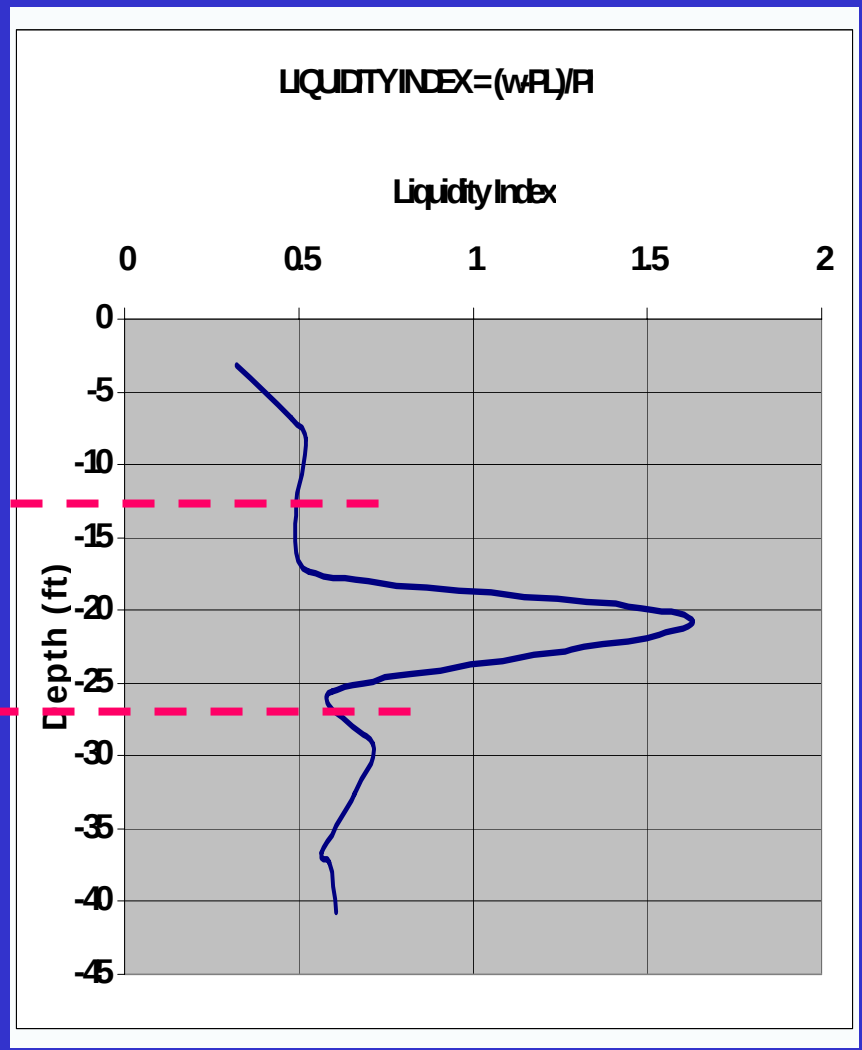
Note: Water content is over 20 % throughout target depth

Results using Standard Dry Mix:

Binder mixing ratios and resulting shear strengths



Available water (for hydration)



Note: Almost same shear strengths for all mixing ratios (arrows) at 0.5 liquidity index

