IOWA STATE UNIVERSITY
Dept. of Civil, Construction & Envr. Engineering

WISCONSIN
UNIVERSITY OF WISCONSIN-MADISON
Dept. of Civil & Envr. Engineering

Determining Pavement Design Criteria for Recycled Aggregate Base and Large Stone Subbase

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MnDOT Project TPF-5(341)
Monthly Meeting
August 2nd, 2018

RESEARCH TEAM

Iowa State University

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  PhD Student – Department of Civil, Construction & Environmental Engineering

University of Wisconsin-Madison

- Co-Principal Investigator – William Likos
  Professor – Department of Civil and Environmental Engineering
- Co-Principal Investigator – Tuncer B. Edil
  Professor Emeritus – Department of Civil and Environmental Engineering

NRRA Members (Agency Partners)

- MnDOT
- Caltrans
- MDOT
- Illinois DOT
- LRRB
- MoDOT
- WisDOT

NRRA Members (Industry Partners)

- Aggregate & Ready Mix of MN
- Asphalt Pavement Alliance (APA)
- Braun Intertec
- Concrete Paving Association of MN (CPAM)
- Diamond Surface Inc.
- Flint Hills Resources
- International Grooving & Grinding Association (IGGA)
- Midstate Reclamation & Trucking
- MN Asphalt Pavement Association
- Minnesota State University - Mankato
- National Concrete Pavement Technology Center
- Roadscanners
- University of Minnesota - Duluth
- University of New Hampshire
- Mathy Construction Company
- 3M
- Asphalt Materials & Pavements Program
- Husky Energy
- Hardrives, Inc.
- Testquip LLC
- The Transtec Group
- The Dow Chemical Company
- Pavia Systems, Inc.
- Michigan Tech Transportation Institute (MTTI)
- University of Minnesota
- National Center for Asphalt Technology (NCAT) at Auburn University
- GSE Environmental
- Helix Steel
- Ingios Geotechnics
- WSB
- Cargill
- PITT Swanson Engineering
- Collaborative Aggregates LLC
- American Engineering Testing, Inc.
- Center for Transportation Infrastructure Systems (CTIS)
- Asphalt Recycling & Reclaiming Association (ARRA)
- First State Tire Recycling
- BASF Corporation
- Upper Great Plains Transportation Institute at North Dakota State University
- All States Materials Group
- Caterpillar
- University of California Pavement Research Centre
- Payne & Dolan, Inc.

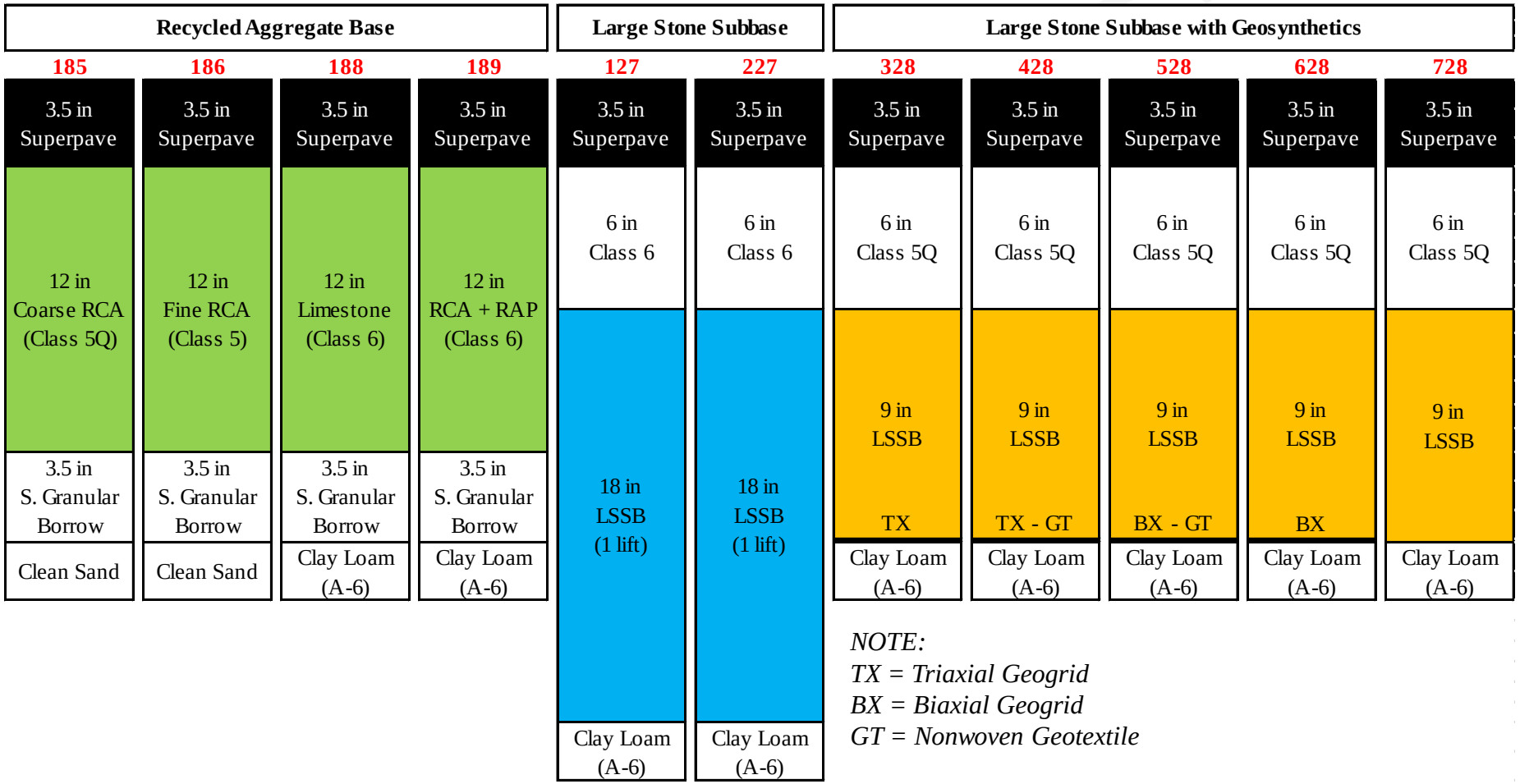
OUTLINE

- Follow-Up
- Task 3 – Construction Monitoring and Reporting
- Task 4 – Laboratory Testing

FOLLOW-UP

- Task 1 – Literature Review and Recommendations
- Task 2 – Tech Transfer “State of Practice”
- **Task 3 – Construction Monitoring and Reporting**
- **Task 4 – Laboratory Testing**
- Task 5 – Performance Monitoring and Reporting
- Task 6 – Instrumentation
- Task 7 – Pavement Design Criteria
- Task 8 & 9 – Draft/Final Report

