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# Ground Tire Rubber (GTR) as a Stabilizer for Subgrade Soils

## FDOT Contract Number: BDK81 977-03


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# Problem Statement

- GTR supplies may increase when not used in Hot Mix
- Are other highway applications possible?

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# Outline

- Objectives
- Task overview
- Results

# Objective

- Determine the key pavement engineering properties of GTR and stabilized Florida subgrade soil blends

# Tasks

- Task 1 Literature Search
- Task 2 Determine GTR Sources
- Task 3 Determine Subgrade Sources
- Task 4 Test Program Development
- Task 5 Database Development
- Task 6 Sampling
- Task 7 Testing
- Task 8 Data Reduction
- Task 9 Data Analysis
- Task 10 Technology Transfer

# Literature Search

- Density
  - Decreased with increase of GTR
- LBR
  - Decreased with increase of GTR
  - Smaller sizes of GTR result in larger decreases of CBR/LBR
- Resilient Modulus
  - Decreased with increase of GTR
- Permeability
  - Increased slightly with maximum percentages of rubber
- Consolidation
  - No literature on Consolidation of granular soils was found
- Creep
  - Minimum failure strain at ~3%

# GTR Subgrade Choices

- Three soil types (FDOT SMO Aided)
  - Low LBR (20) – A-3
  - Medium LBR (40) – A-2-4
  - High LBR (80) –A-2-4
- FDOT approved GTR supplier with three sizes
  - 1 inch (Range:1-inch to 3/8-inch)
  - 3/8 inch (Range: 1/2-inch to #4 sieve)
  - #40

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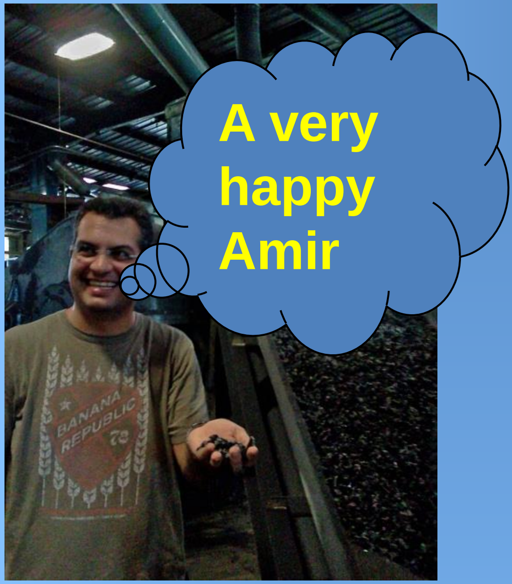
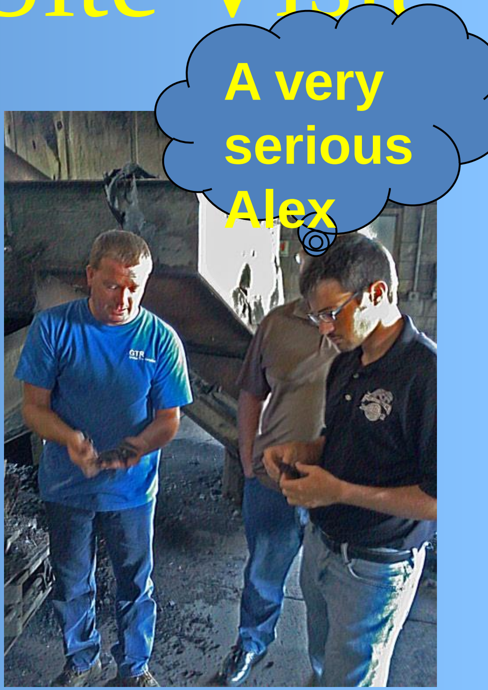
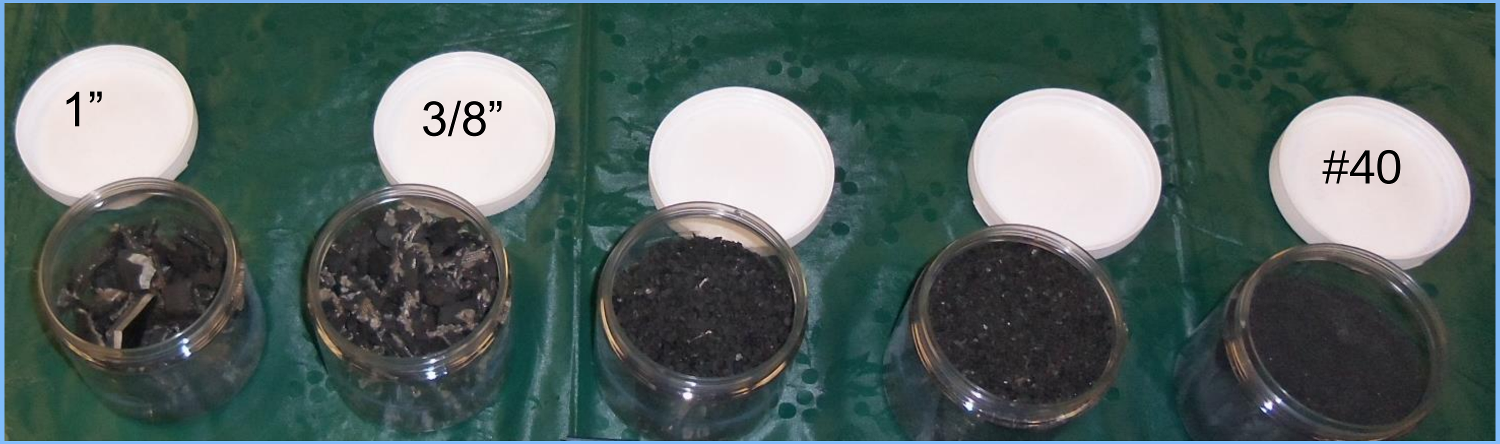
# Global Tire Recycling Plant Site Visit



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# Testing Program

1. Atterberg Limits
2. Optimum Moisture Content
3. Sieve Analysis
4. Volumetric Mixing
5. LBR
6. Resilient Modulus
7. Creep
8. Permeability
9. Consolidation

Subgrade Only (items 1–3)

Subgrade GTR Blends (items 4–9)

# Atterberg limits

- Low LBR Subgrade
  - No fines
- Medium & High LBR Subgrade
  - No plastic fines

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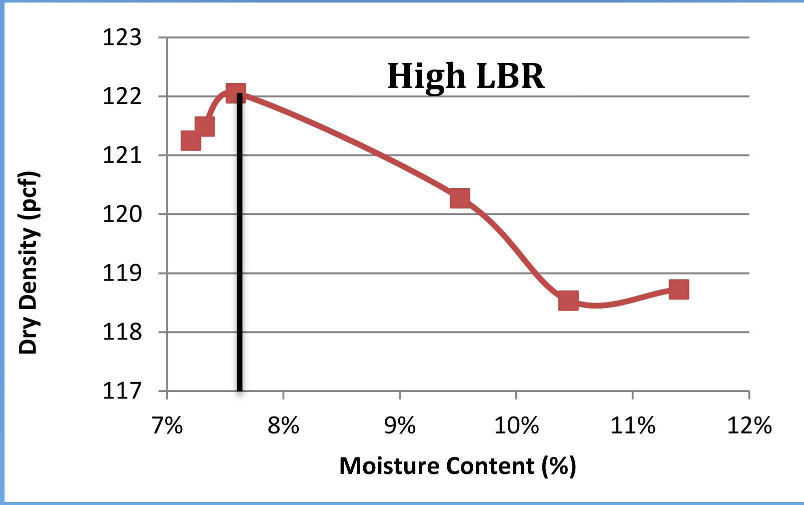
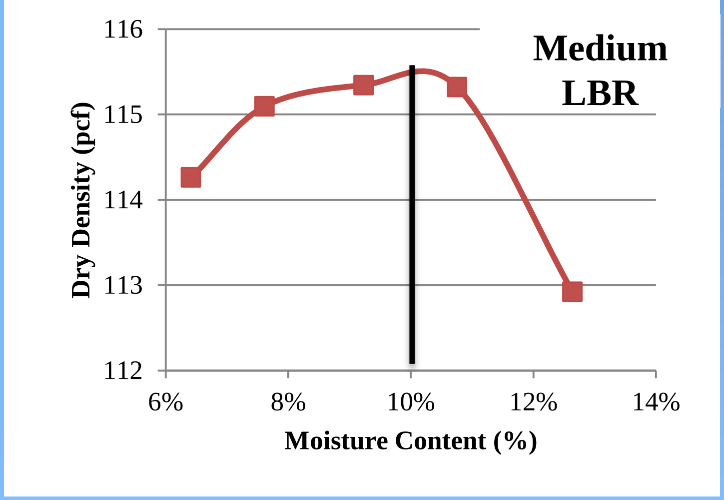
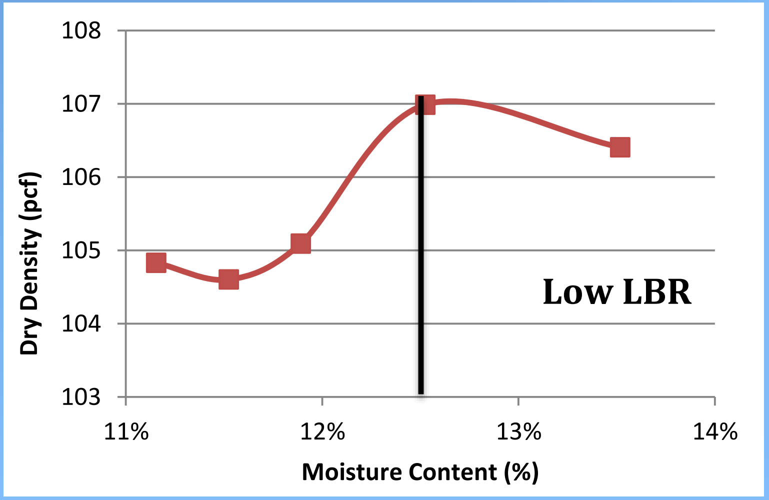
# Moisture Density (Modified Proctor)