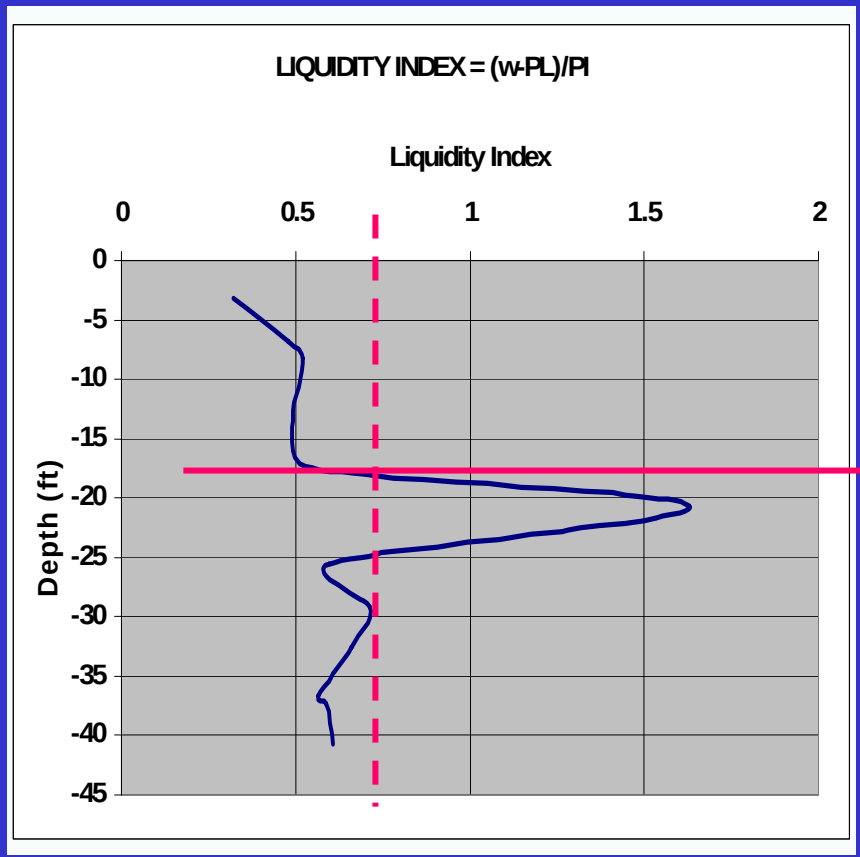
cont.:

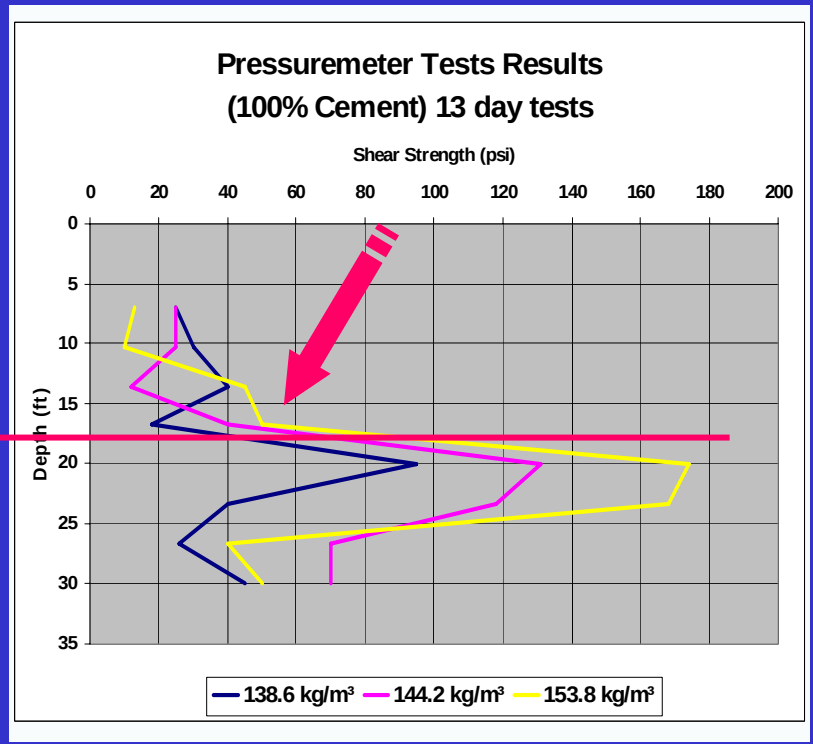
In areas of low L.I. column interlock properties nonexistent. Separation of panels occurred (without load).

Non uniform mixing in areas of low L.I. Center of column consists of dry “pebbles”.

