



# 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?



# 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%

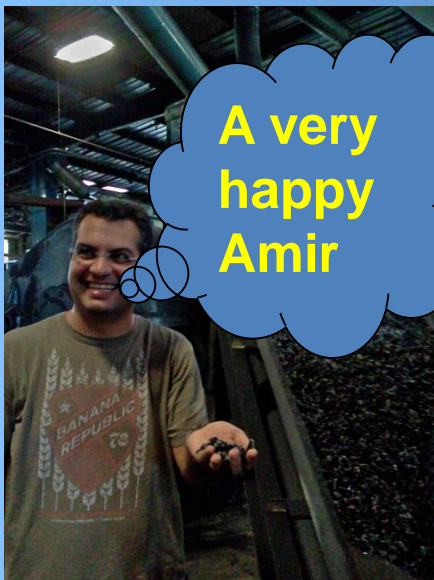


# GTR Subgrade Choices

- 🐾 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



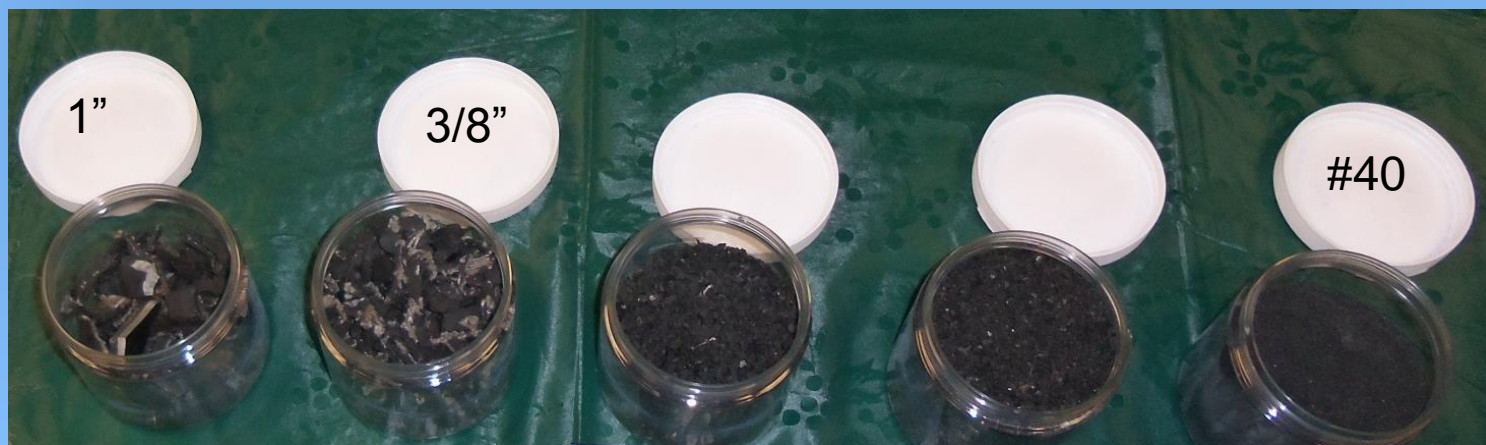
# Global Tire Recycling Plant Site Visit



A very happy Amir



A very serious Alex





# 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



Subgrade GTR Blends



# Atterberg limits

 Low LBR Subgrade

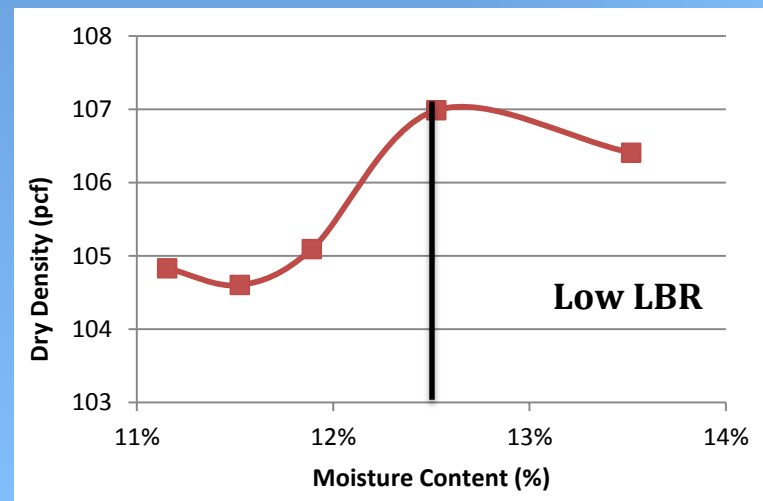
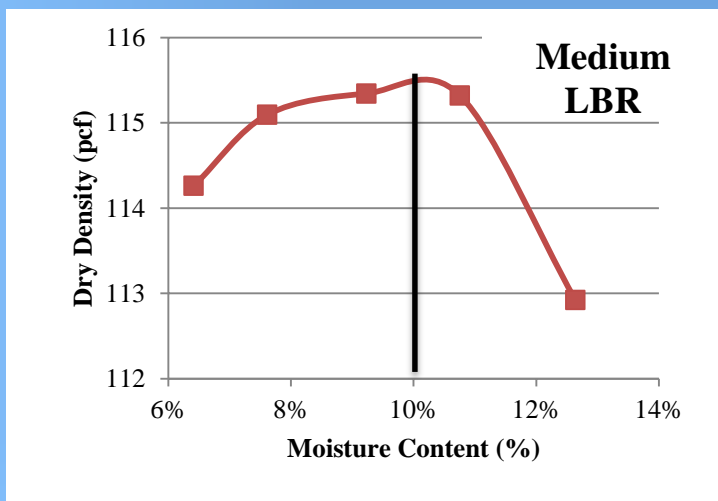
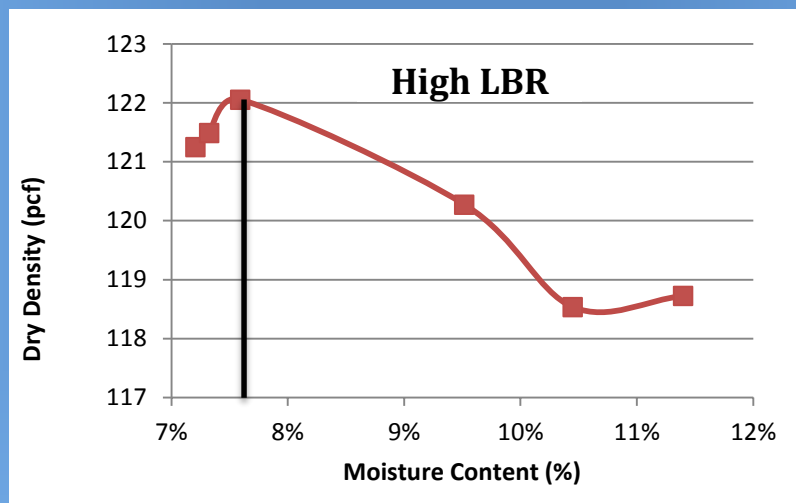
 No fines

