A Laboratory Technique for Estimating the Resilient Modulus Variation of Unsaturated Soil Specimens from CBR and Unconfined Compression Tests

by:

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Presented to

Civil Engineering Department

Lakehead University, Canada

Outline

- Introduction
- Scope
- Procedure
- Results
- Recommendations
- Conclusions

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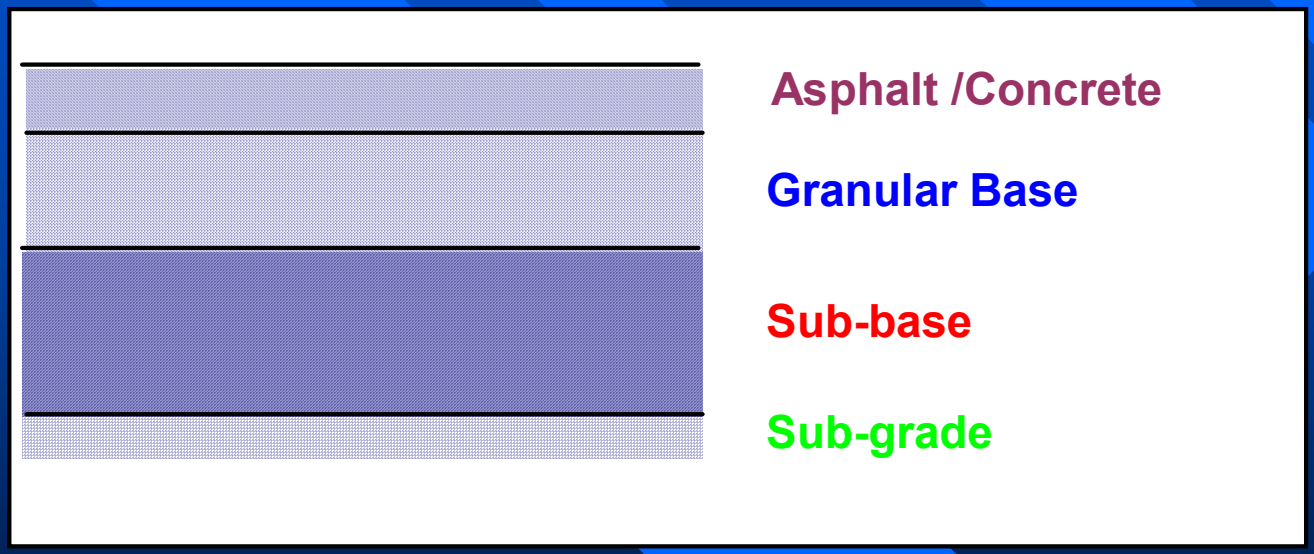
Introduction

Pavement system composition



Introduction

- Question: Pavement Design Method????
- Key Soil Properties:
  - CBR values
  - R-values
  - Resilient Modulus, M_r
- Mechanistic-Empirical Design Method (ME)

CBR Values

- Indicates:
  - the soil's resistance to force
  - the swell and strength potential of soils
- Used to determine:
  - Resilient modulus (M_r)
  - R- values

- CBR tests incorporate the effects of the asphaltic layer by placing the appropriate surcharge on the sample

R-Values

- Indicates the ability to resist lateral deformation
- Determining the expansion pressure of a soil gives the thickness of the material above the soil that will prevent swelling
- Indirect method of determining M_r:

$$M_r\,(\text{MPa}) = 8.0 + (3.8 \times \text{R-value})$$

$$M_r\,(\text{psi}) = 1000 + (555 \times \text{R-value})$$

Resilient Modulus (M_r)

- Primary soil property: Dynamic test
- Defined as the ratio between repeated deviator stress and resilient strain:

$$M_r = (\sigma_1 - \sigma_3) / \varepsilon_{al}$$

- Calculated by:

$$M_r\,(MPa) = 10.342\,(CBR)$$

$$M_r\,(psi) = 1500\,(CBR)$$

Laboratory Setup for M_r

Specimen

For aggregate base

Diameter: 6”; Height: 12”