TEST SECTIONS



TASK 3

Task 3 – Construction Monitoring and Reporting

- Dynamic Cone Penetrometer (DCP) Test
- Lightweight Deflectometer (LWD) Test
- Validated Intelligent Compaction (VIC)
- Falling Weight Deflectometer (FWD) Test

TASK 3

Dynamic Cone Penetrometer (DCP) Test (ASTM D6951)

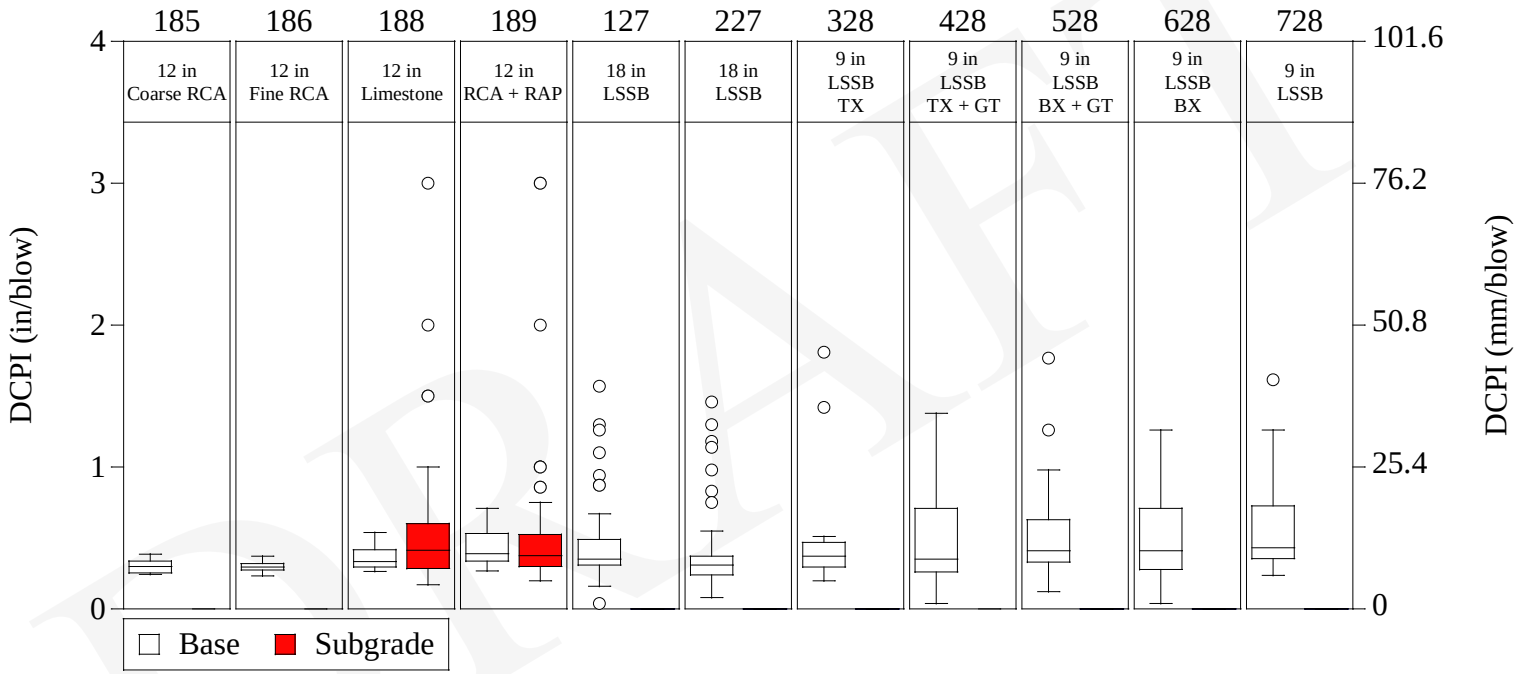
- Subgrade layers – data available for cells 188 and 189 [penetration depth = 18 in (457.2 mm)]
  - Cells 185 – 186 ➔ No test due to bad weather
  - Cells 328 – 728 ➔ No test due to very soft subgrade (for LSSB)

    [DCPI: 2.5 - 3.5 in/blow (63.5 – 88.9 mm/blow)]

- Base layers – data available for each cell
  - Cells 185 – 189 ➔ Depths corresponding to 12 drops
  - Cells 127 – 728 ➔ Penetration depth = 6 in (152 mm)

TASK 3

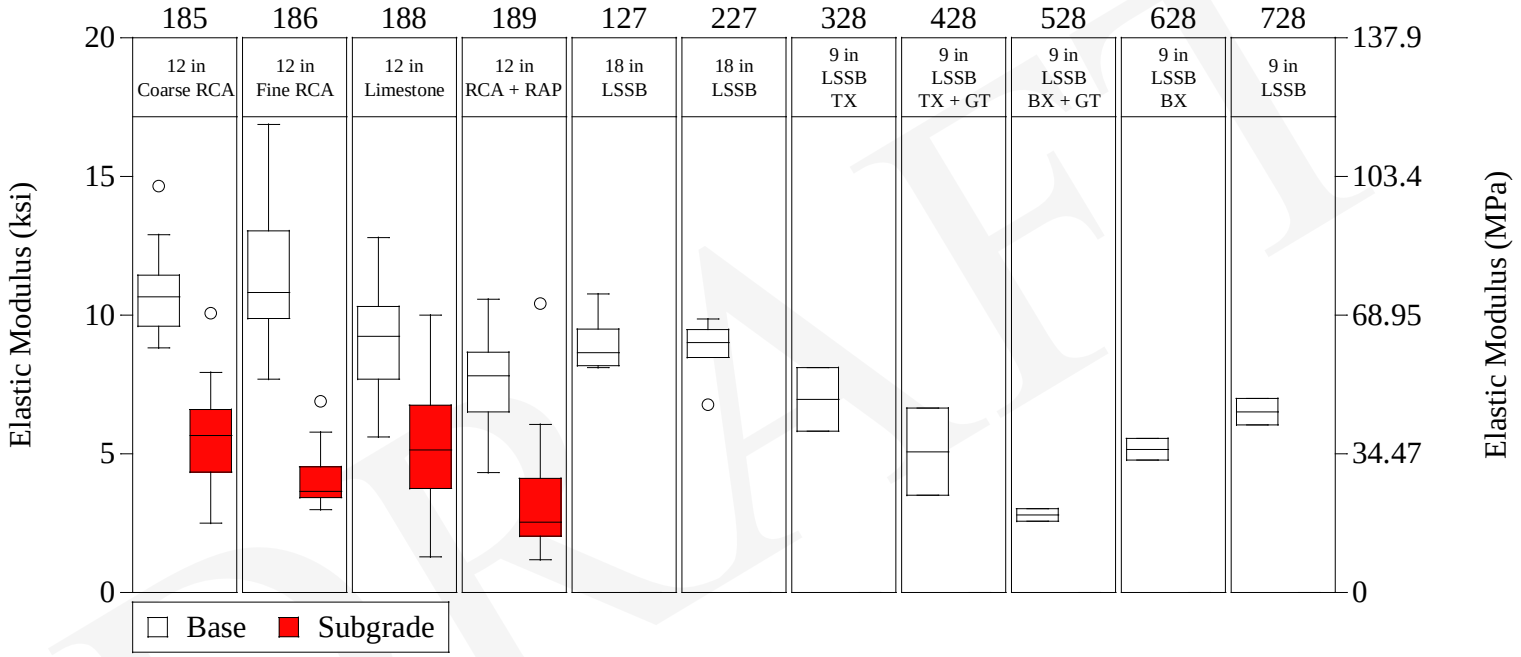
Dynamic Cone Penetrometer (DCP) Test (ASTM D6951) – Cont'd