 Medium & High LBR Subgrade

 No plastic fines



# Moisture Density (Modified Proctor)



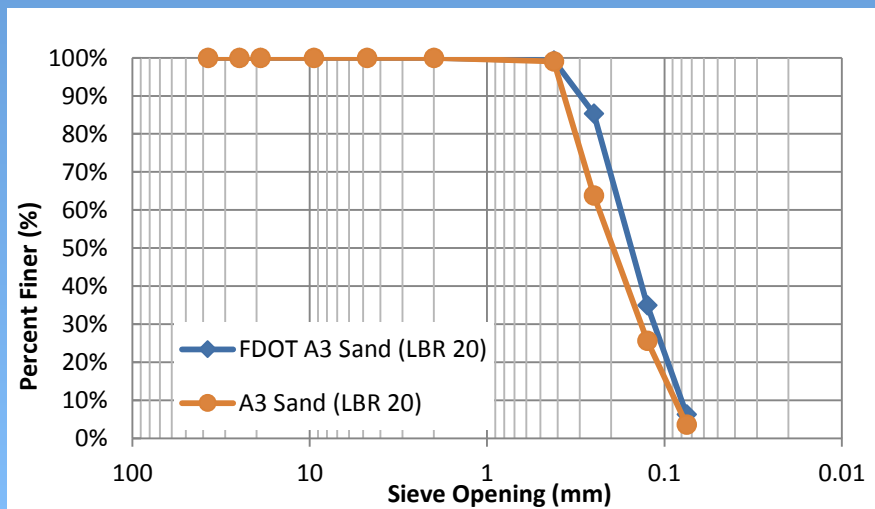
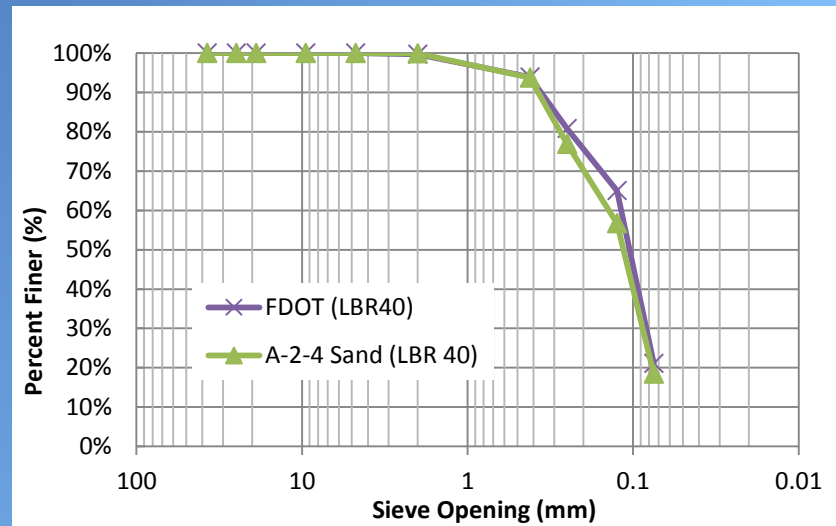
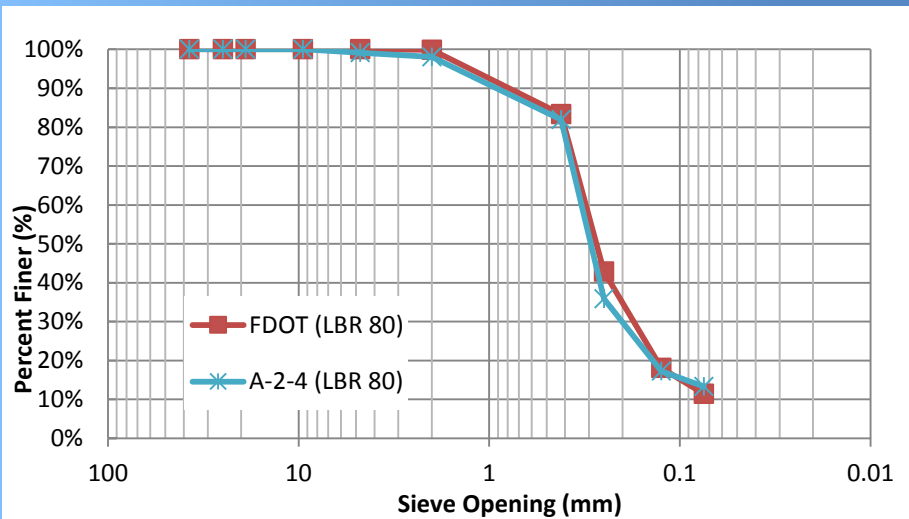