# Test Results: Optimum Moisture Content

| Source | Maximum Dry Density | Optimum Moisture Content |
|---|---|---|
| | (pcf) | (%) |
| Low LBR | 107 | 12.5% |
| Medium LBR | 115 | 10.0% |
| High LBR | 122 | 7.5% |

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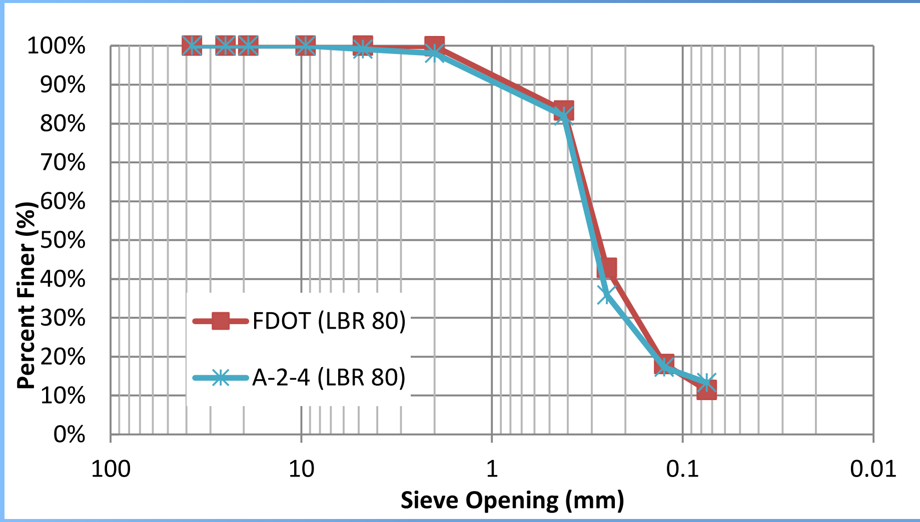
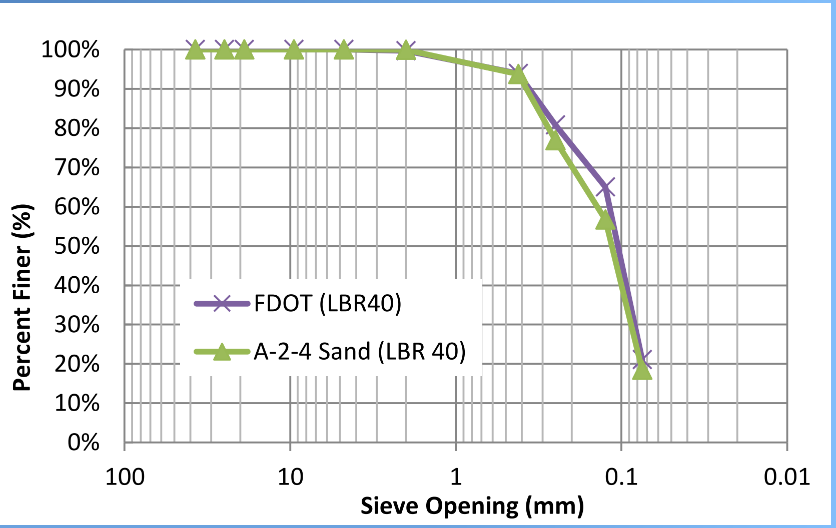
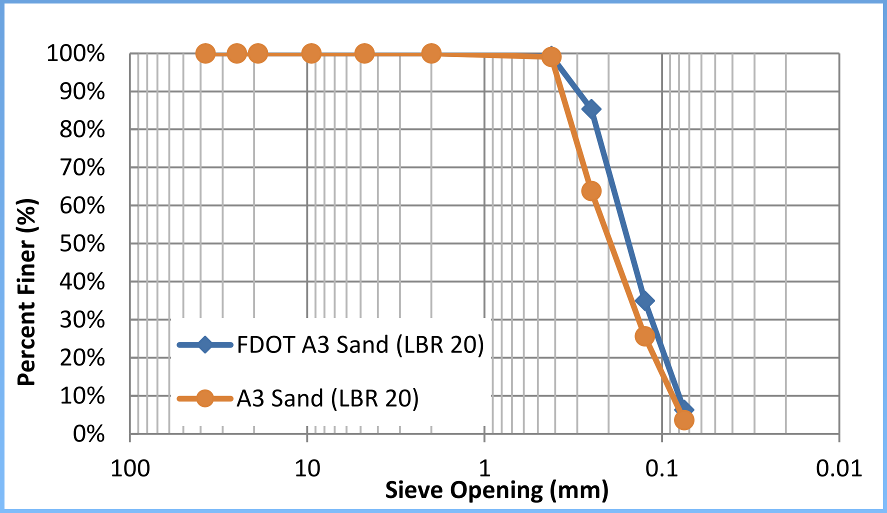
# Sieve Analyses



# Sieve Analysis Results

| Grain Size Characteristic | Low LBR Material | Medium LBR Material | High LBR Material |
|---|---|---|---|
| Uniformity Coefficient | 2.2 | 2.0 | 4.1 |
| Curvature Coefficient | 1.1 | 63.9 | 1.4 |
| Passing # 200 | 5% | 20% | 12% |
| AASHTO Classification | A-3 | A-2-4 | A-2-4 |
| USCS Classification | SP | SM | SM |

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# Volumetric Blending

- Mixing by volume used in the field
  - 4%, 8%, 16%, 24%, 32% GTR by volume
- Corresponds to
  - 1/2”, 1”, 2”, 3” and 4” GTR layers in a 12” lift

# Lab Blending Equivalences

| Soil Type | GTR % by Weight | GTR % by Volume |
|---|---|---|
| High LBR | 1.1 | 4 |
| | 2.3 | 8 |
| | 4.7 | 16 |
| | 7.1 | 24 |
| | 9.7 | 32 |
| Medium LBR | 1.2 | 4 |
| | 2.4 | 8 |
| | 4.8 | 16 |
| | 7.4 | 24 |
| | 10.0 | 32 |
| Low LBR | 1.3 | 4 |
| | 2.6 | 8 |
| | 5.3 | 16 |
| | 8.0 | 24 |
| | 10.9 | 32 |

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# Blending

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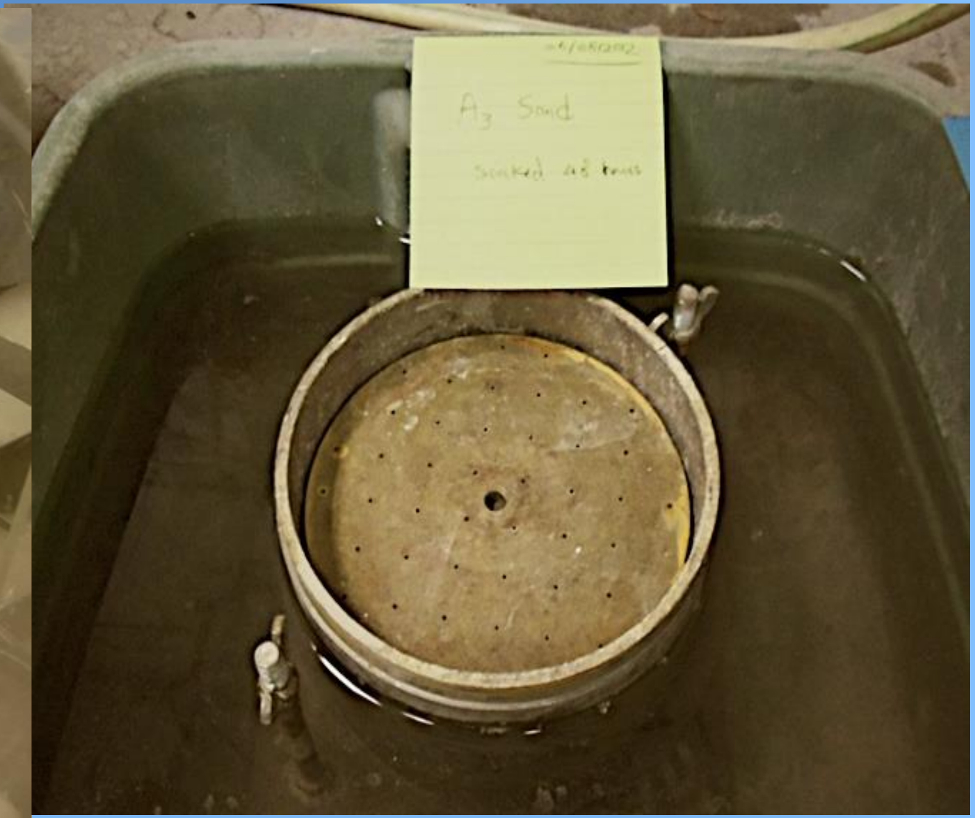
# LBR