Stress hardening for granular materials

For subgrade soils

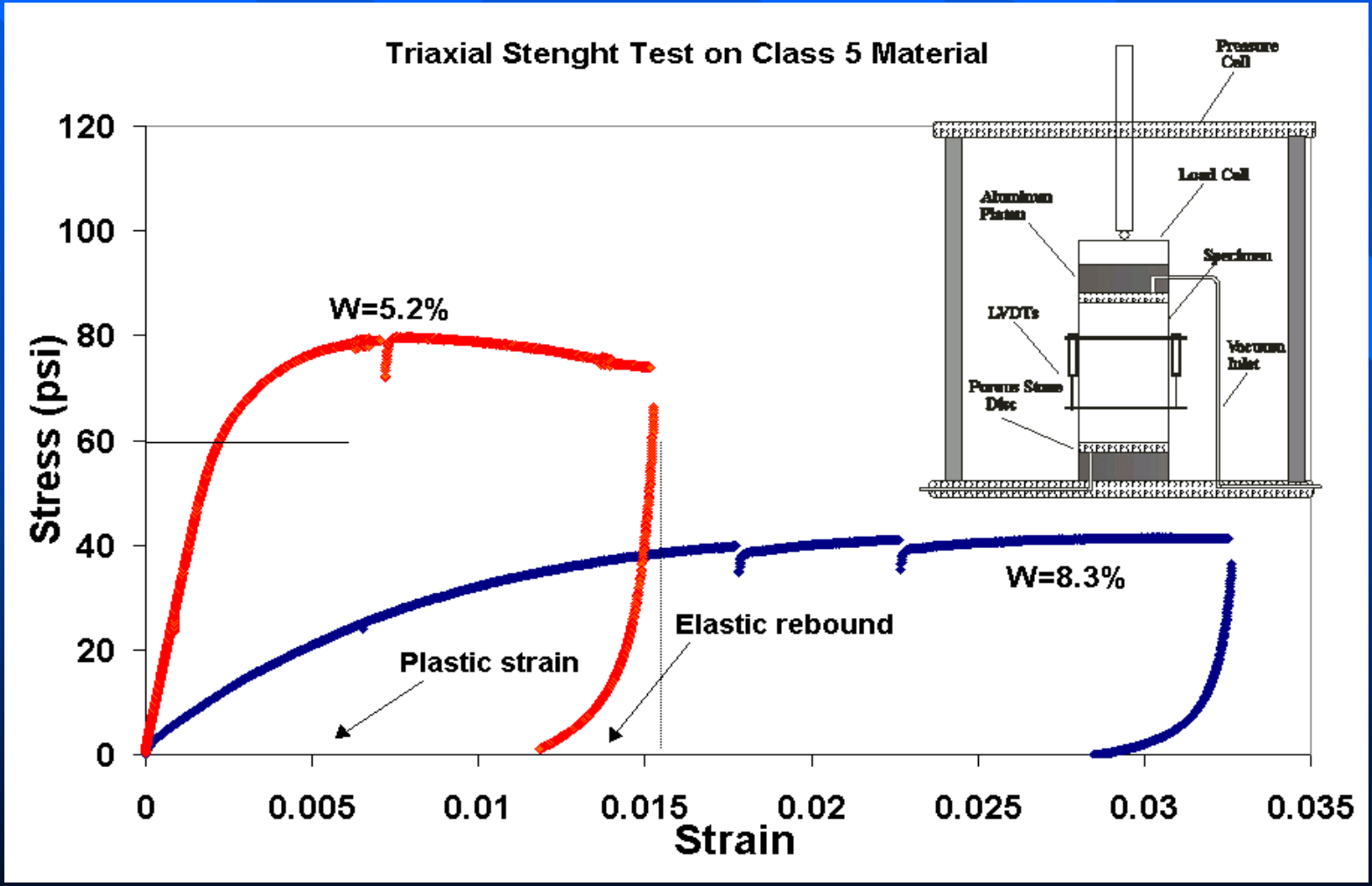
Diameter: 2.8”; Height: 6”

Stress softening for fine grained materials

Test protocol: LTPP P- 46

Testing Equipment for M_r

Typical Triaxial Test Results