- Cells 185 – 186 (Base) ➔ Lowest DCPI
- Cells 188 – 189 (Base) ➔ Low DCPI (no outliers)
- Cells 127 – 782 (Base) ➔ Higher and wider DCPI (with outliers)

TASK 3

Lightweight Deflectometer (LWD) Test (ASTM E2583)

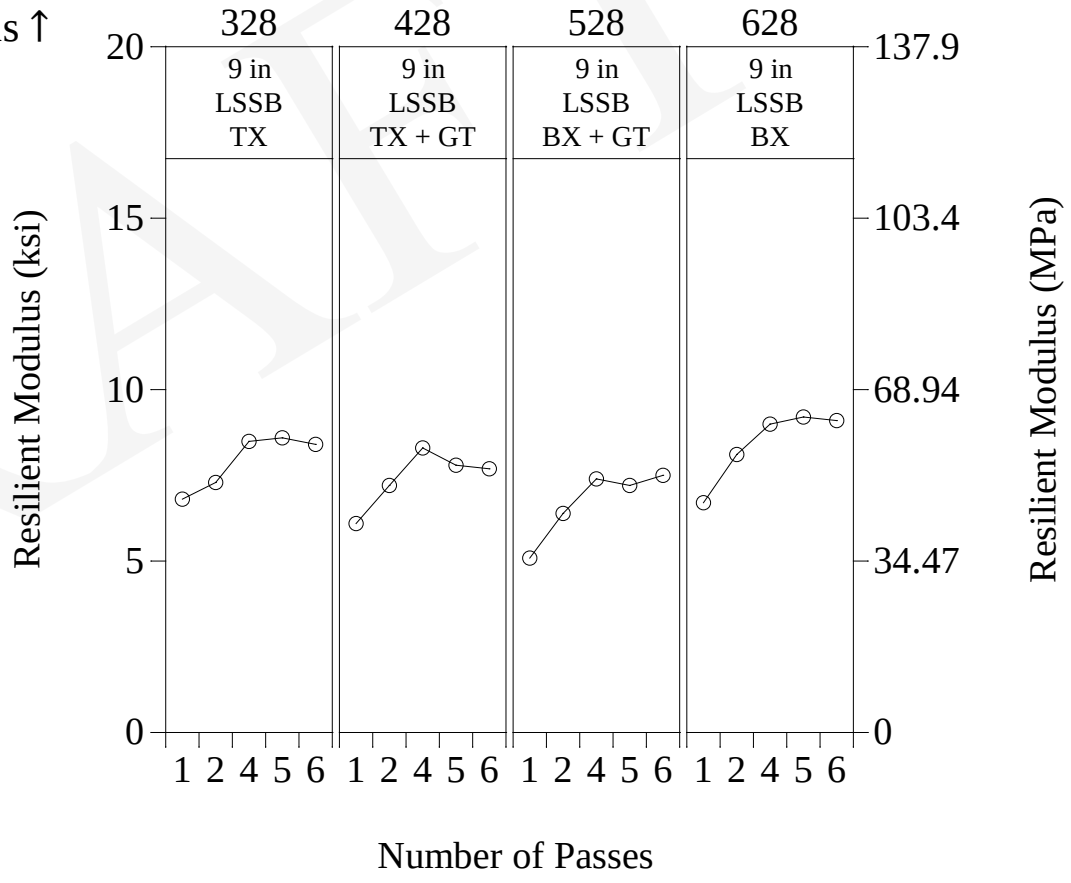


- Cells 127 – 728 ➔ No test due to very soft subgrade
- Cells 185 – 189 ➔ Base modulus > Subgrade modulus
- Cells 185 – 186 (Base) ➔ Higher modulus
- Cells 328 – 728 (Base) ➔ Lower modulus

TASK 3

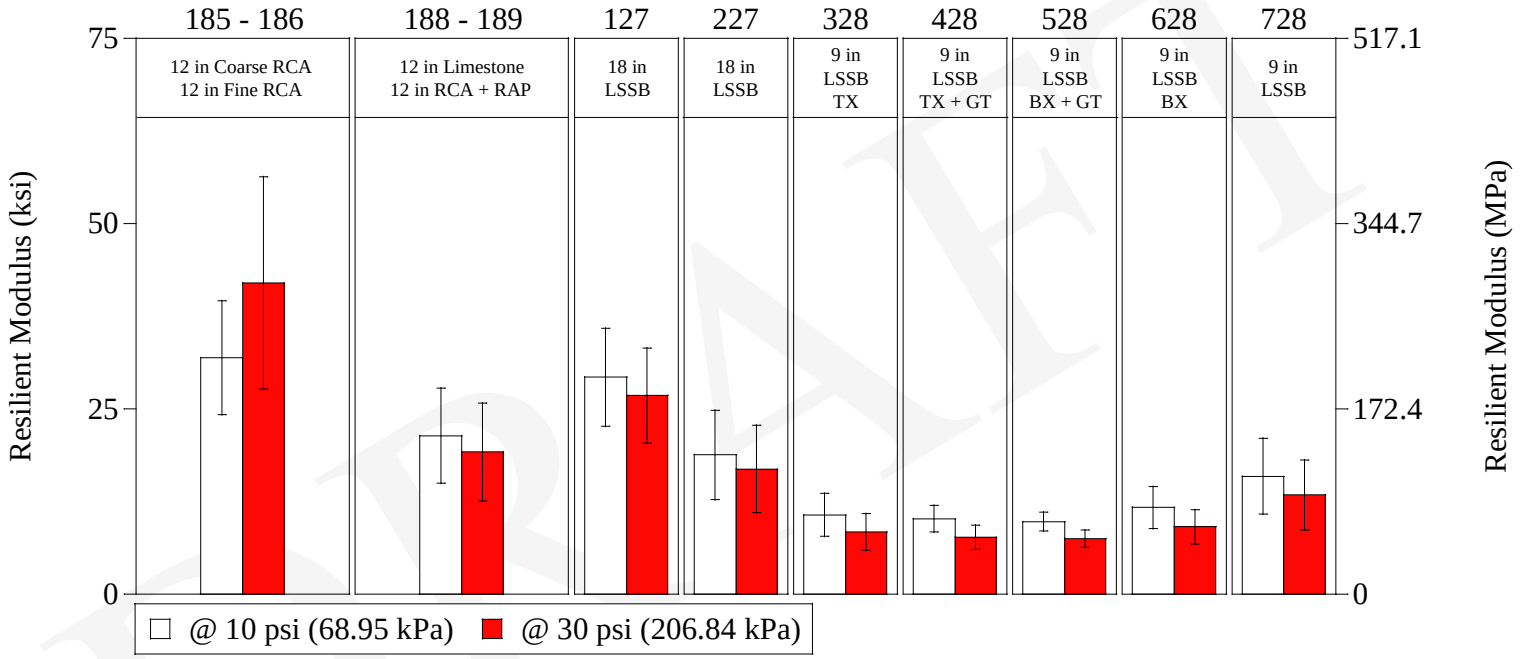
Validated Intelligent Compaction (VIC) (White and Vennapusa 2017)