# LBR (cont.)

- Limerock Bearing Ratio
  - 15 lb surcharge for subgrade

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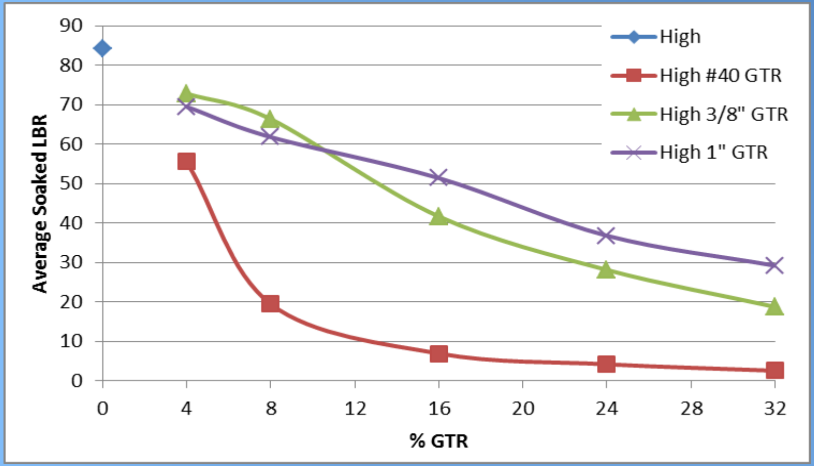
# Limerock Bearing Ratio Results

- Subgrades

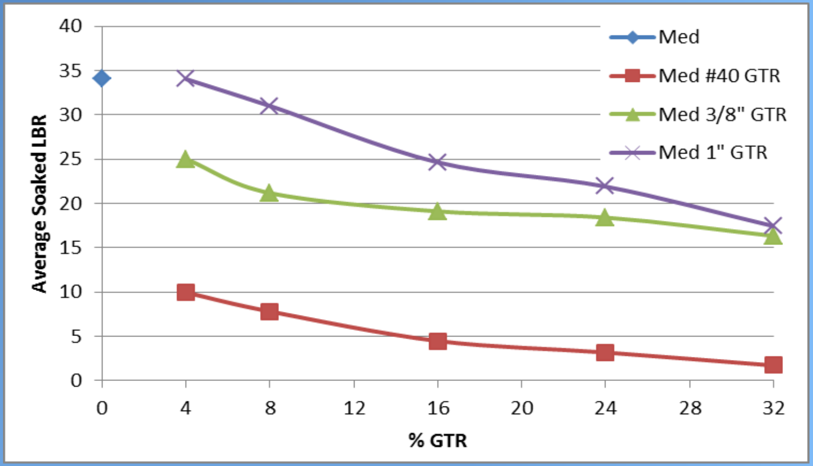
| Soil | Soaked LBR |
| --- | --- |
| High LBR | 88 |
| Med LBR | 38 |
| Low LBR | 20 |

# Limerock Bearing Ratio Results

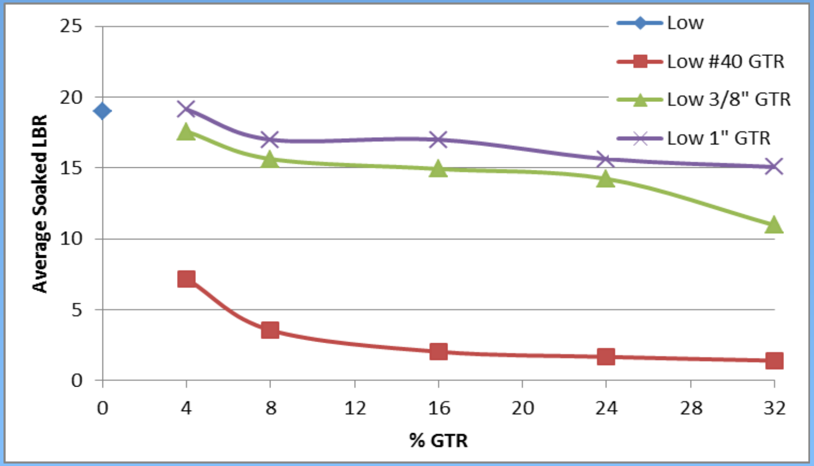
## High LBR Blends




## Medium LBR Blends



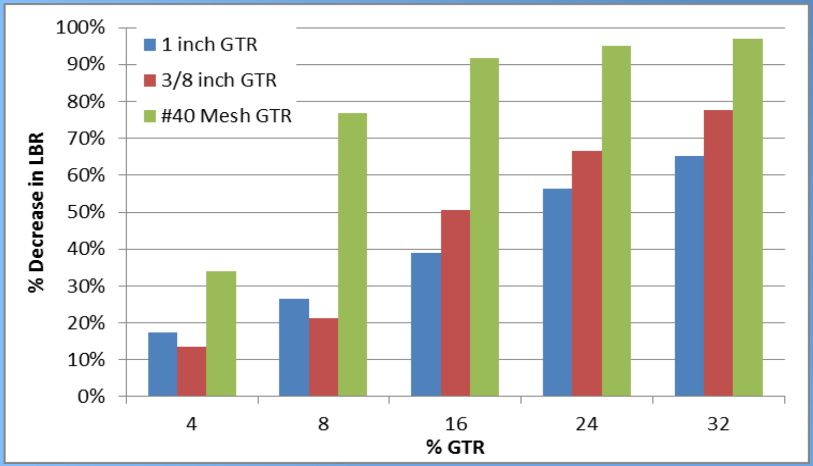

## Low LBR Blends



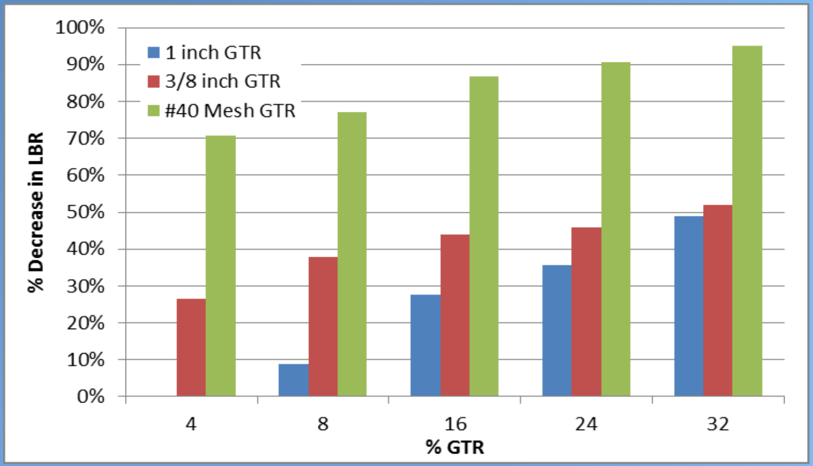

- All Decrease
- # 40 Blends Worst

# Limerock Bearing Ratio Results

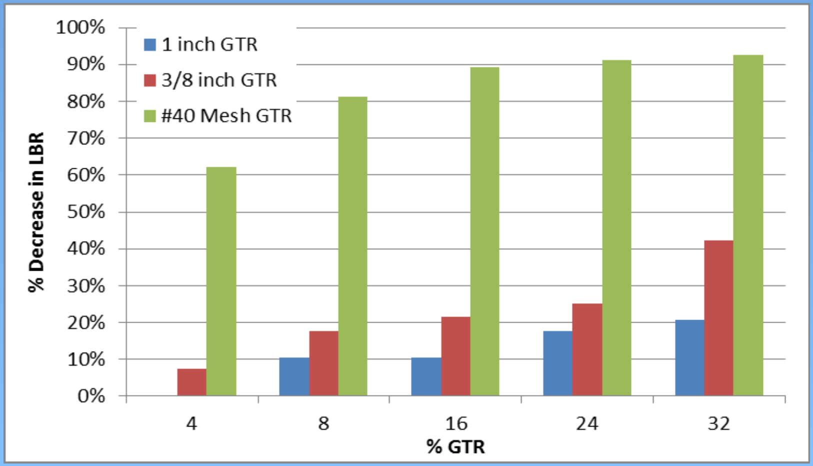
## High LBR Blends




## Medium LBR Blends




## Low LBR Blends




- Largest Decrease # 40

# Resilient Modulus

- Tests performed by the State Materials Office (SMO)