# Test Results: Optimum Moisture Content

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



# 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



# 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

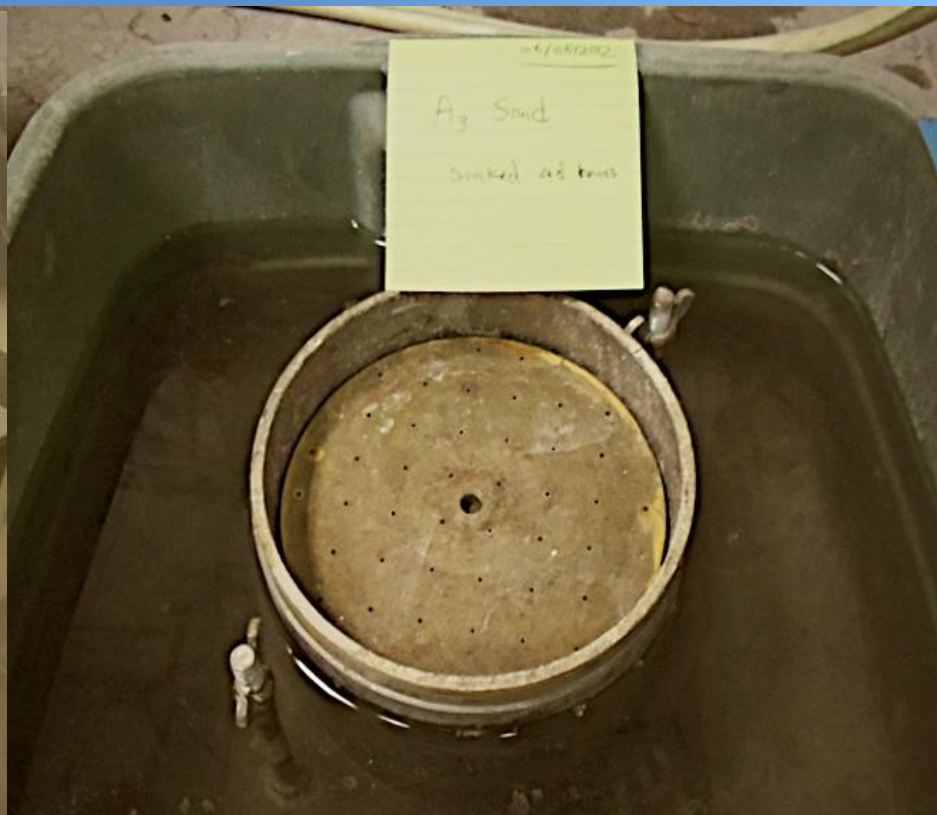


# Blending





# LBR





# LBR (cont.)

 Limerock Bearing Ratio

 15 lb surcharge for subgrade





# Limerock Bearing Ratio Results

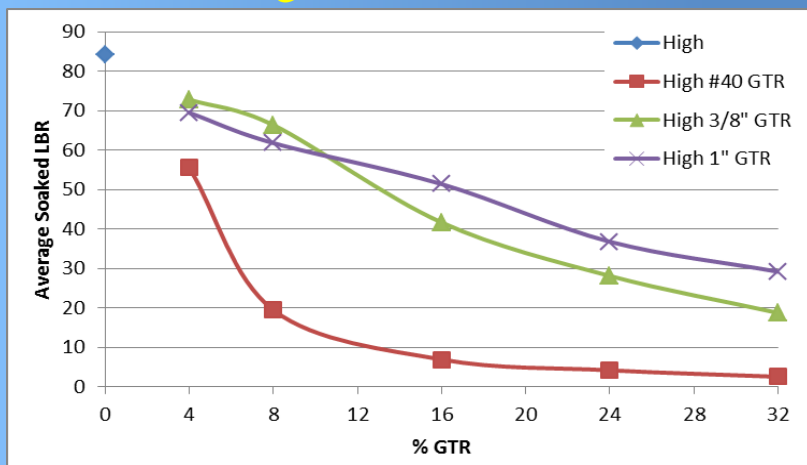
## Subgrades

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

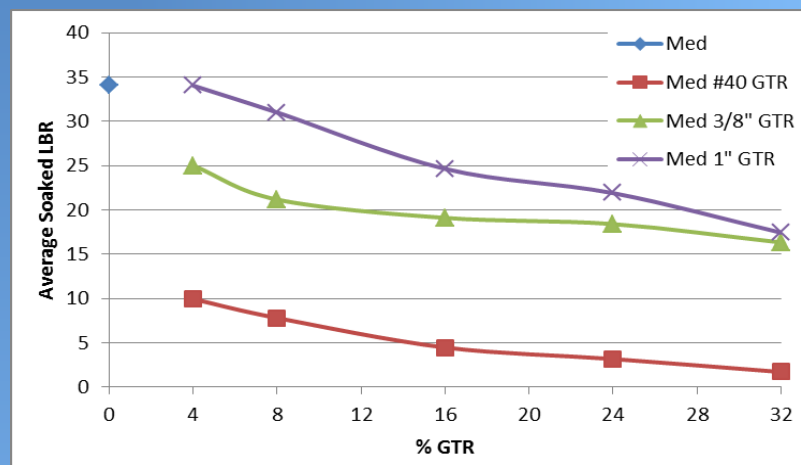