- Cells 328 – 628
  - No. of passes ↑, resilient modulus ↑
- Insufficient compaction



TASK 3

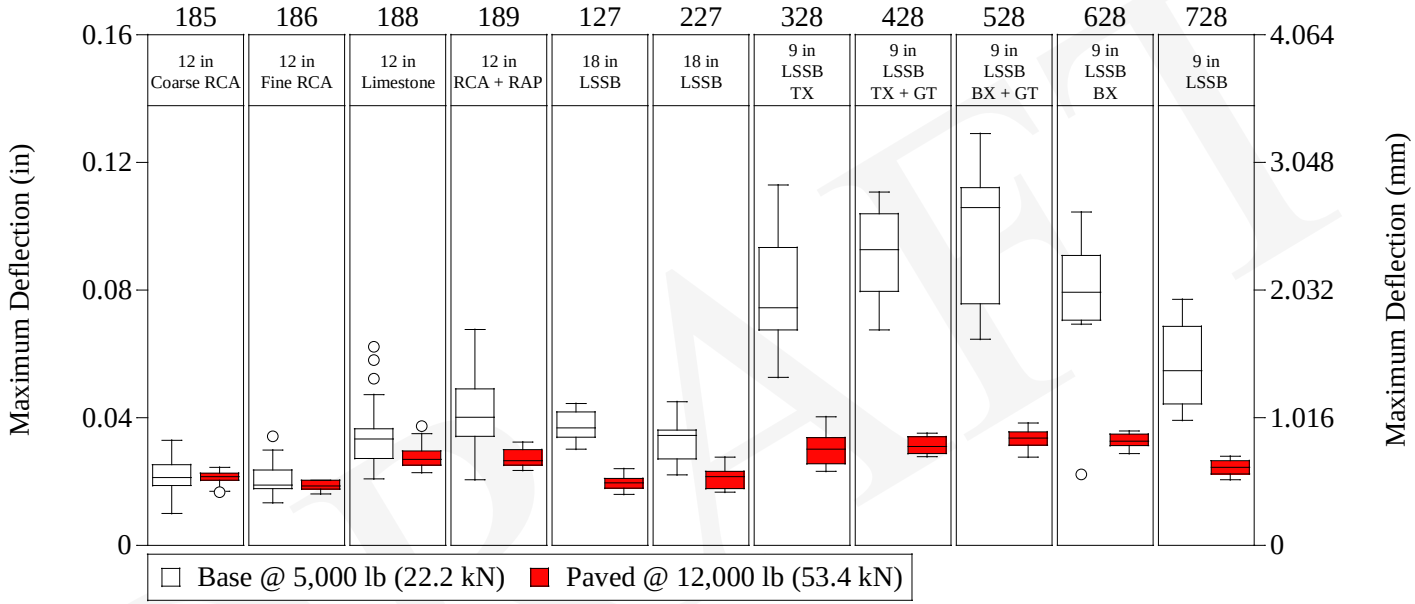
Validated Intelligent Compaction (White and Vennapusa 2017) – Cont'd



- Only in cells 185 – 186 (Base) ➔ Modulus @ 30 psi > Modulus @ 10 psi
- Cells 185 – 186 (Base) ➔ Highest modulus
- Cells 127 – 227 (Base) ➔ Similar or higher modulus than cells 188 - 189
- Cells 328 – 728 (Base) ➔ Lowest modulus