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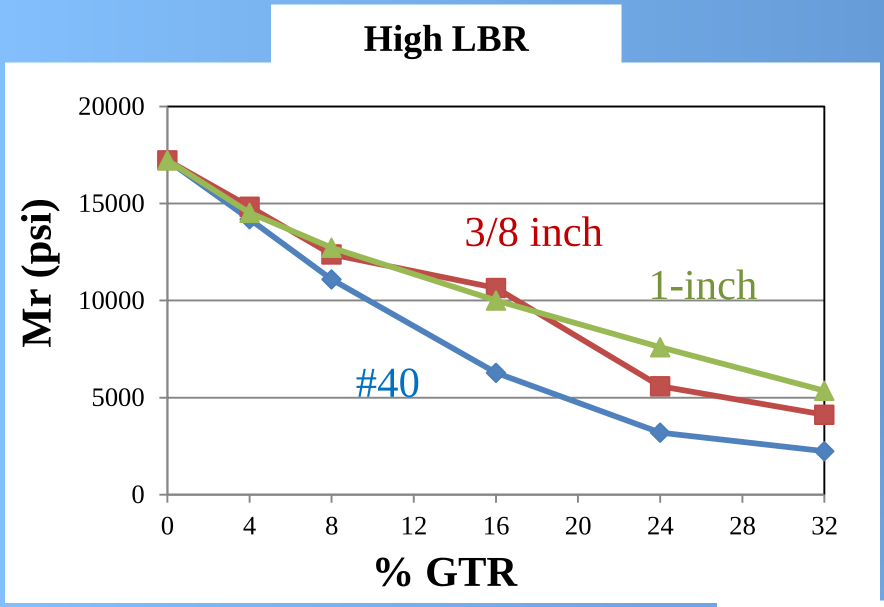
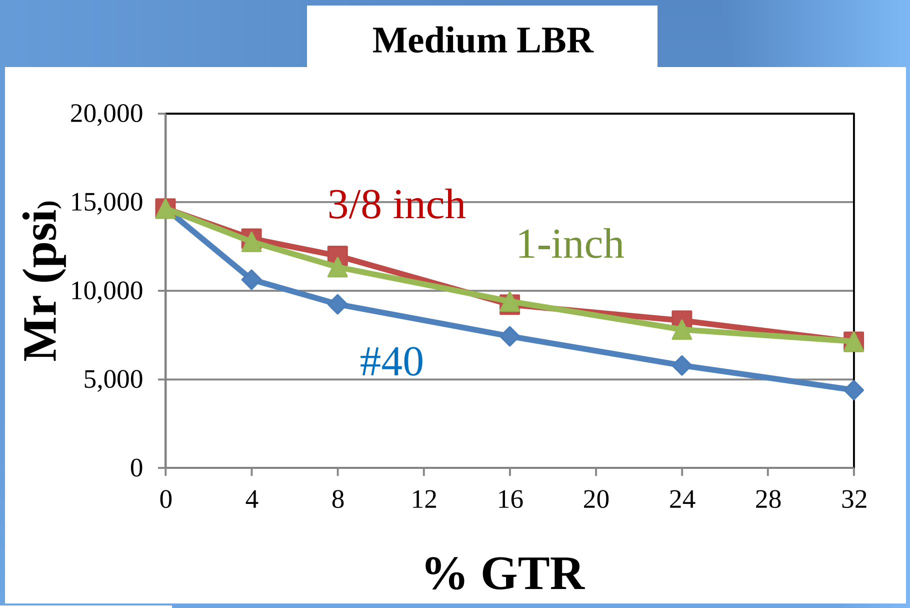
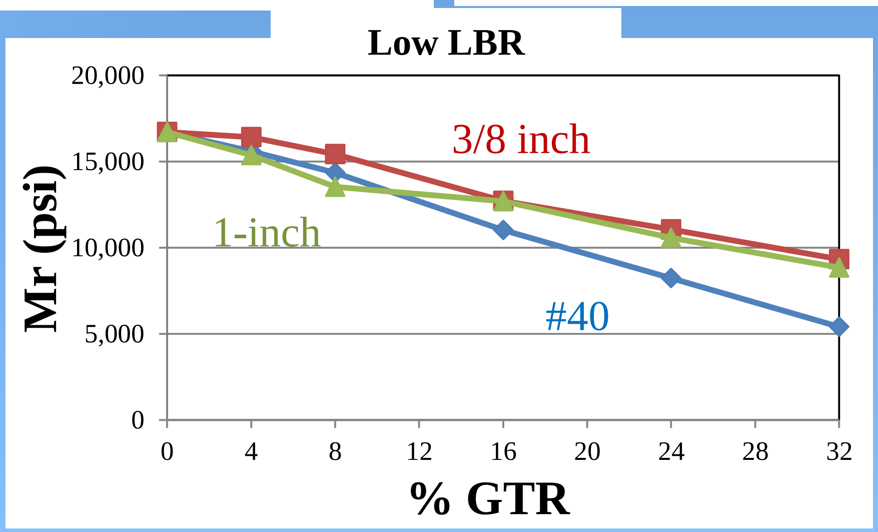
# % GTR vs. Resilient Modulus




- All Decrease
- Low Mr Decrease < Medium LBR < High LBR

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# Creep

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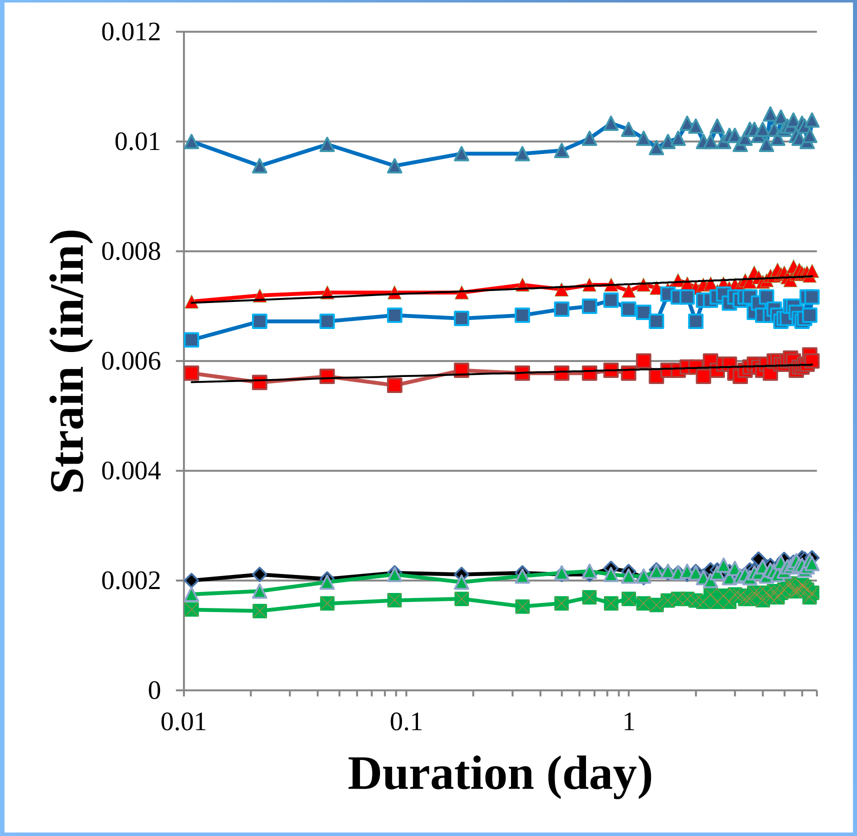
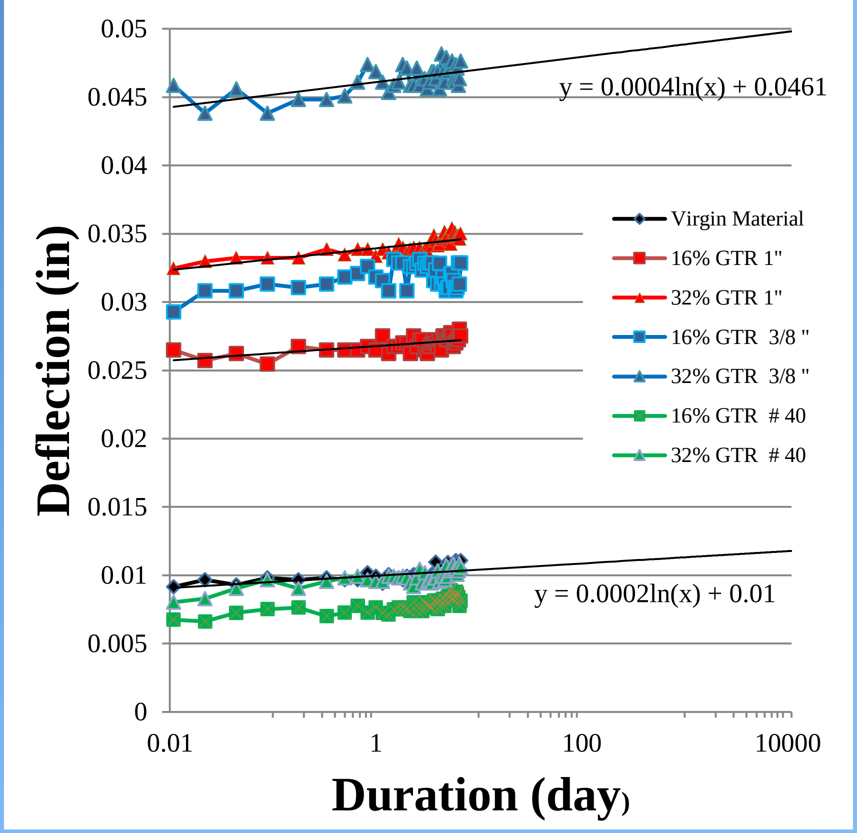
# High LBR Material