# Limerock Bearing Ratio Results

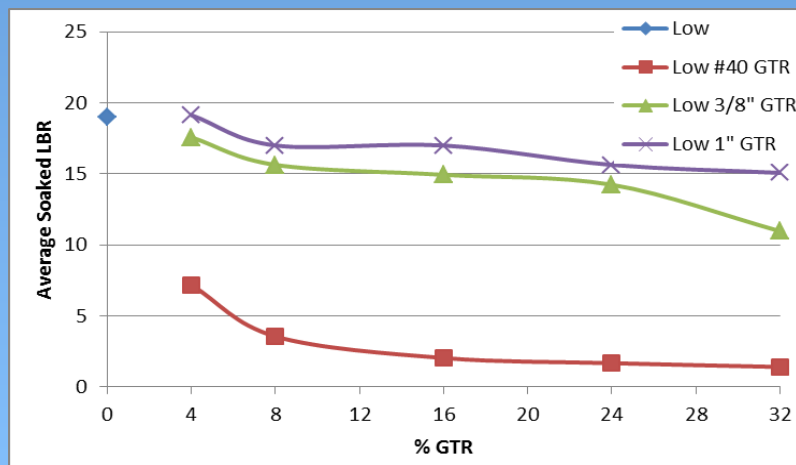
## High LBR Blends



## Medium LBR Blends



## Low LBR Blends



All Decrease

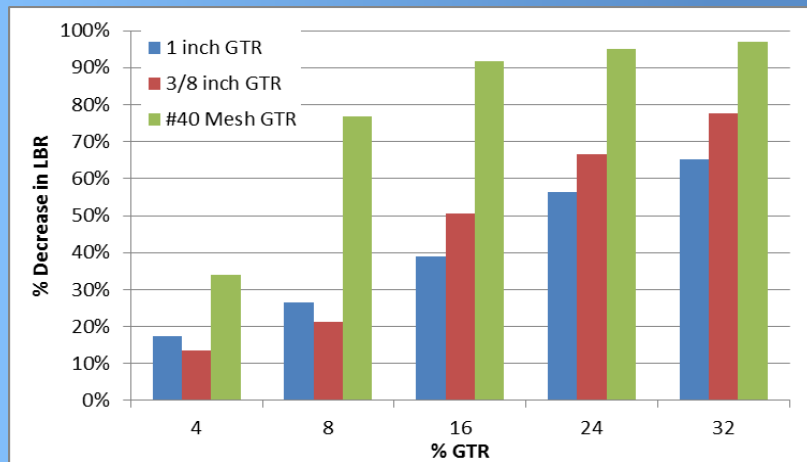


# 40 Blends Worst

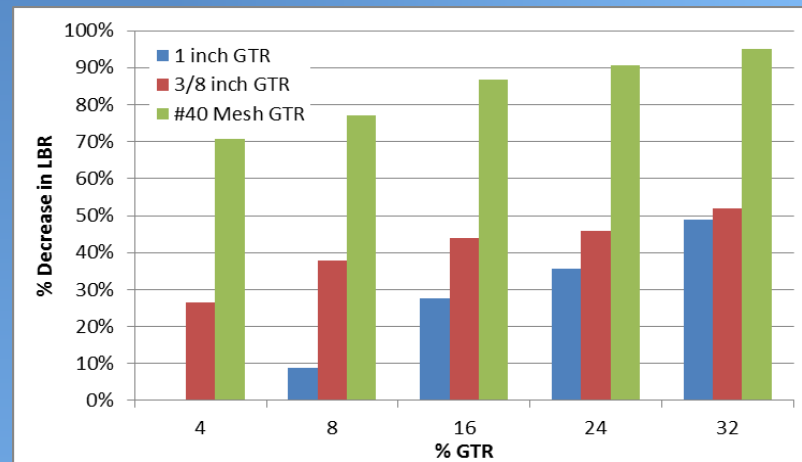


# Limerock Bearing Ratio Results

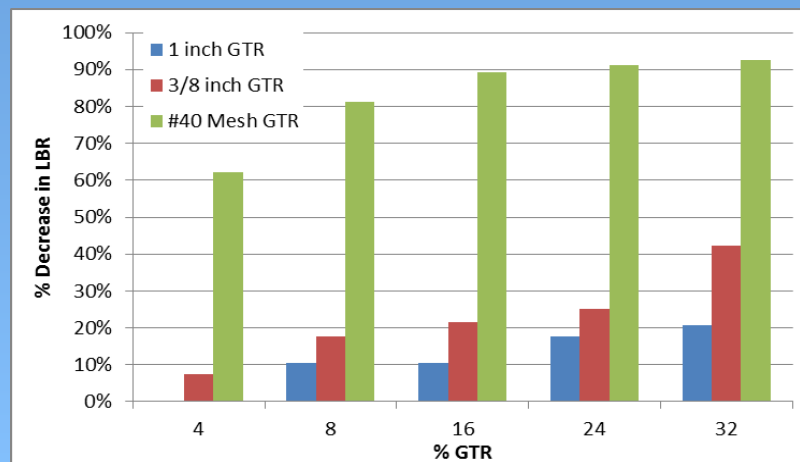
## High LBR Blends



## Medium LBR Blends



## Low LBR Blends



Largest Decrease # 40



# Resilient Modulus

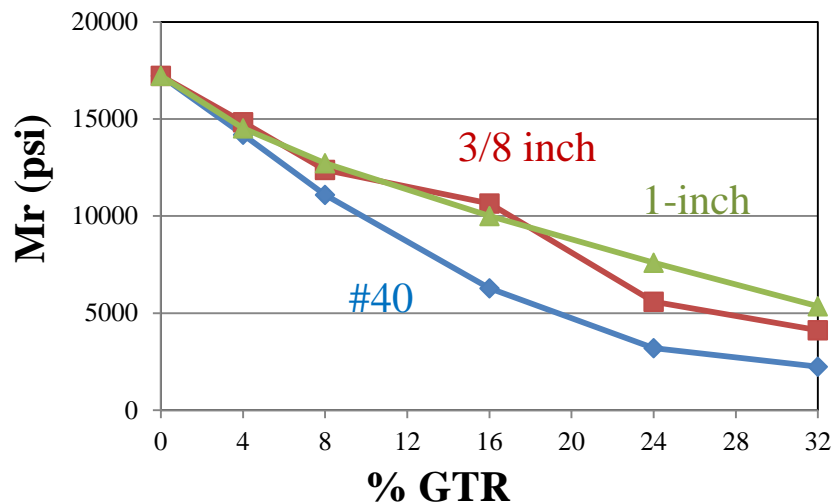
 Tests performed by the State Materials Office (SMO)