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Scope

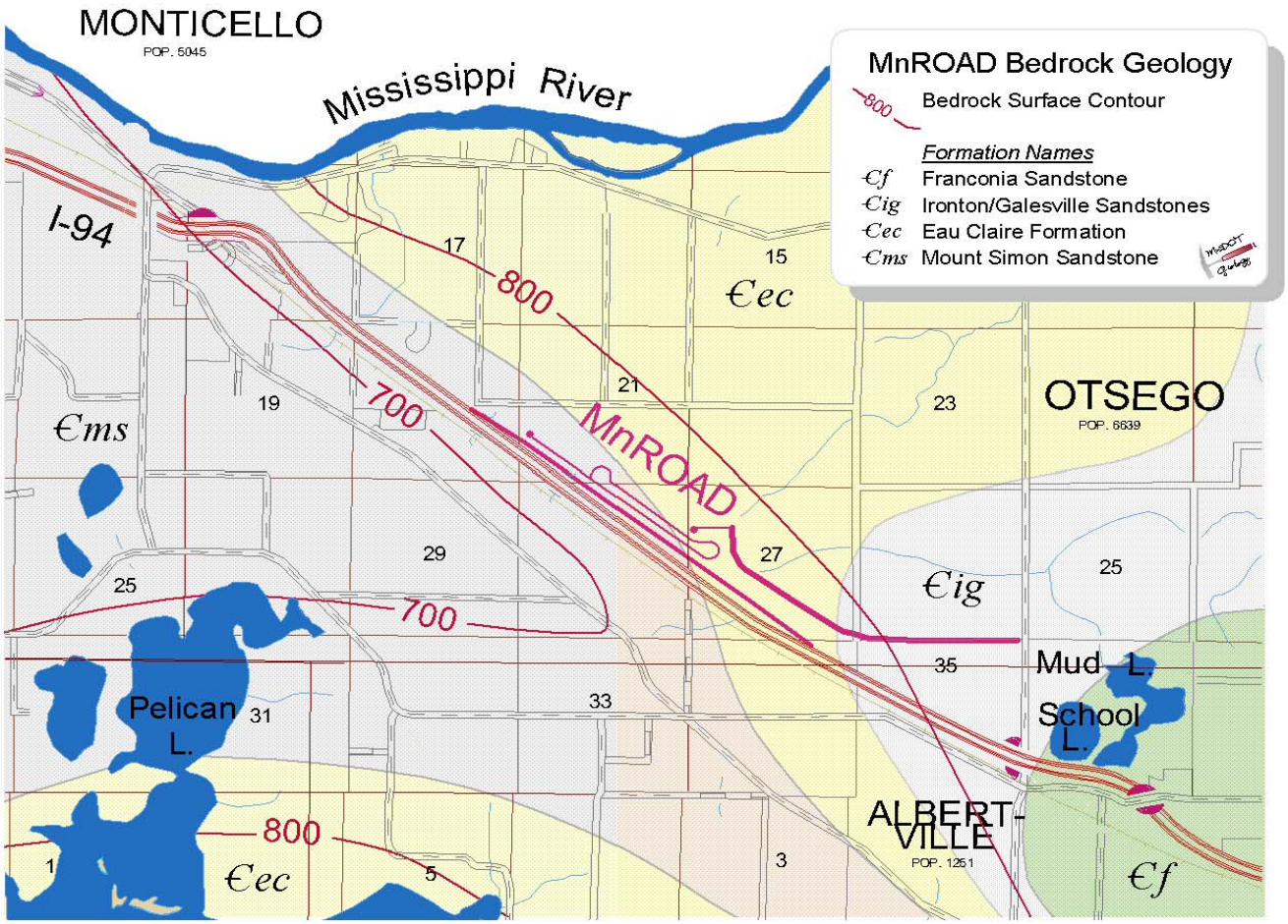
Determine correlations between California Bearing Ratio (CBR) tests and unconfined compression tests (UCS) on unsaturated soils and propose a simple technique for estimating M_r