Strain vs. Duration High LBR Material



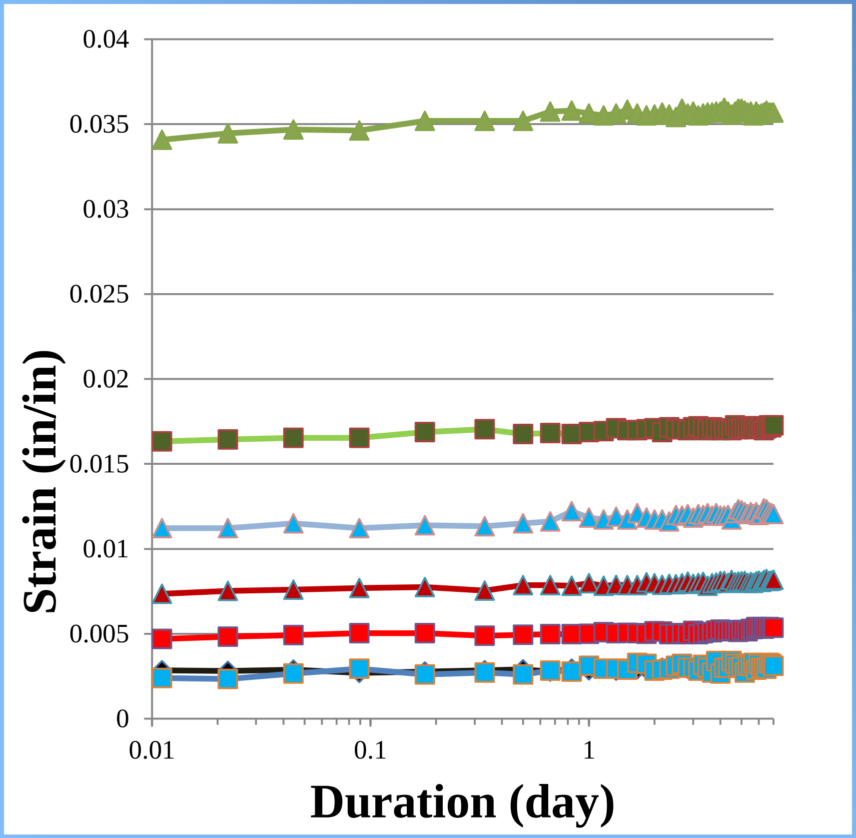

30-Year Deflection Projection

High LBR Material

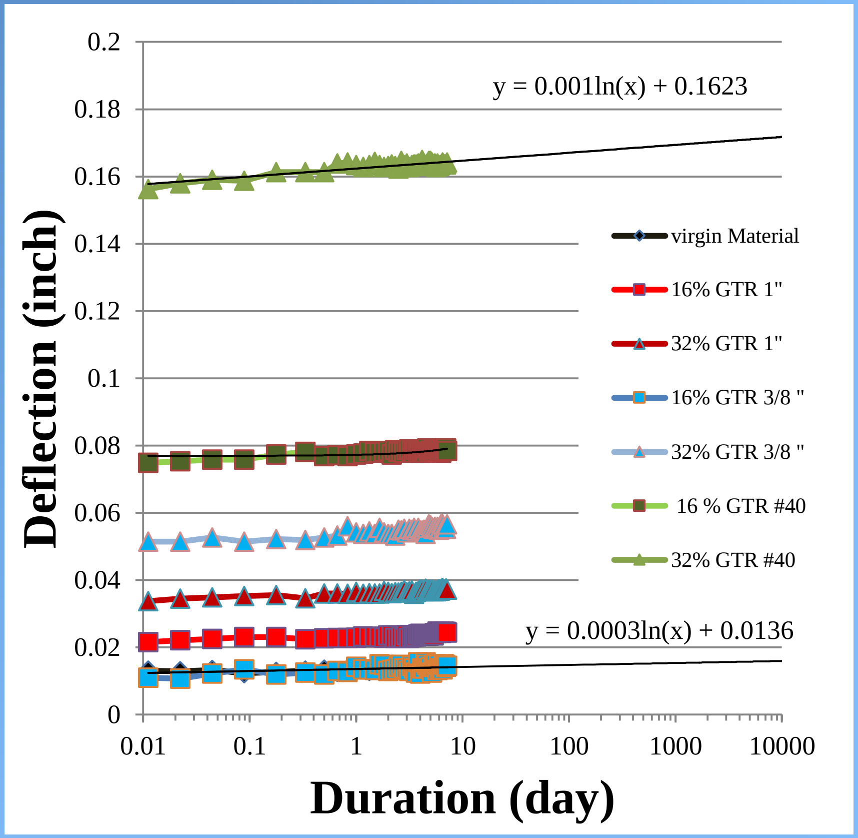


# Medium LBR Material

## Strain vs. Duration Medium LBR Material

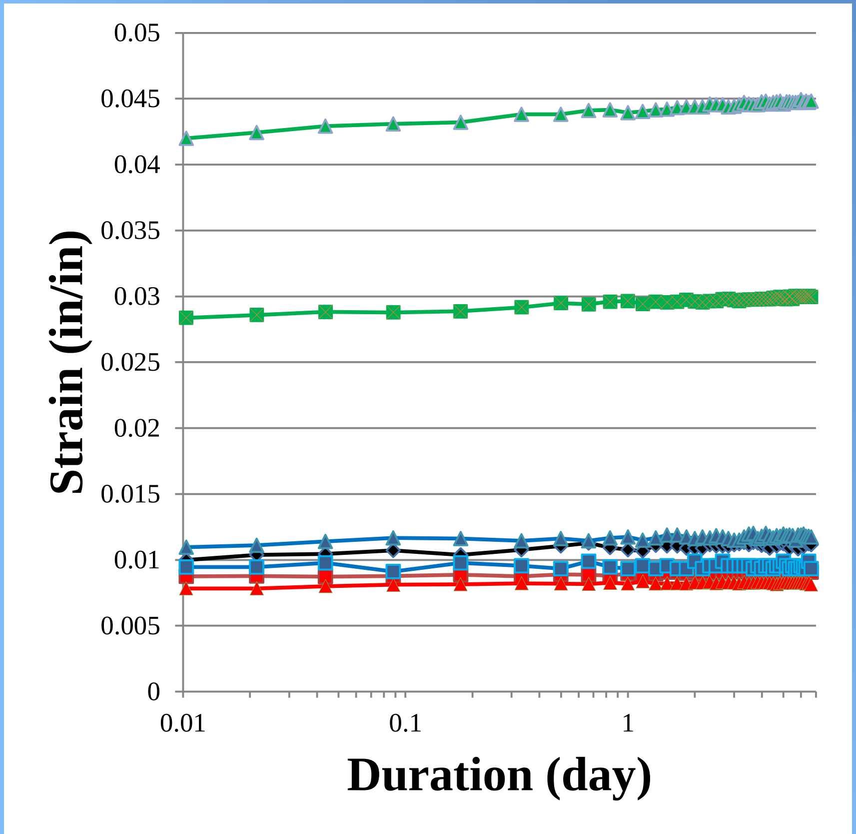



## 30-Year Deflection Projection for Medium LBR Material

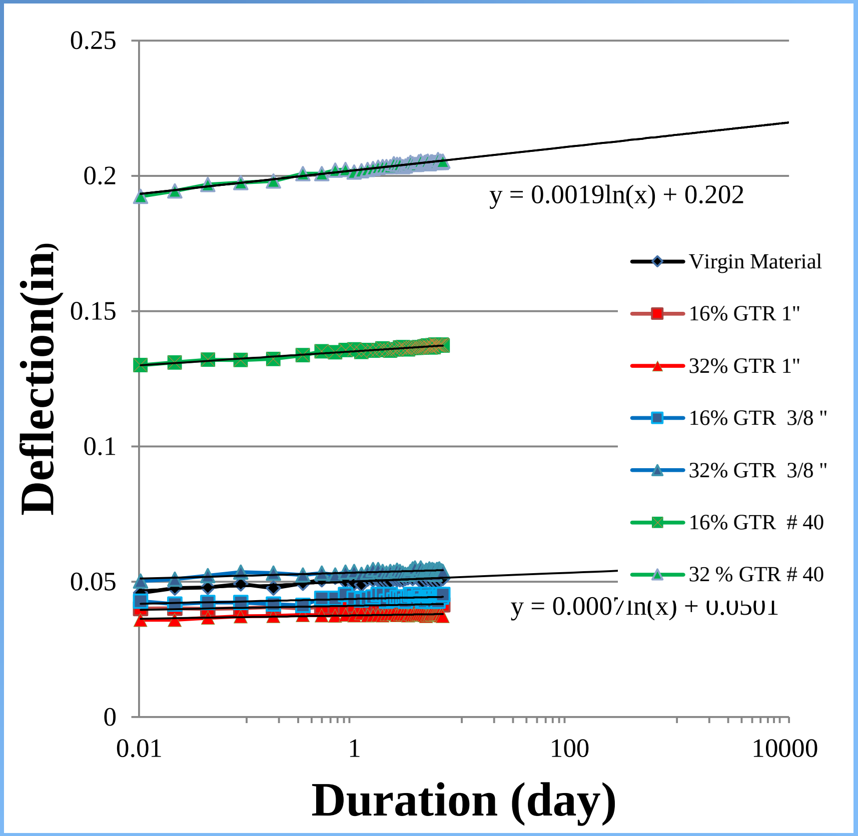


# Low LBR Material

Strain vs. Duration Low LBR Material




30-Year Deflection Projection for Low LBR Material



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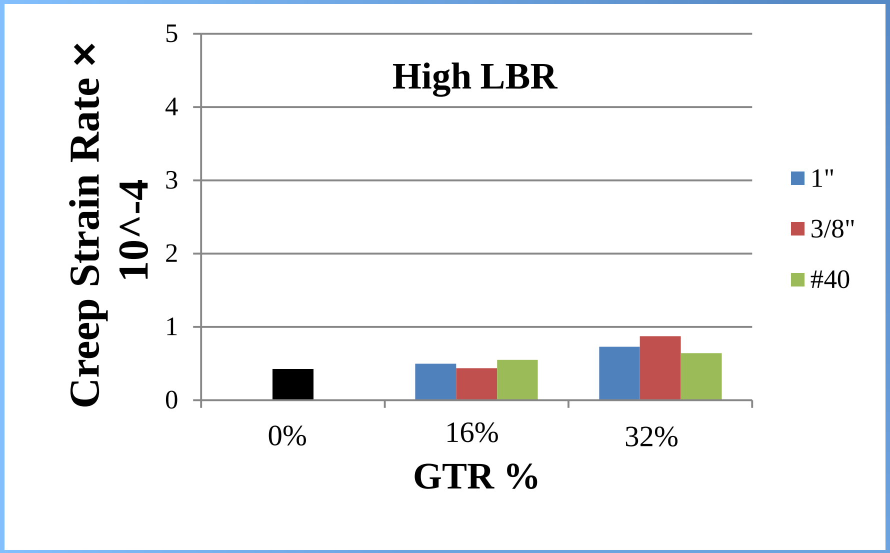