TASK 3

Falling Weight Deflectometer (FWD) Test

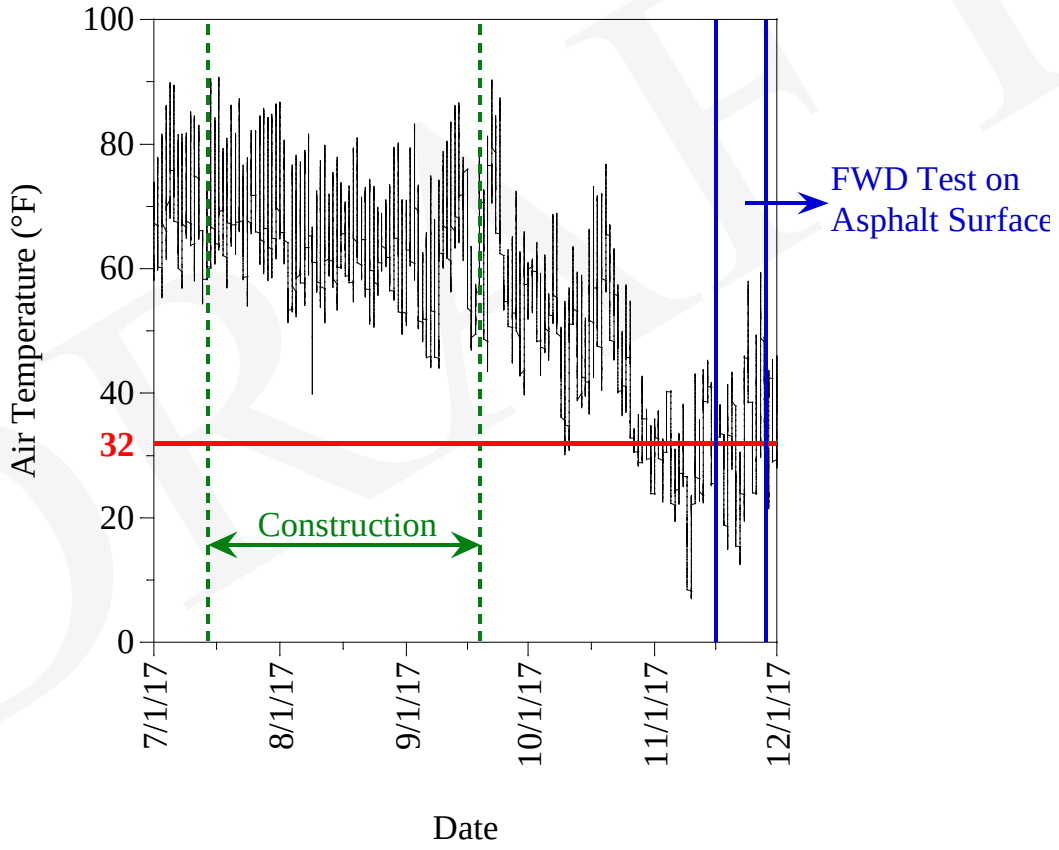


- Base Layers
  - Cells 185 and 186 ➔ Lowest deflections
  - Cells 188 – 227 ➔ Similar median but wider range in cells 188 – 189
  - Cells 328 – 728 ➔ Higher deflections
- Asphalt Surface
  - Similar deflections

TASK 3

Falling Weight Deflectometer (FWD) Test – Cont'd

- Possible frozen road condition during FWD testing on asphalt in November 2017.



TASK 4

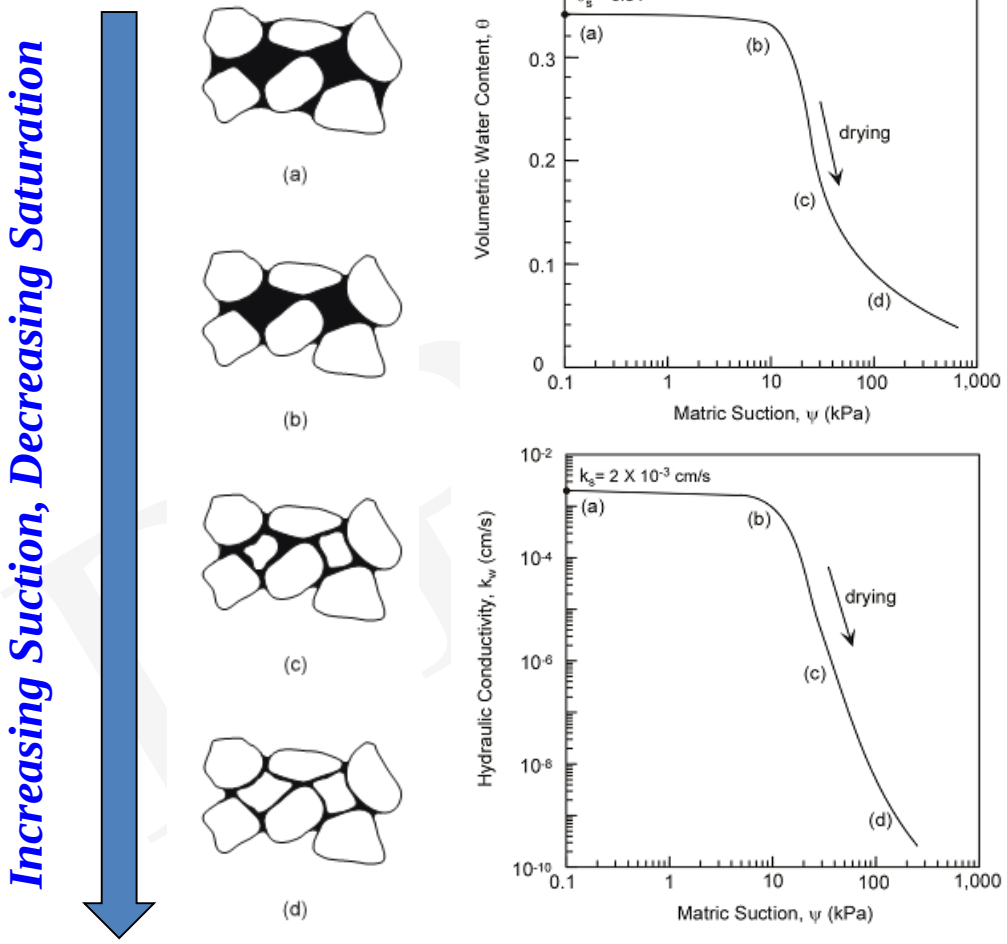
Task 4 – Laboratory Testing

- **Iowa State University**
  - Soil classification
  - Image analysis
  - Proctor & gyratory compaction
  - Asphalt & cement content determination
  - Contact angle measurement

- **University of Wisconsin-Madison**
  - Soil-water characteristic curve
  - Permeability

TASK 4

Soil-Water Characteristic Curve (SWCC) and Hydraulic Conductivity Function (HCF)



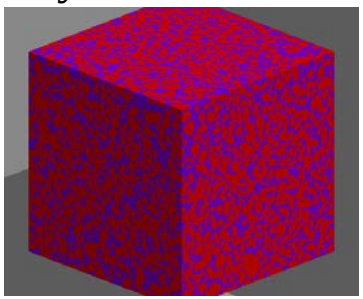
Soil-Water Characteristic Curve (SWCC)

Hydraulic Conductivity Function (HCF)

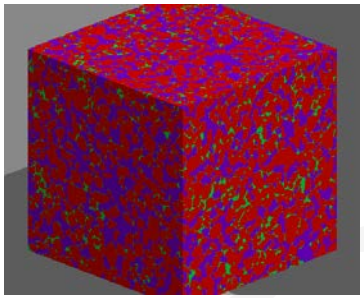
(Lu and Likos, 2004)

TASK 4

Dry Sand



S = 0.17



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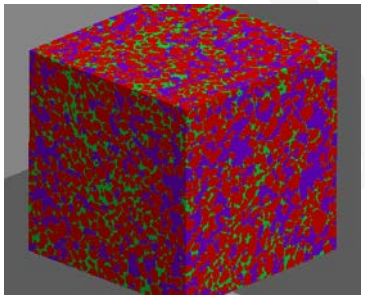