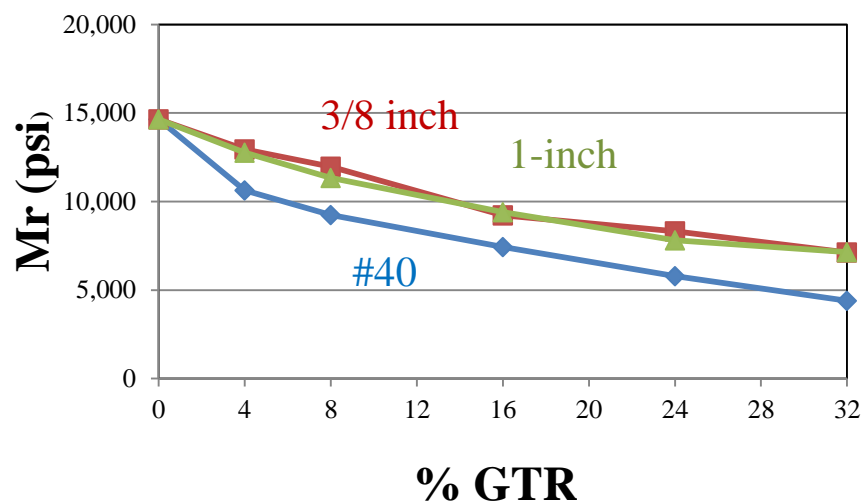


# % GTR vs. Resilient Modulus

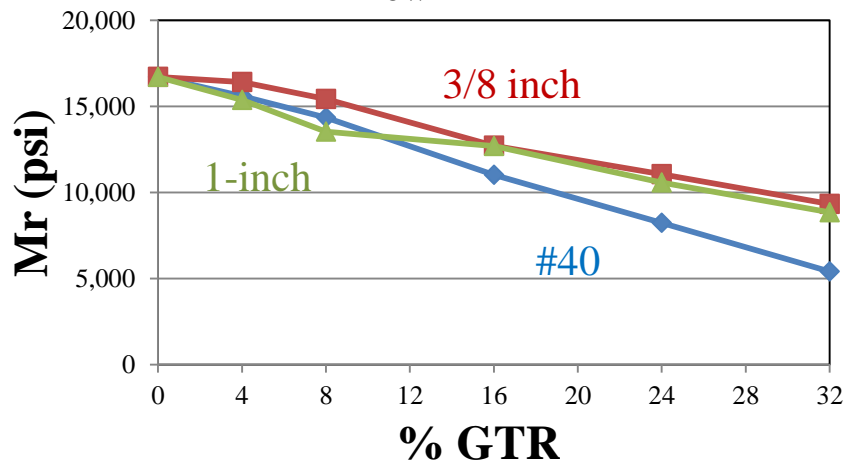
### High LBR




### Medium LBR



### Low LBR



 All Decrease  
 Low Mr Decrease < Medium LBR < High LBR



# Creep

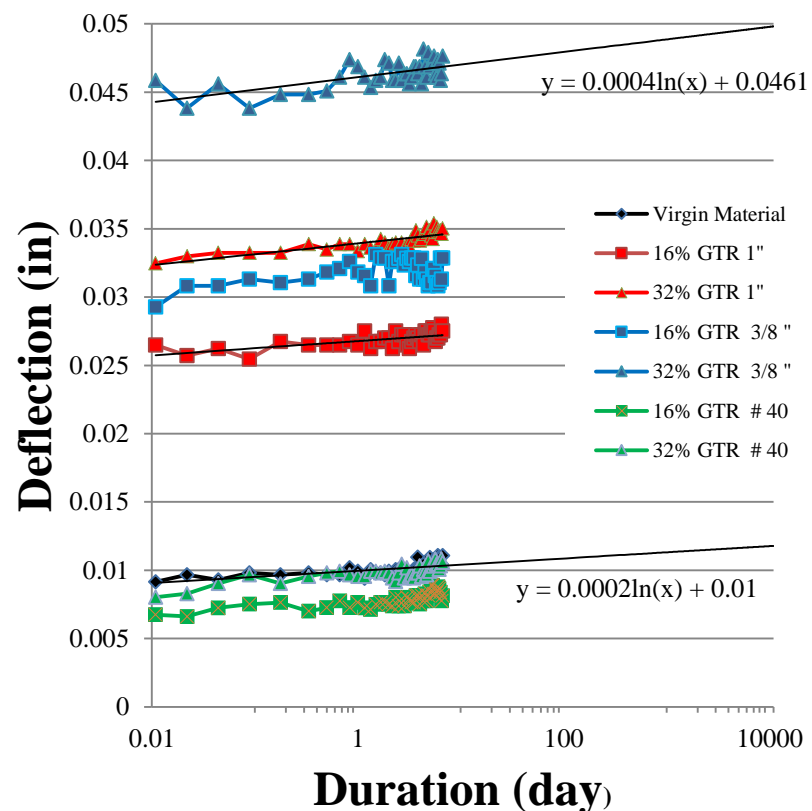
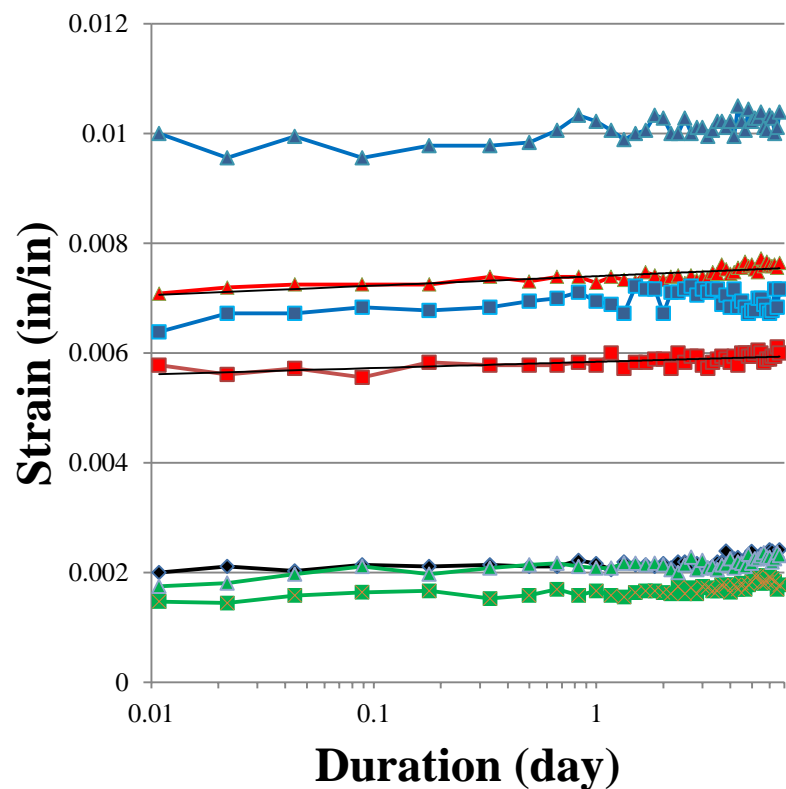