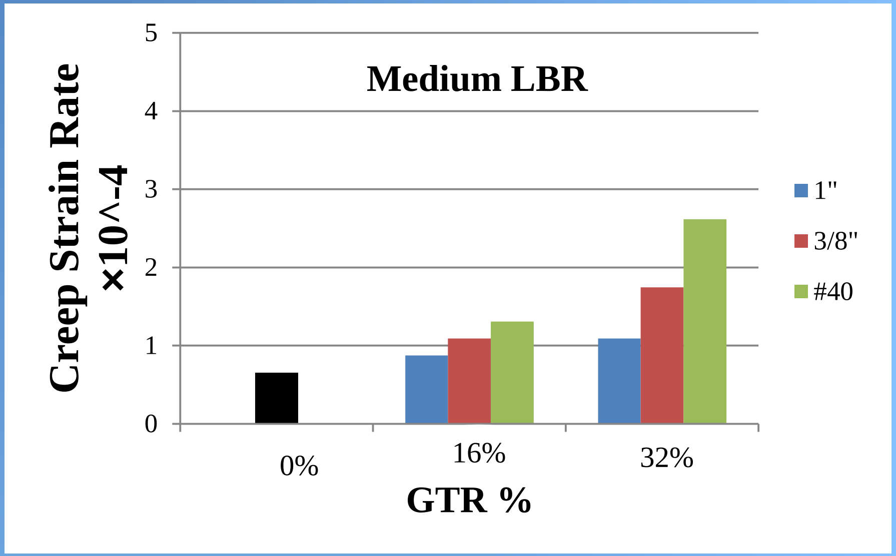
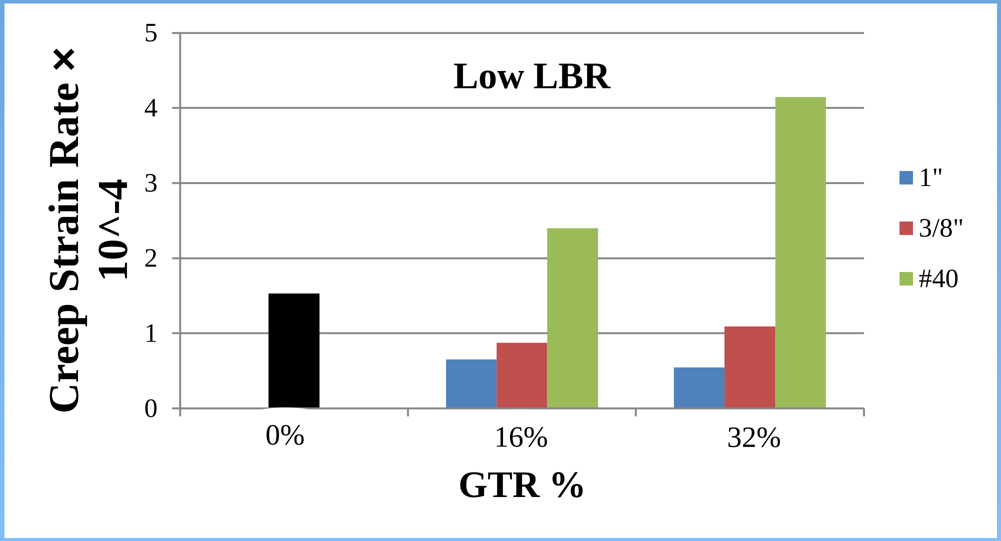
# Strain Rate vs. GTR % for each Soil Type



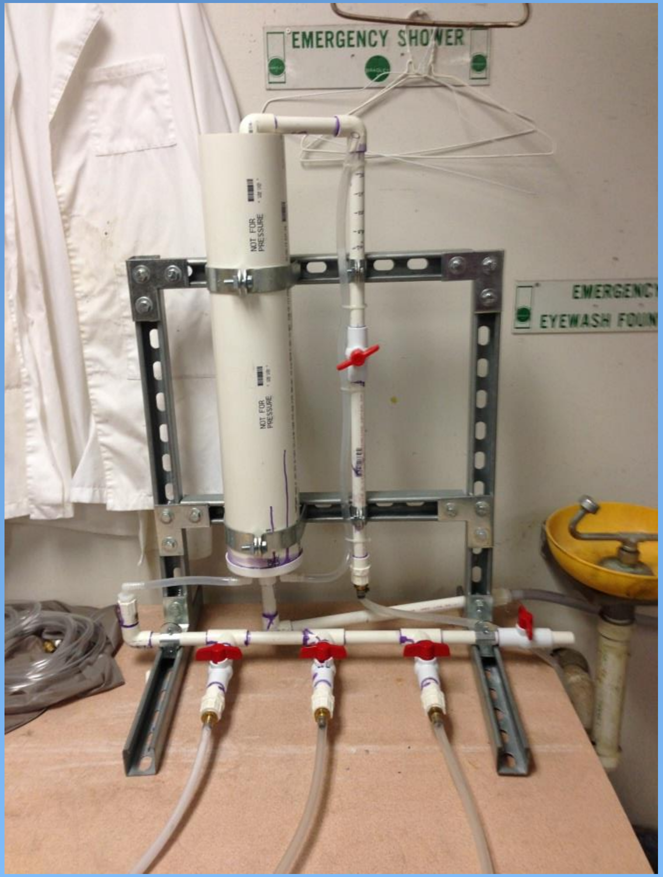




- Creep not a concern
- All relatively acceptable if $10^{-4}$
- #40 with Low Material will produce 0.3 % strain over 30 years

# Permeability

Constant Head Permeability
Test Set-up



# Test Results: Constant Head Permeability

- Virgin Material
  - One Order of Magnitude Differences

| Soil | Hydraulic Conductivity, k (cm/sec) |
|---|---|
| High LBR | $1.2 \times 10^{-5}$ |
| Medium LBR | $2.8 \times 10^{-6}$ |
| Low LBR | $3.7 \times 10^{-4}$ |