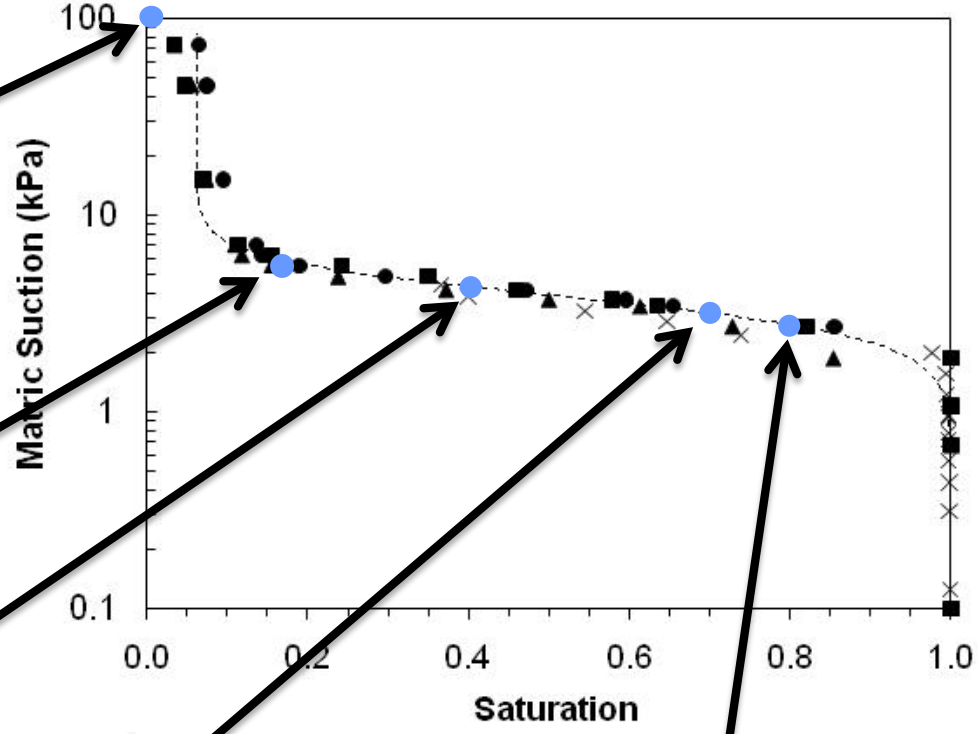

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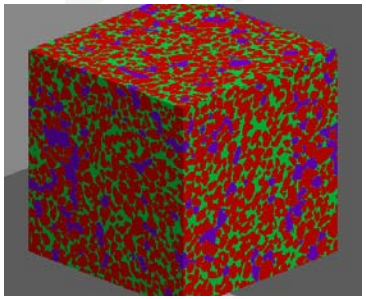

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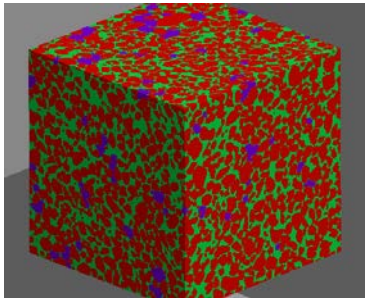
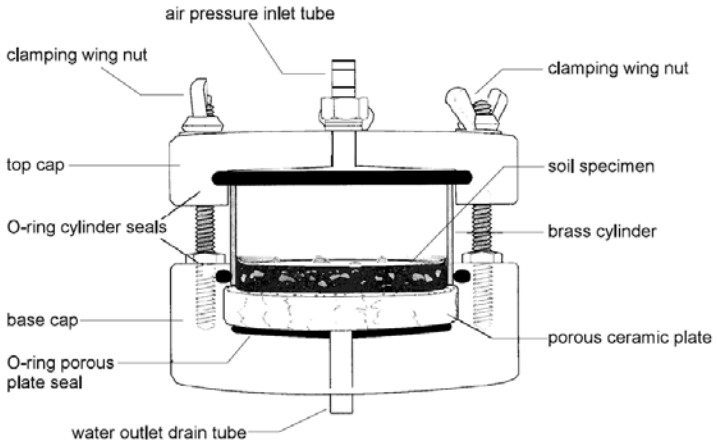
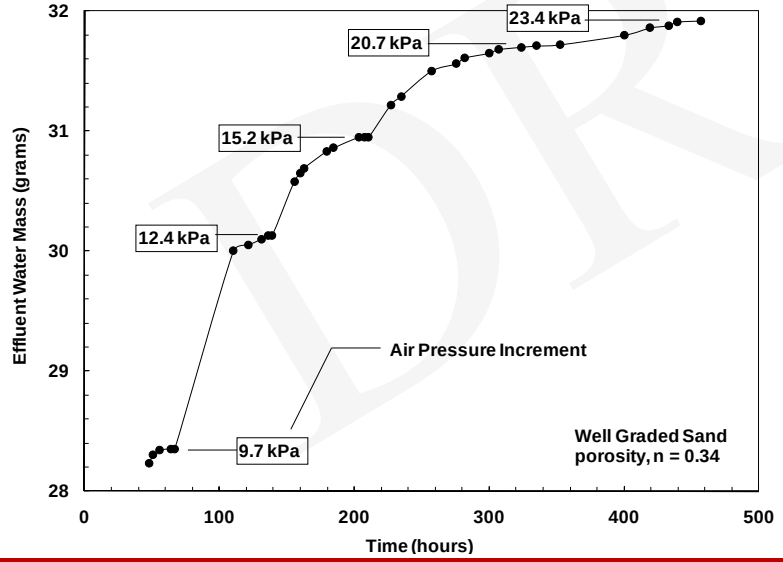