# High LBR Material

## 30-Year Deflection Projection High LBR Material

### Strain vs. Duration High LBR Material

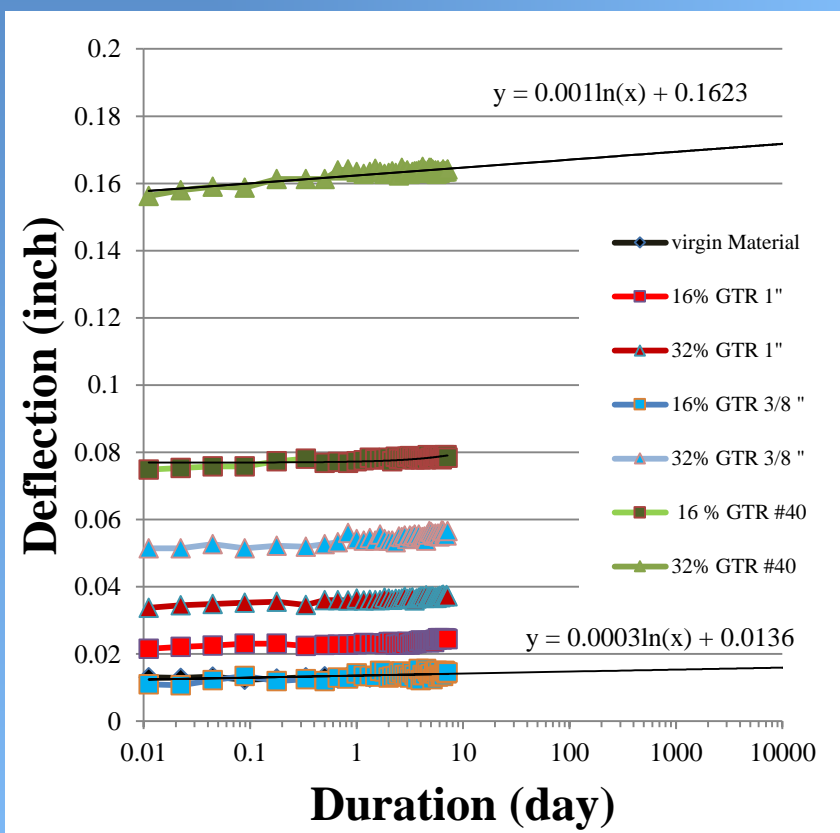
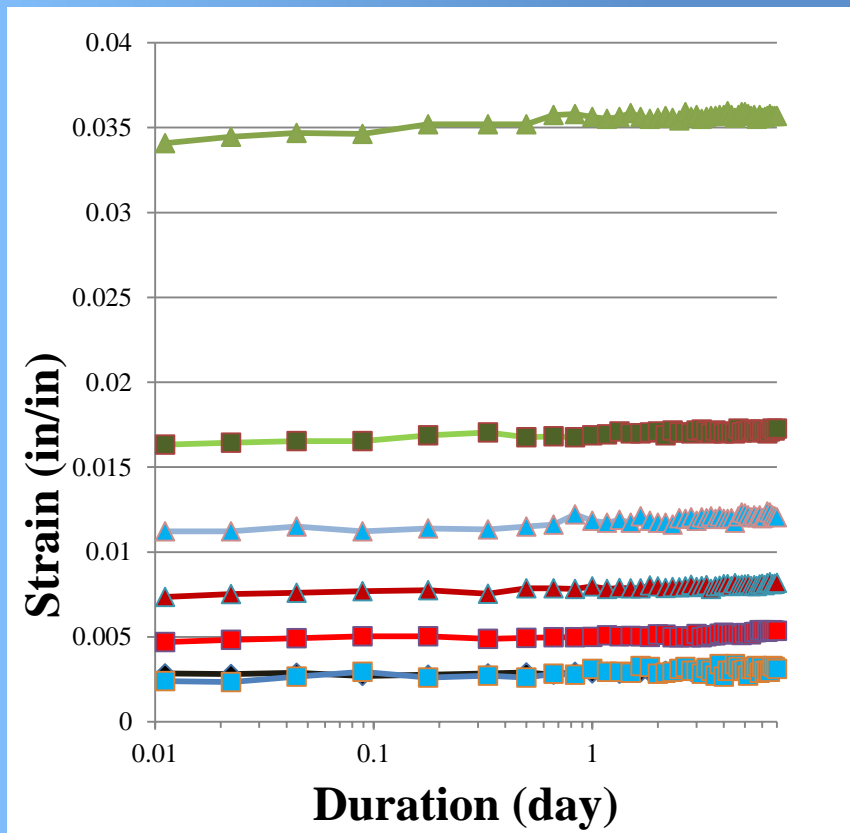