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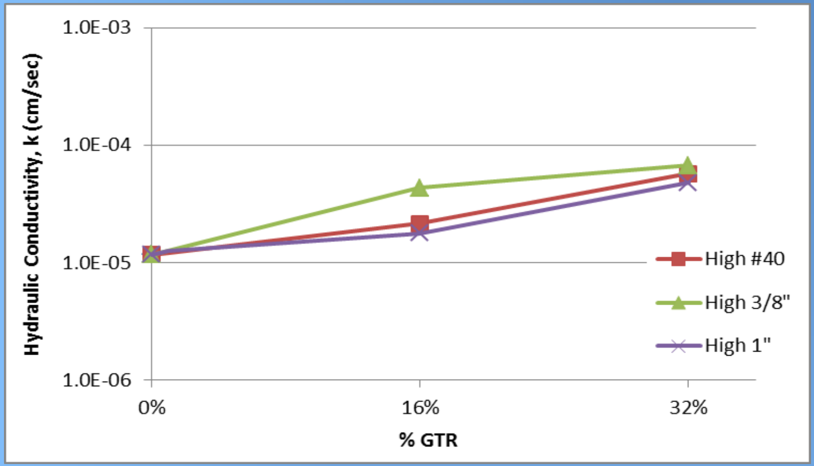
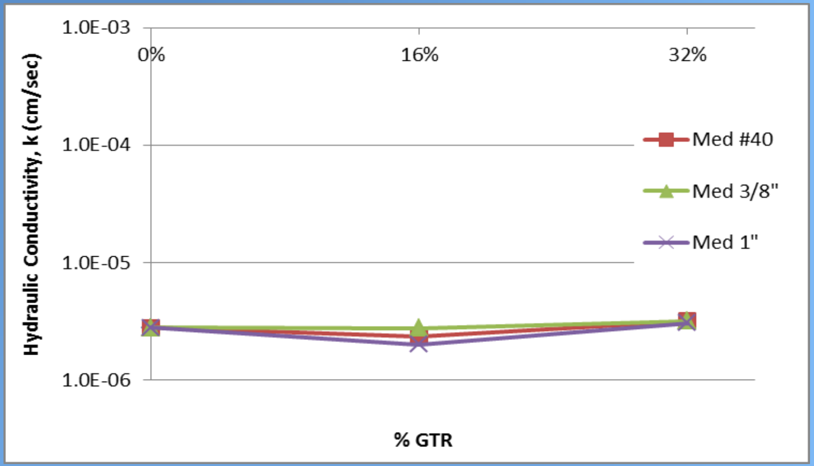
# Constant Head Permeability

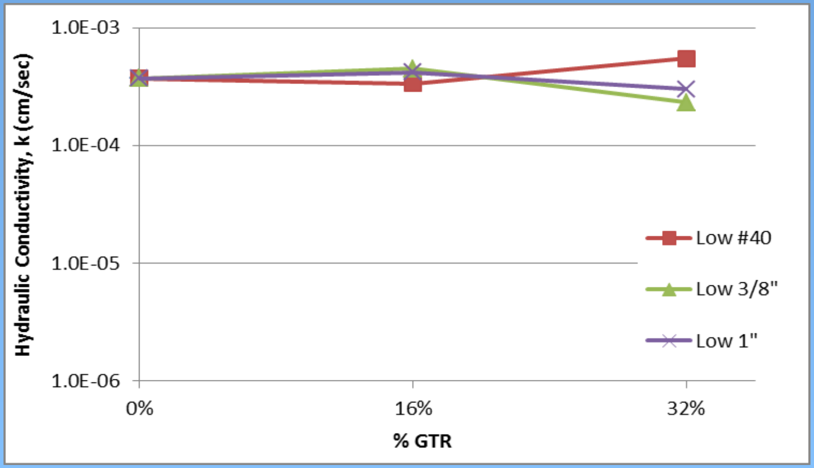
High LBR Blends




Medium LBR Blends




Low LBR Blends




- Very little change for all cases

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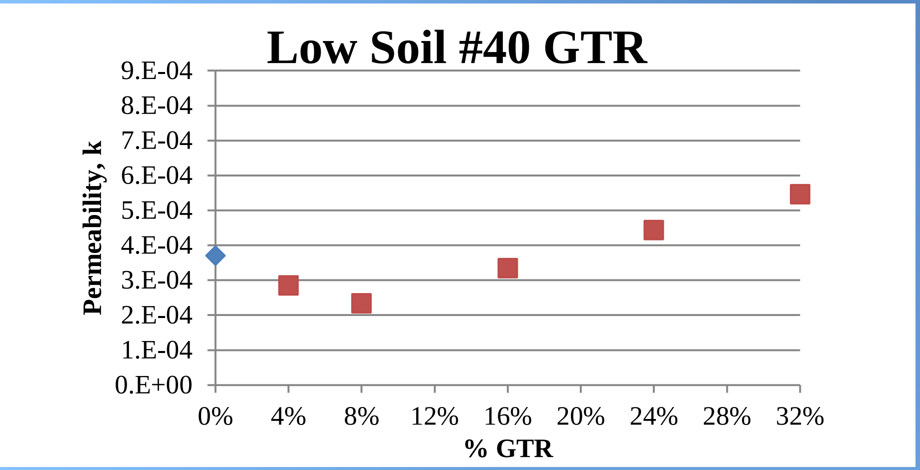
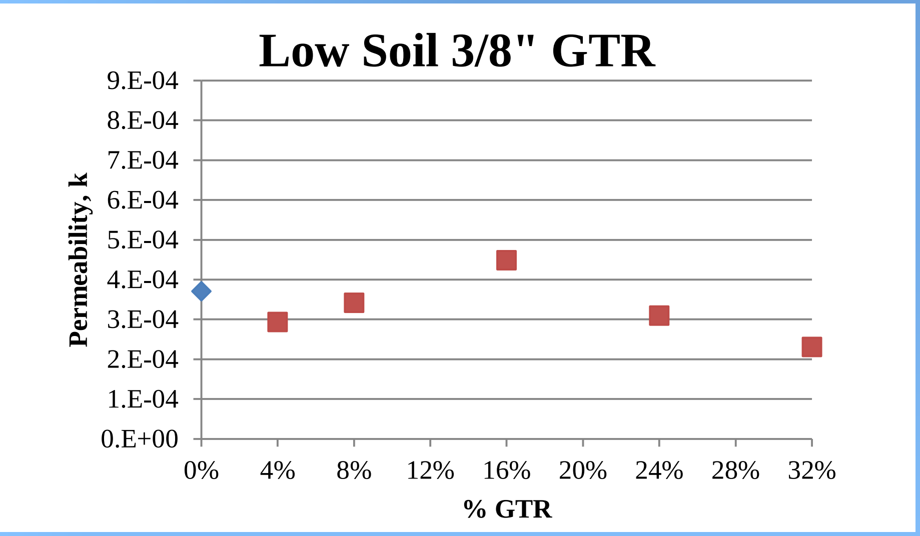
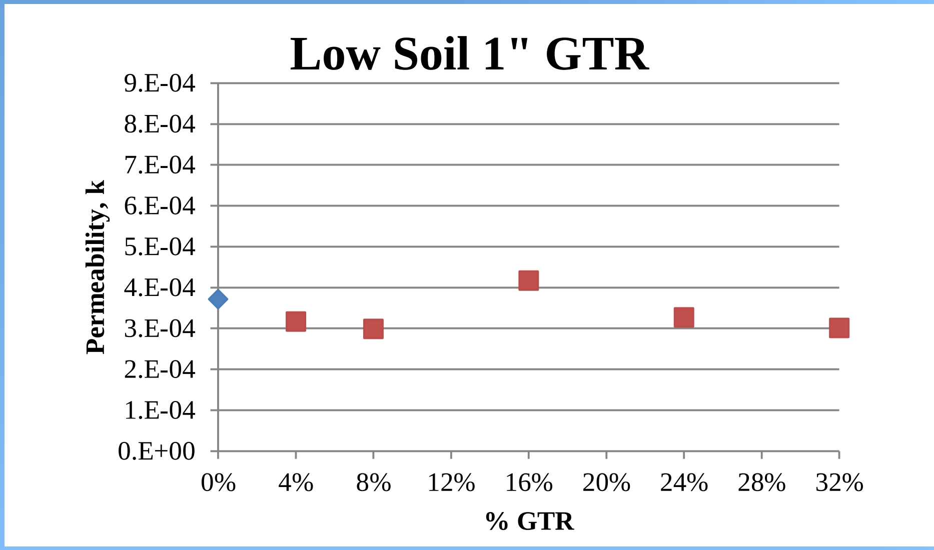
# Low LBR Material




- Typical results
- No significant change

| Soil | GTR | k (cm/sec) |
|---|---|---|
| Low LBR | 0 | 3.7E-04 |
| Med LBR | 0 | 4.2E-06 |
| High LBR | 0 | 6.3E-06 |



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# Consolidation

Custom 4-inch Consolidation Molds

# Consolidation

- Virgin Material Slope

| **Soil** | **Compression Index, $C_c$** |
|---|---|
| High LBR | 0.010 |
| Med LBR | 0.007 |
| Low LBR | 0.008 |