Soil supplied by the Minnesota Department of Transportation (Mn DOT) was used in test program

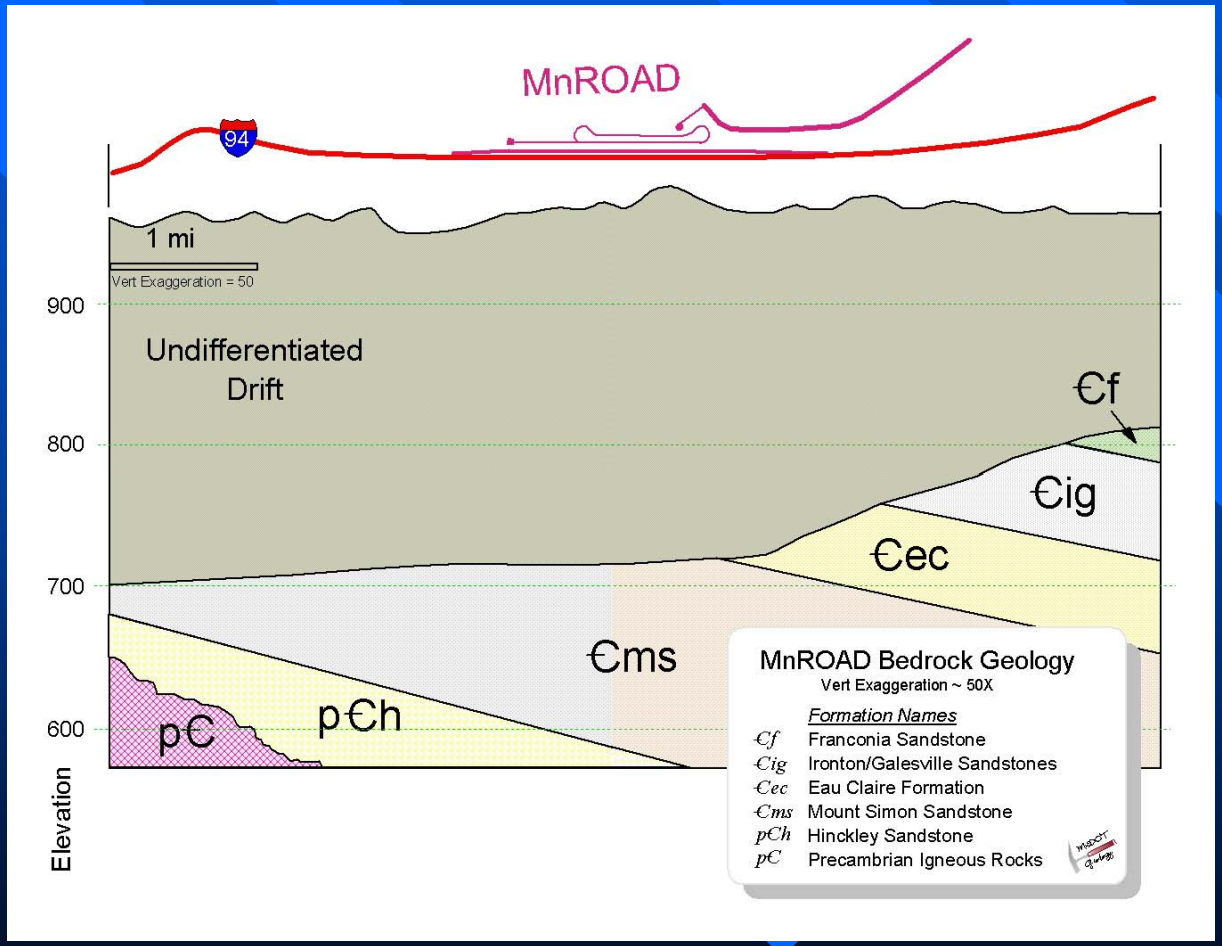
Mn-DOT Full Scale Test Facility

MnROAD

Site Map of Mn-DOT Test Facility



MnRoad Bedrock Geology



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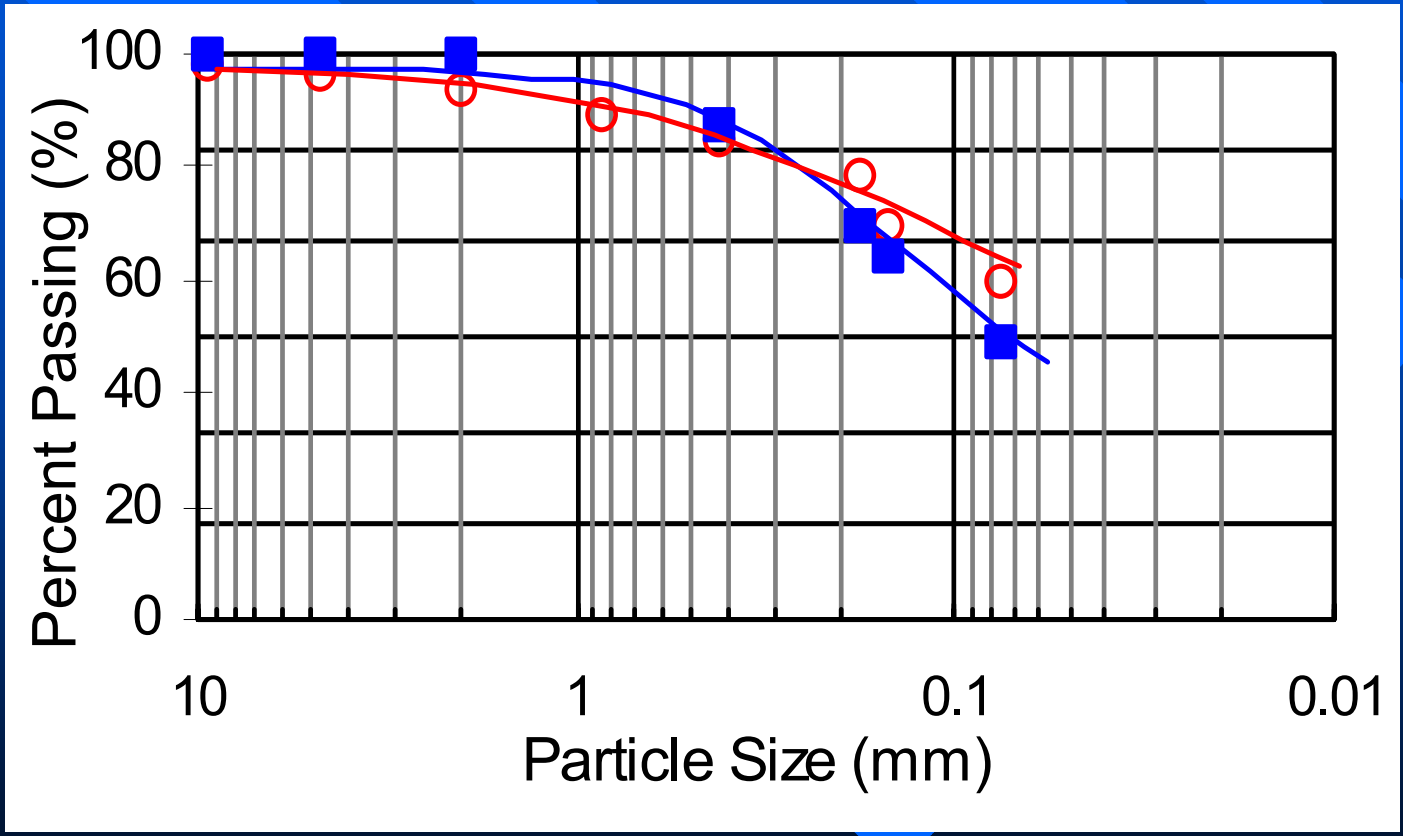
Grain Size Analysis Data