# Medium LBR Material

## 30-Year Deflection Projection for Medium LBR Material

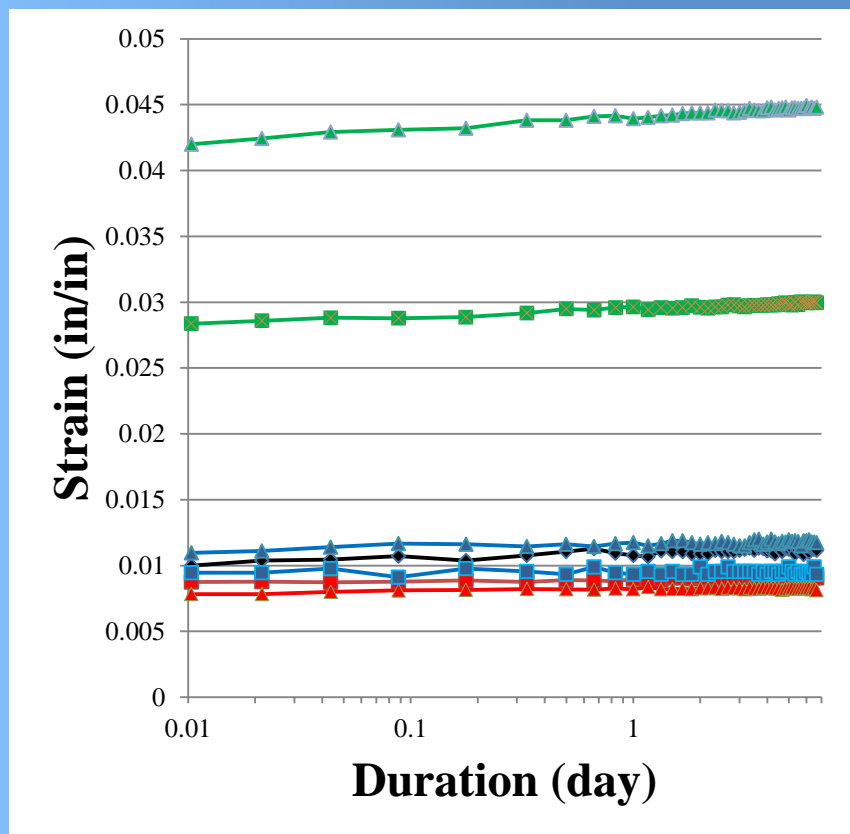
### Strain vs. Duration Medium LBR Material