TASK 4

Axis Translation Method



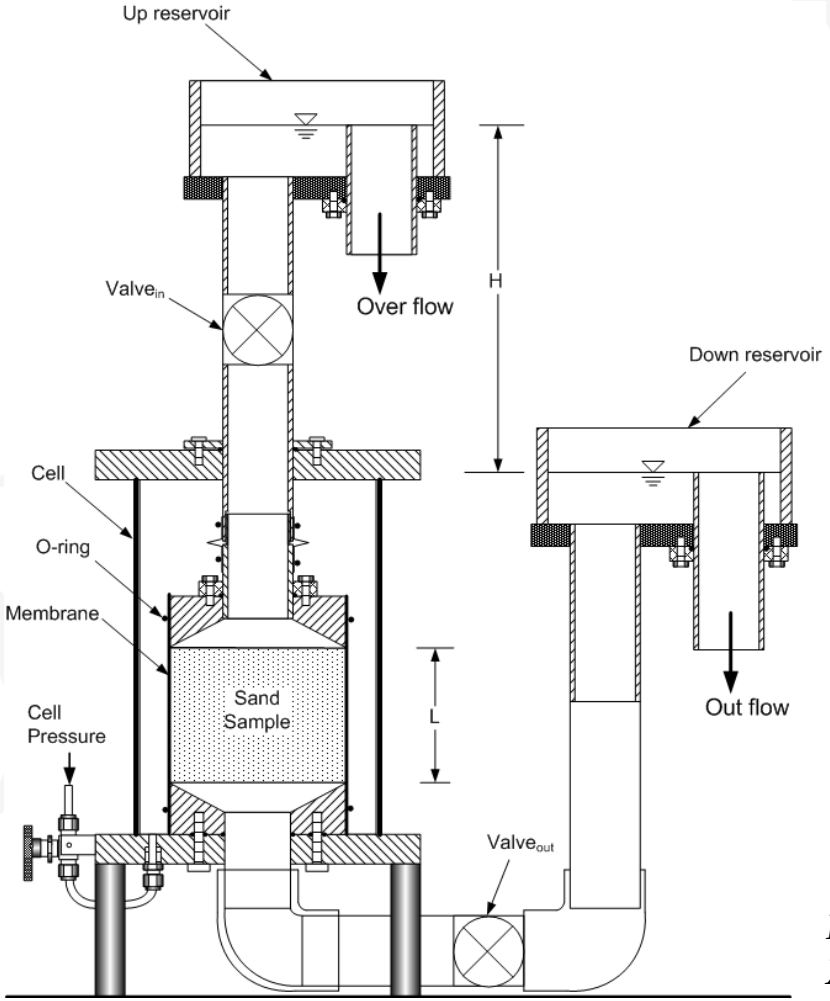


TASK 4

Large-Scale Axis Translation Methods

TASK 4

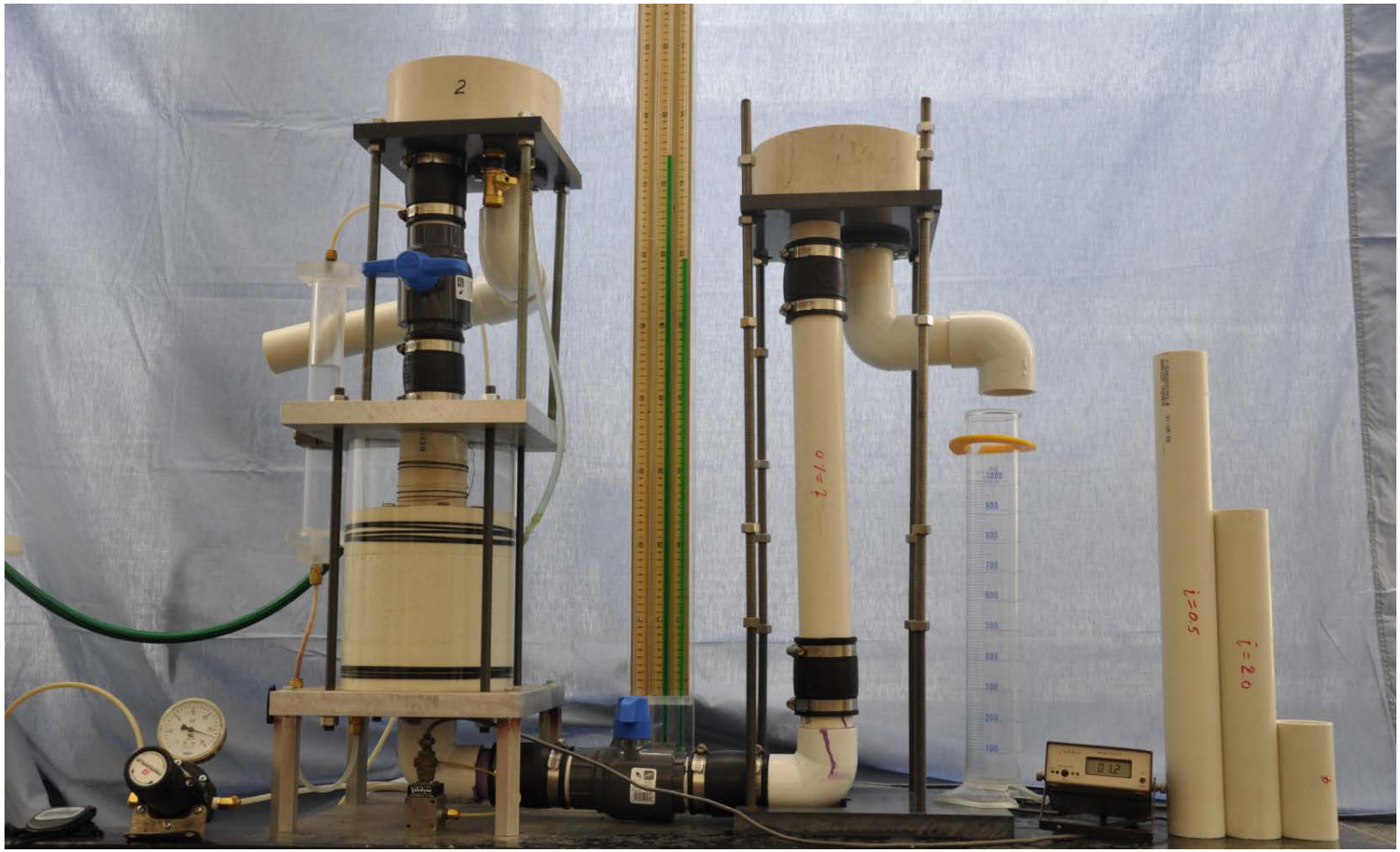
UW-Madison Flexible-Wall Permeameter for Coarse-Textured Soils