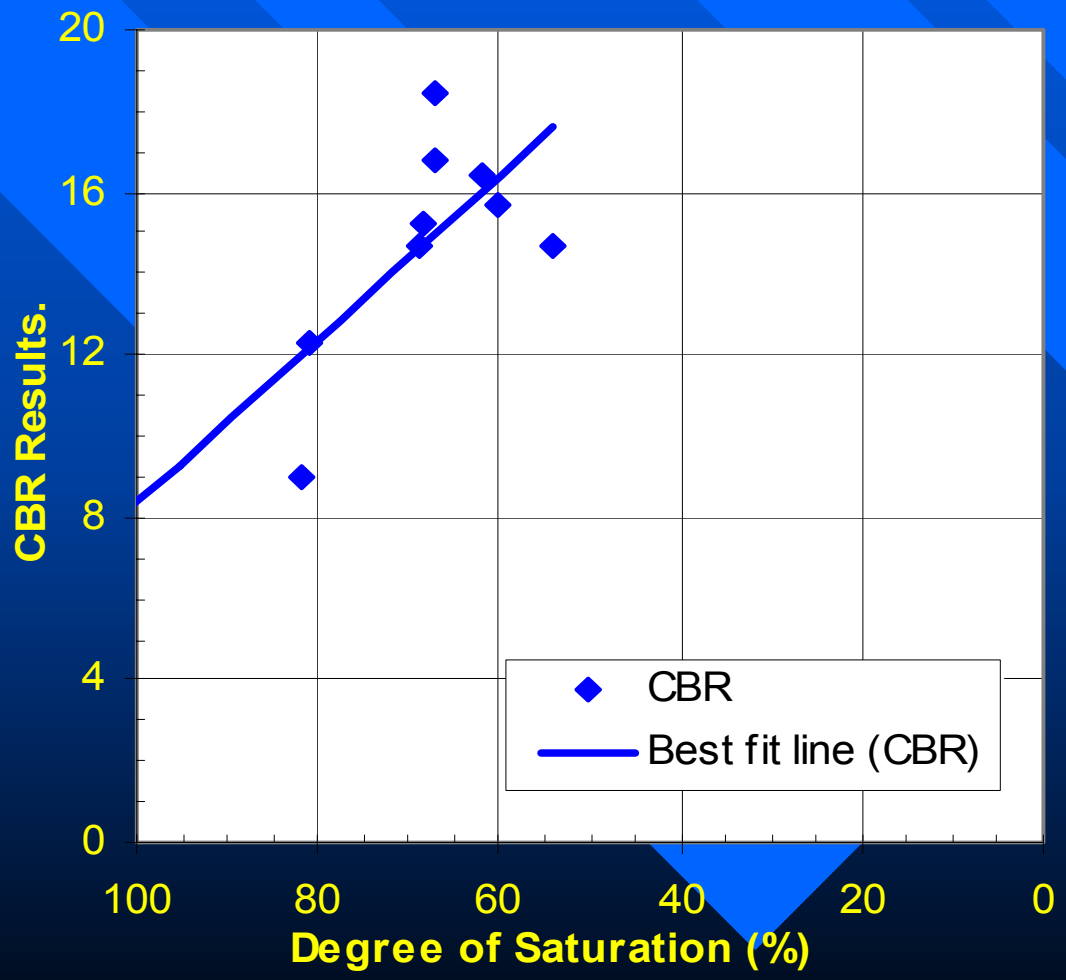


Modified CBR Testing Procedure

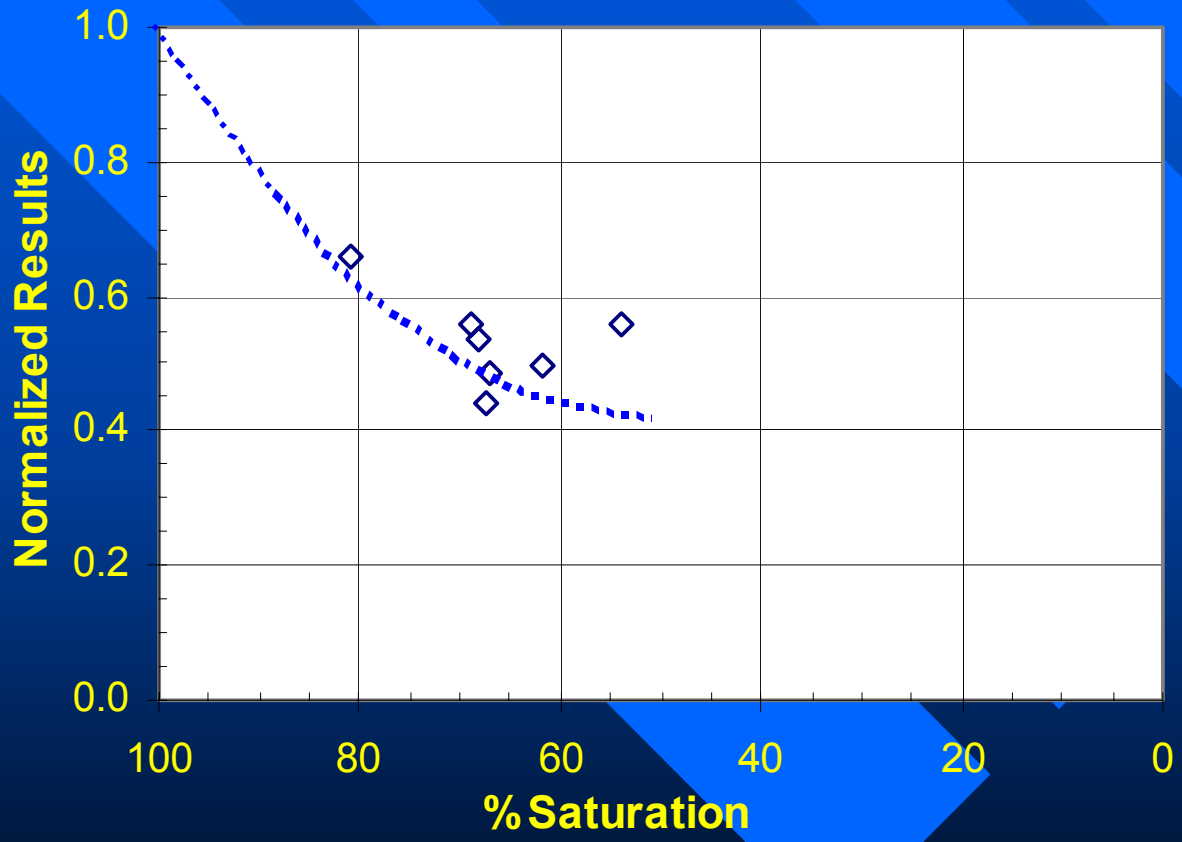
- Soil dried to 0% w.c.
- Mixed 16% w.c.
- Rest for 24 hours
- Compacted in 5 layers, 56 blows per layer

- Initial density and w. c: Saturated sample
- Dry the sample under two – 40 watt lights
- One week in constant moisture room
- Test conducted
- Degree of saturation determined