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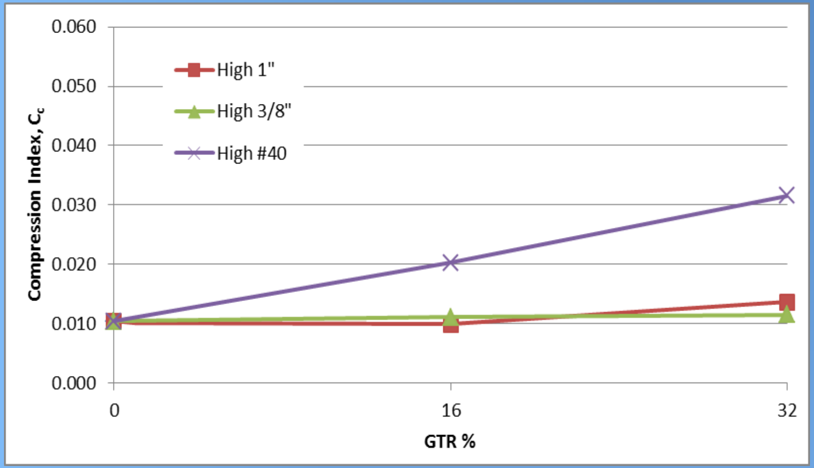
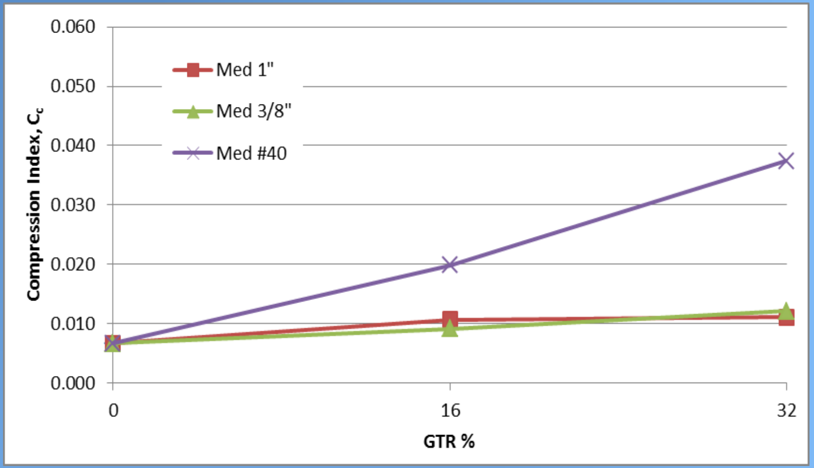
# Consolidation Results

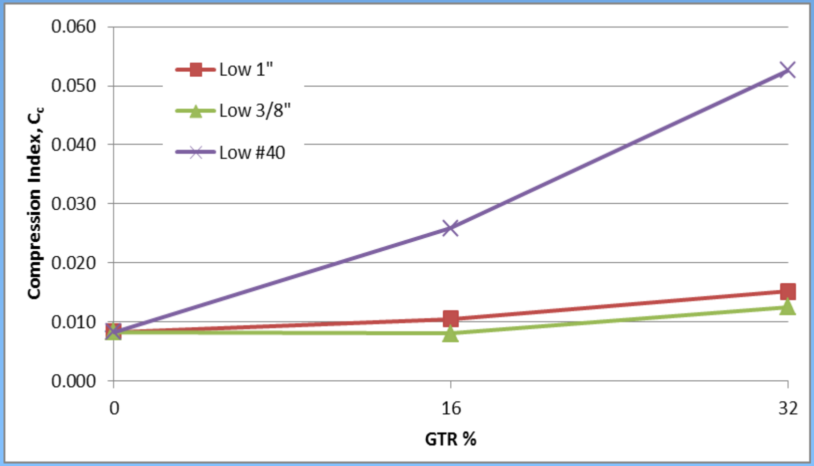
## High LBR Blends




## Medium LBR Blends




## Low LBR Blends




- 1” and 3/8 “ produce no change
- # 40 blend causes change

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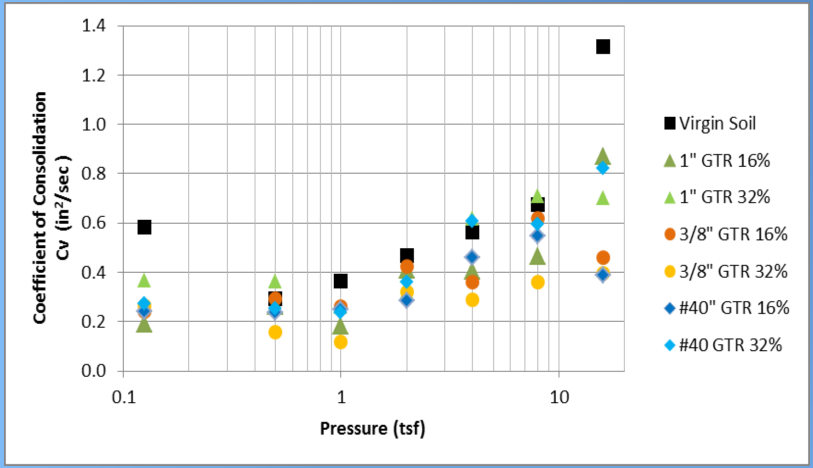
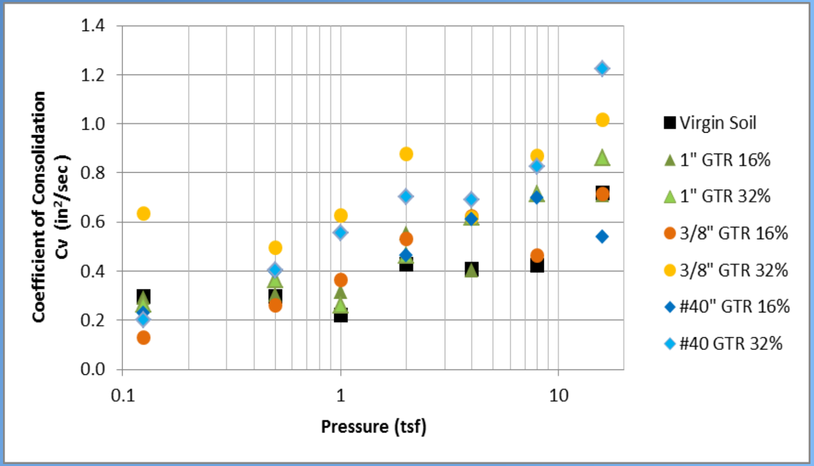
# Consolidation Results

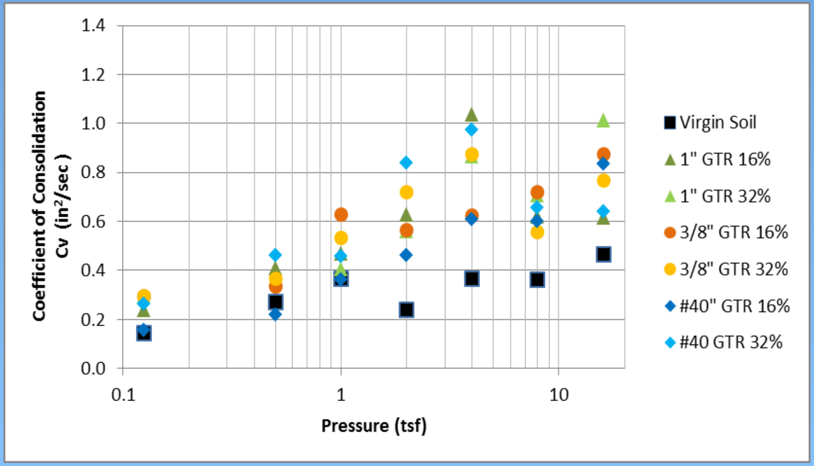
## High LBR Blends




## Medium LBR Blends




## Low LBR Blends




- No clear trends
- Typical clays
  - $10^{-3}$ to $10^{-4}$
- Much higher

# Summary

- With increasing GTR %:
  - Density decreases
  - LBR decreases
  - Resilient Modulus decreases
  - No significant Creep
  - Not Consolidating
  - No significant change in Permeability

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# Conclusions

- GTR Subgrade blends are not desirable for highway use
- LBR
  - Decreases linearly with an increase of GTR
  - #40 mesh GTR blends produced largest LBR decrease
  - Low and Medium LBR subgrade blends were classified as unsuitable for use as a subgrade material
  - High LBR subgrade blends with 1-inch GTR and 3/8-inch GTR produce acceptable LBR’s up to 8% GTR by volume
  - #40 GTR High LBR blends produce acceptable LBR’s only at 4% GTR by volume

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# Conclusions

- Constant Head Permeability
  - High LBR soil blends produce a small increase in k
  - Low and Medium LBR soil blends showed no significant k changes
- Consolidation
  - Compressibility of 1”and 3/8” blends showed no change compared to virgin material
  - Compressibility of #40 mesh GTR blends increased by three to five magnitudes over the virgin material
  - $C_v$ values in the soil/GTR blends were three to four orders of magnitude larger than typical remolded clays

# Recommendations

- Blends of High LBR Subgrade with minimal GTR concentrations could be suitable for the subgrade layer
- Could be suitable as a possible lightweight, non-structural backfill due to decrease in density and increase in internal friction angle

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# Questions ?