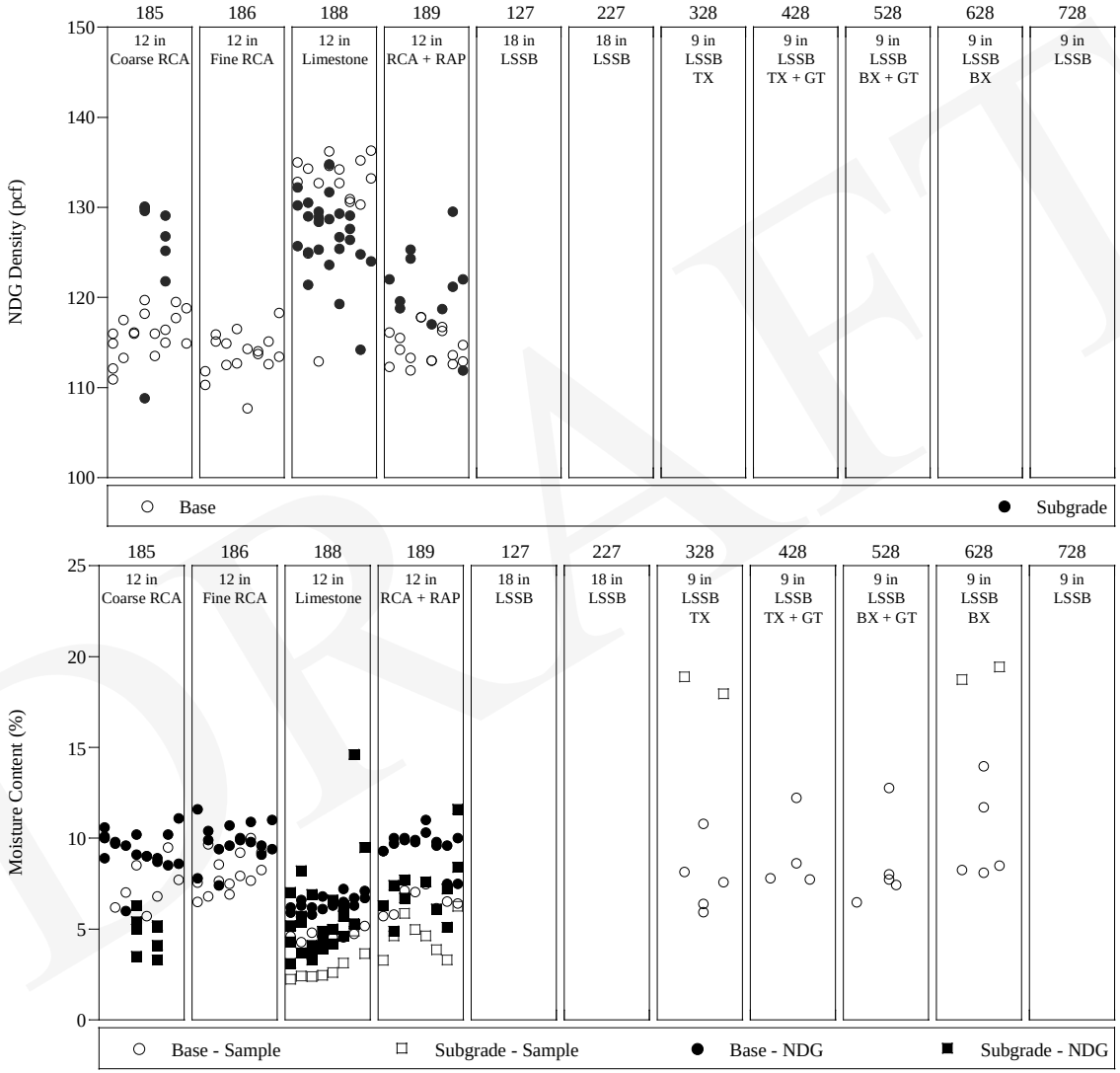
Photographic Portrayal by Xiaodong Wang & Craig H. Benson

TASK 4

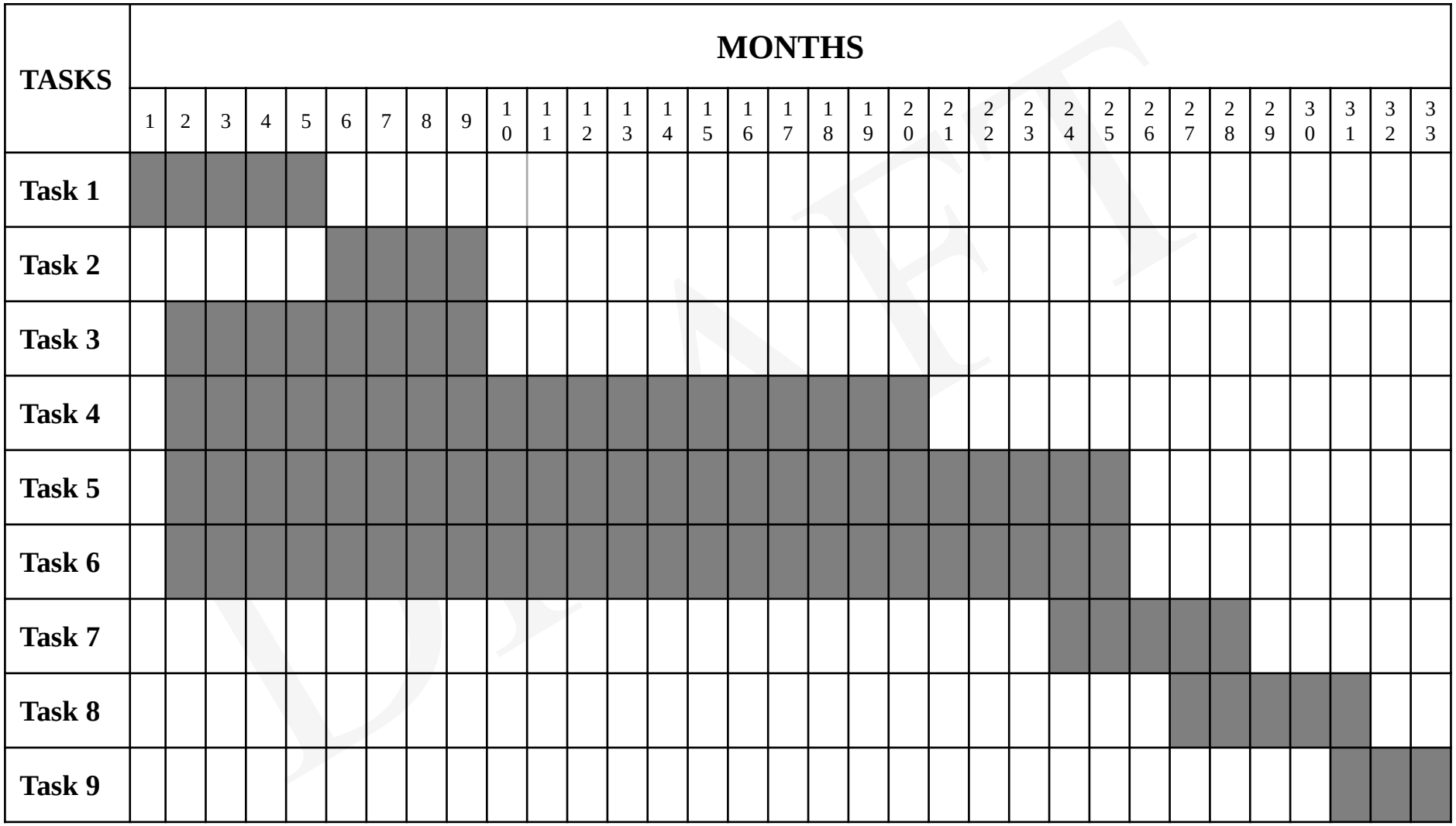
Permeameter with Constant Head Reservoirs for Headwater & Tailwater



TASK 4


185
186
188
189
127
227
328
428
528
628
728
12 in Coarse RCA
12 in Fine RCA
12 in Limestone
12 in RCA + RAP
18 in LSSB
18 in LSSB
9 in LSSB TX
9 in LSSB TX + GT
9 in LSSB BX + GT
9 in LSSB BX
9 in LSSB
NDG Density (pcf)
150
140
130
120
110
100
Base
Subgrade
Moisture Content (%)
25
20
15
10
5
0
Base - Sample
Subgrade - Sample
Base - NDG
Subgrade - NDG

SCHEDULE


TASKS
MONTHS
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33
Task 1
Task 2
Task 3
Task 4
Task 5
Task 6
Task 7
Task 8
Task 9

Thank You!

QUESTIONS??