CBR Test Results



Analysis: CBR Results

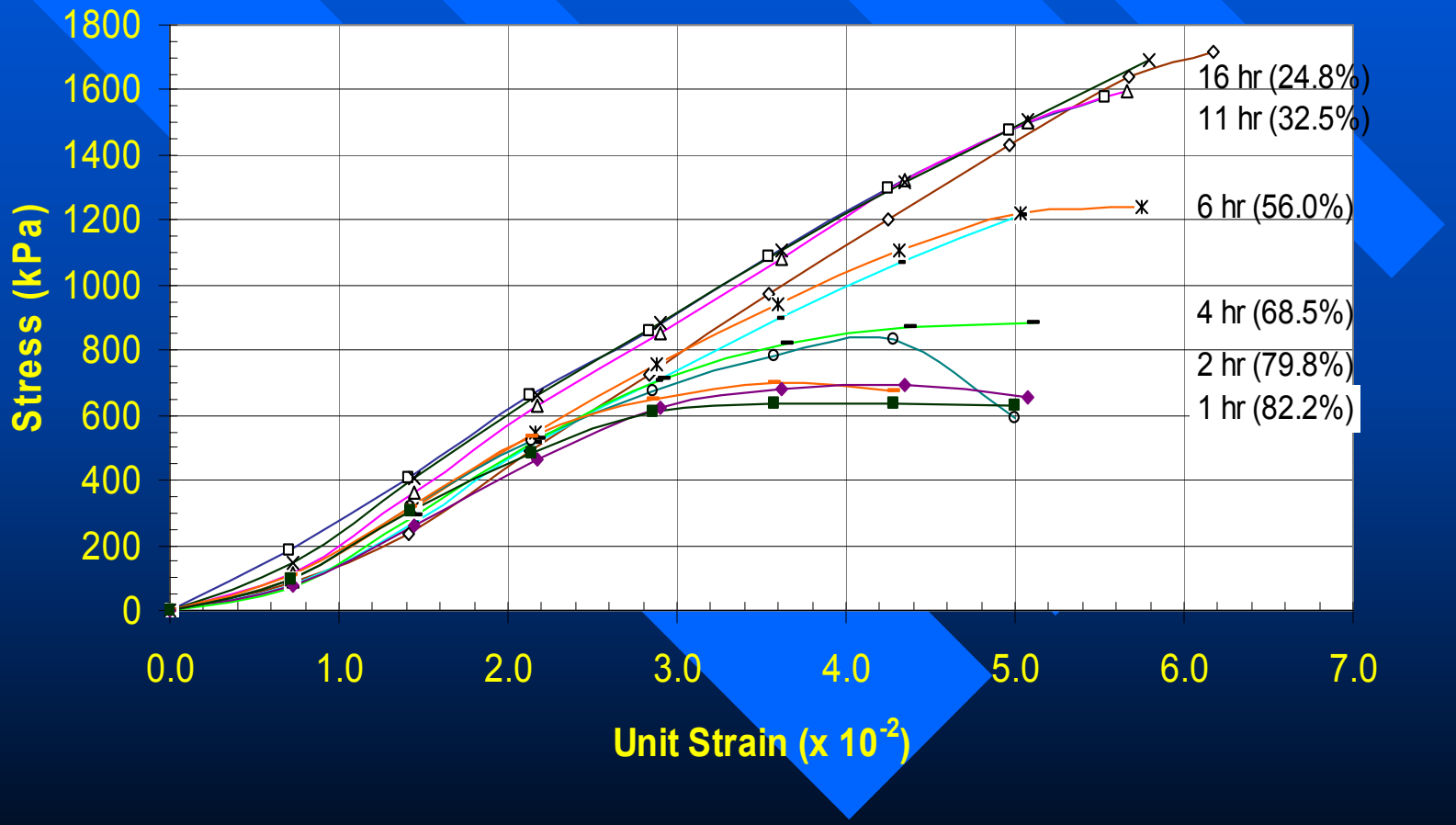


Modified UCS Testing Procedure

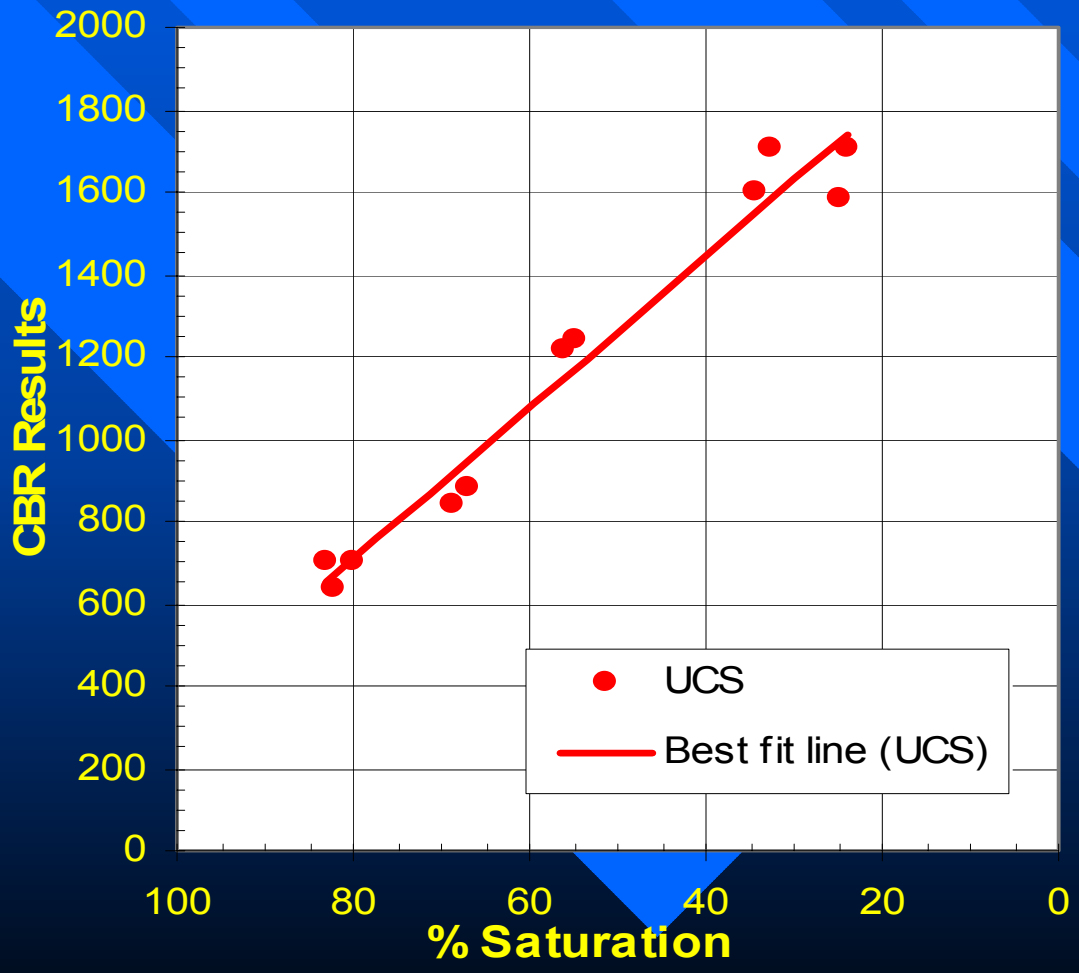
Drying the samples using two- 40 watt lamps