Observations:

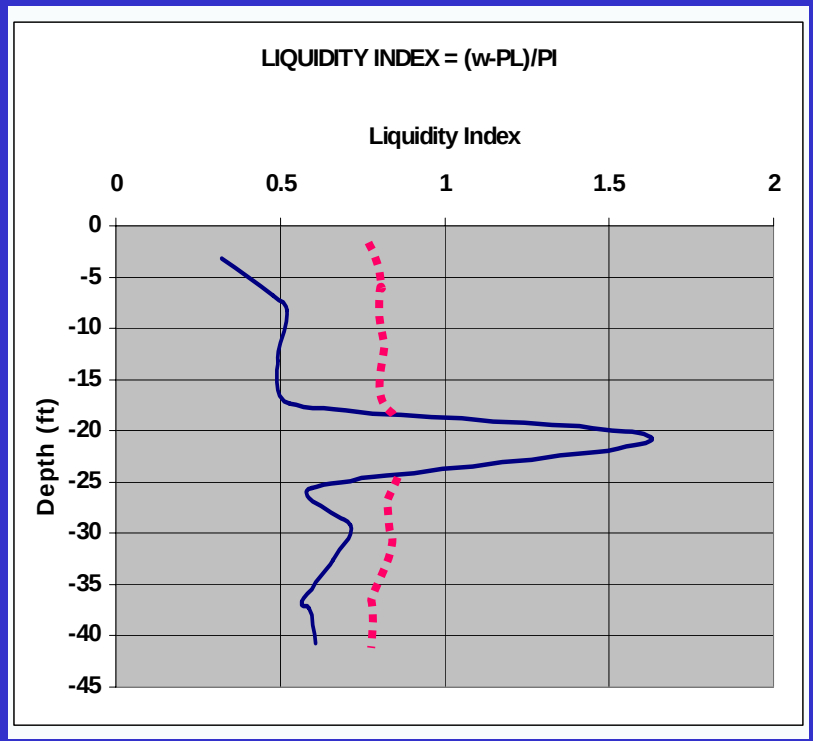
- Low strength per unit weight of binder added at low L.I.
- Varying shear strengths within columns (10 – 190 psi @ 13 days)
- Strength of columns directly related to L.I.
- At liquidity index of 0.65 – 0.70 the lowest binder rate (138 kg) produced 20 % over target strength (arrow)



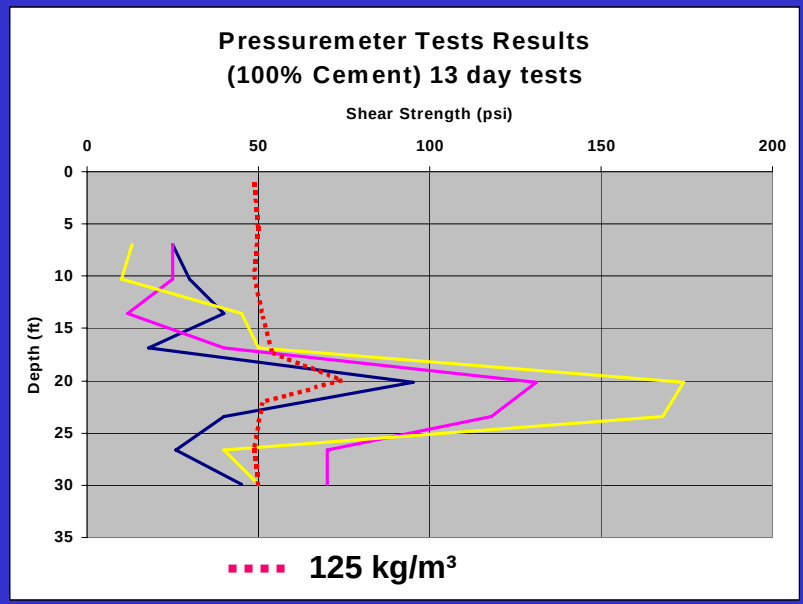


Results using Modified Dry Mix:

Modified water content/ liquidity index ~ 0.75 (red line)



Higher average minimum shear strength reached (~ 50 psi) with a smaller amount of binder used.



Column strength is uniform throughout with no “valleys”

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 (>40 psi) can be created. (more binder req. more water)
- With an MDM™ high quality column the replacement ratio, or number of columns, can be reduced.
- Q/A is achieved by consistently producing a column with a high degree of efficiency.

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