- Prepared according to AASHTO designation T 208, Unconfined Compression Strength of Cohesive Soils
- Modifications:
  - Sample Preparation – creating unsaturated conditions

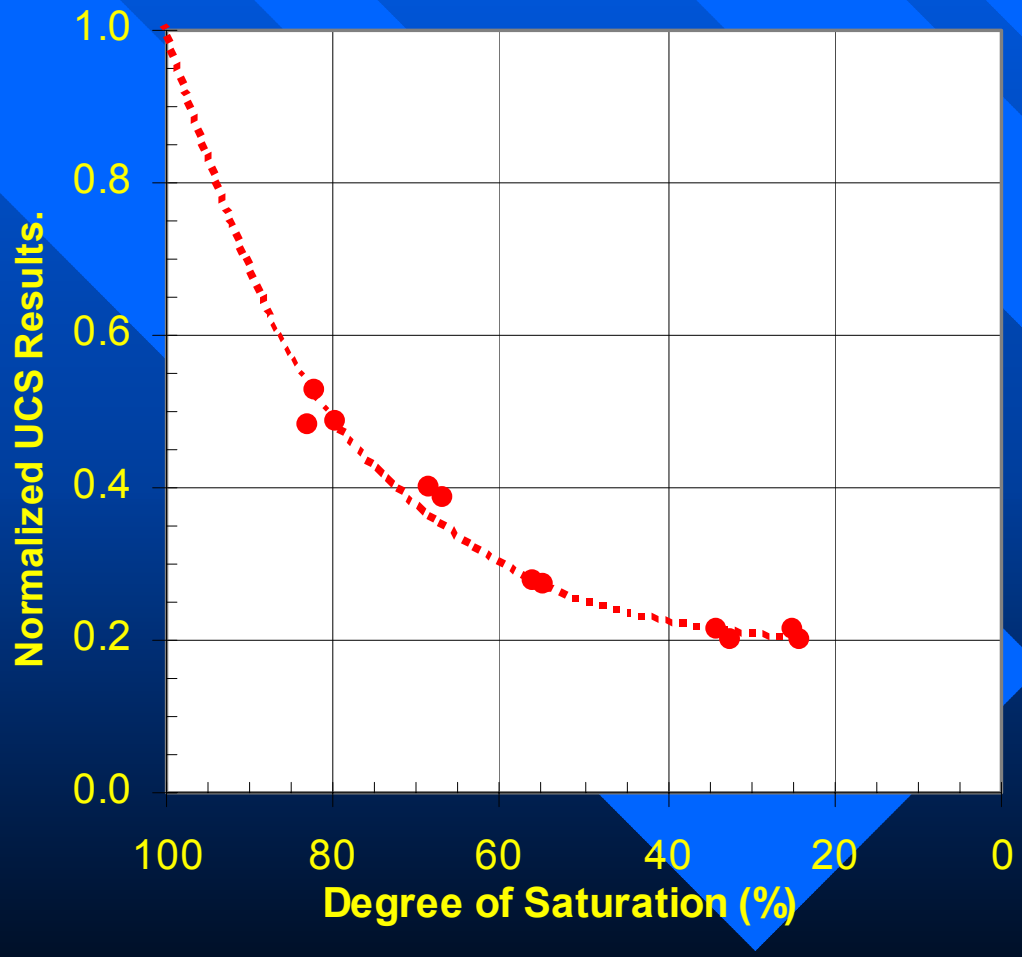
Unconfined Compression Test Results – Varying Times



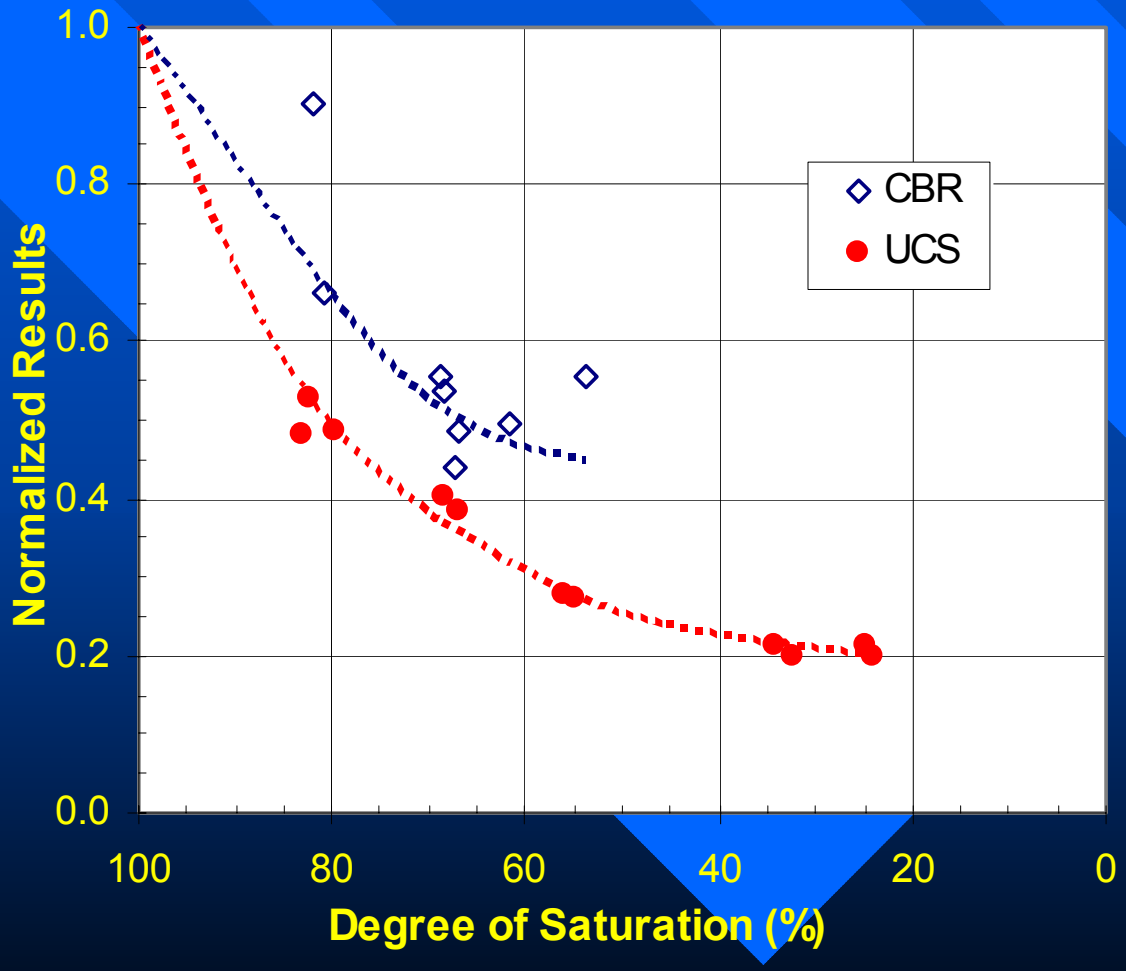
Unconfined Compression Test Results



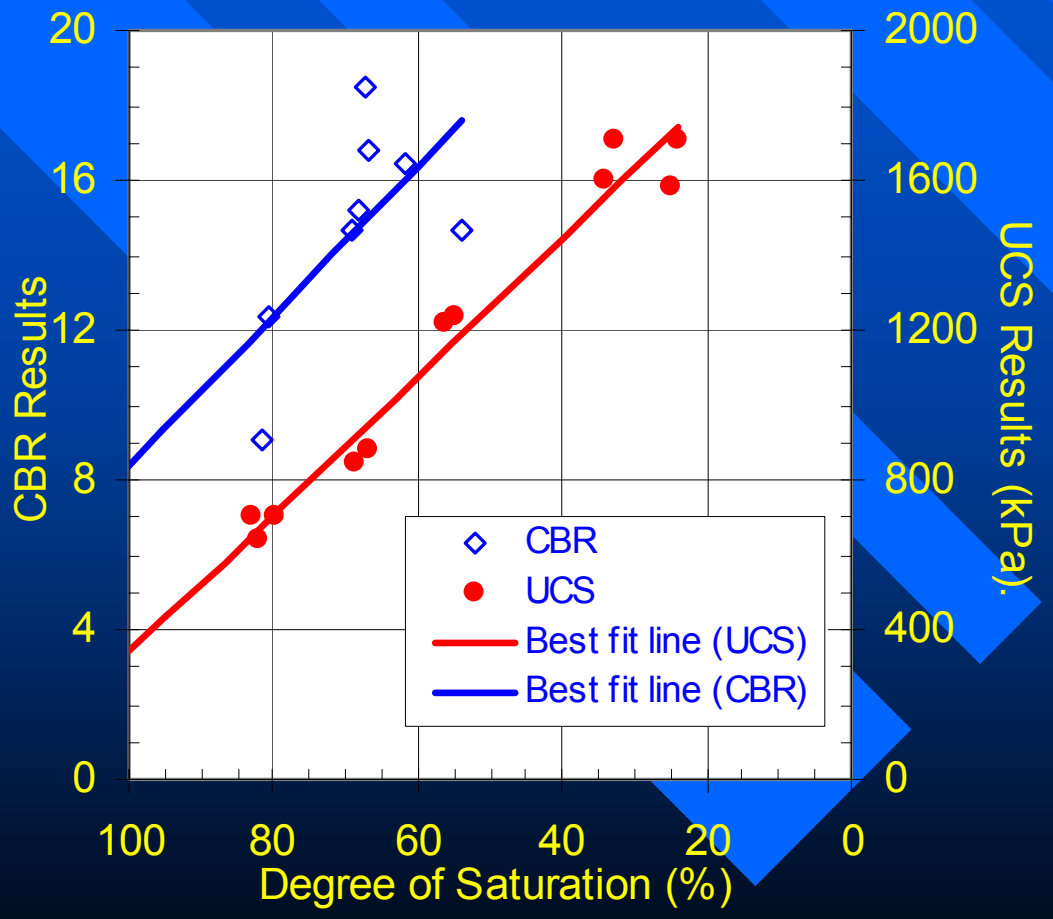
Analysis: UCS Results



CBR and UC Comparison



Comparison of CBR and UCS



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Recommendations

- Longer equilibrium time for CBR molds in moisture control room before testing in order to achieve uniform water contents.
- Direct M_r testing procedures to eliminate errors with regards to the mathematical CBR-M_r correlations.
- A better understanding to incorporate the principles of unsaturated soils behavior in the mathematical relationship relating unconfined compression test results and M_r values

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Conclusions

- Research Study: Promising
- This method of testing could be a useful technique in relating simple soil properties to more complex soil parameters such as resilient modulus values used in the design of pavements.
- Strong relationship: Correlations between the test data
- More testing and large database is required for proposing such correlations.

Acknowledgements

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Thank You