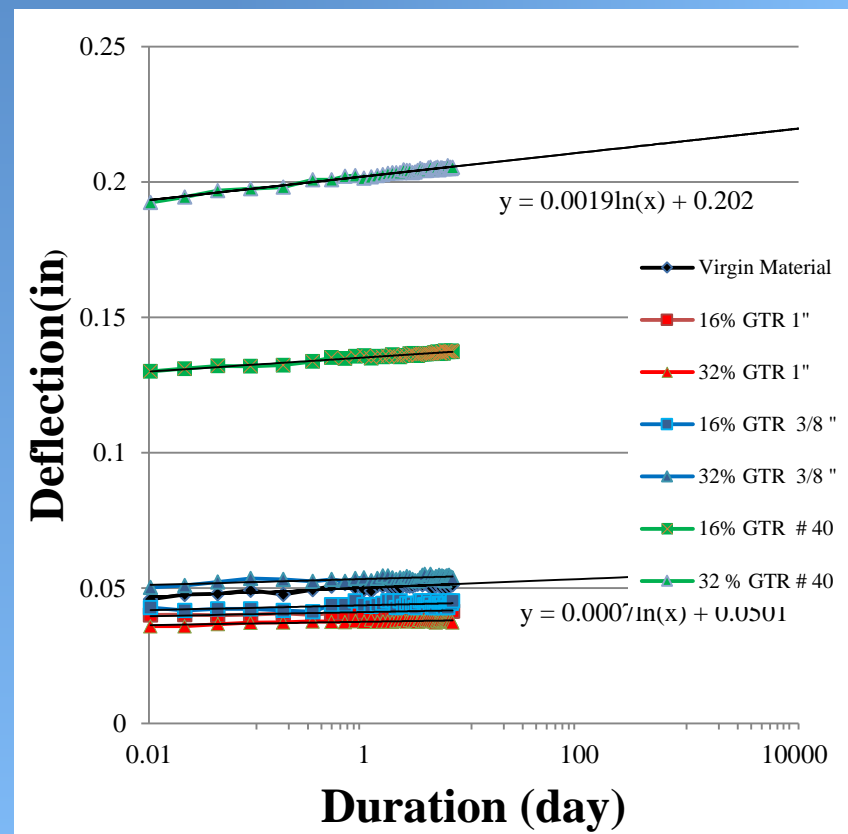


# Low LBR Material

## Strain vs. Duration Low LBR Material

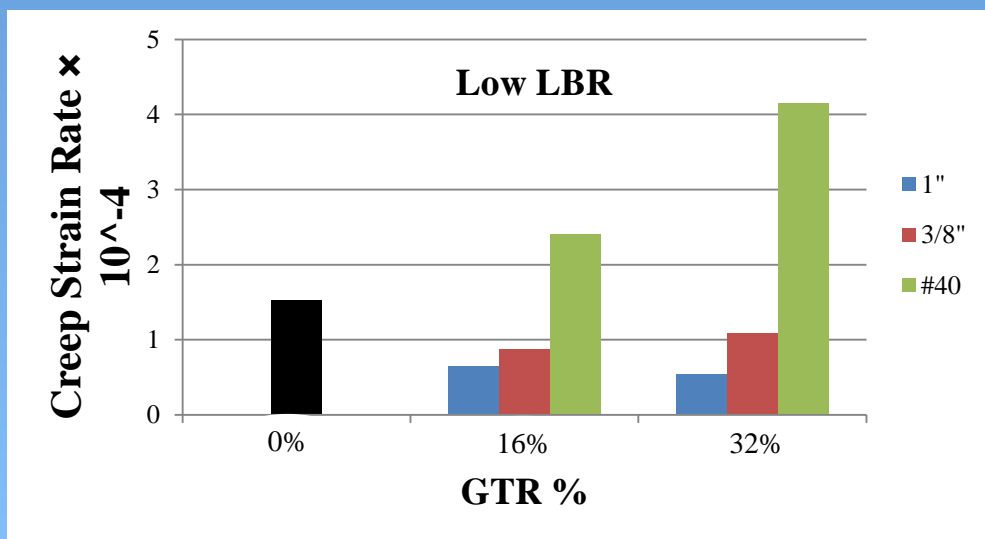
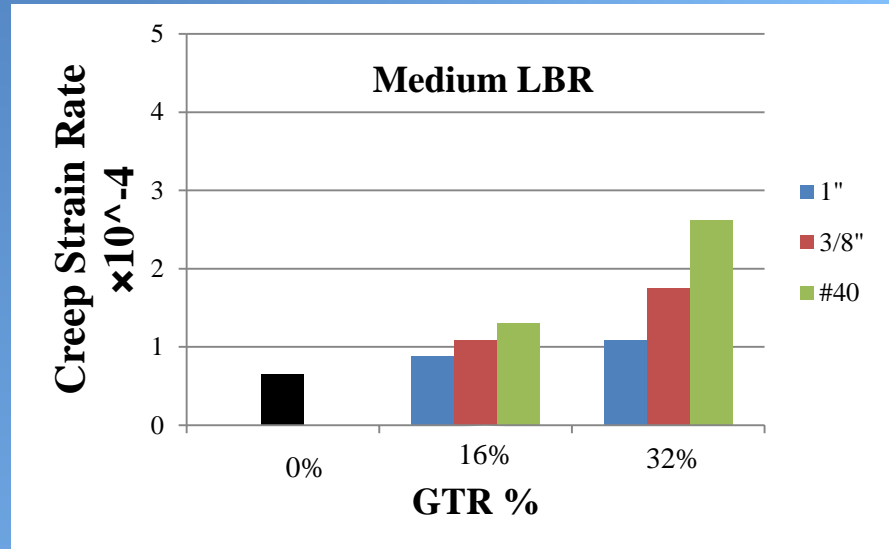
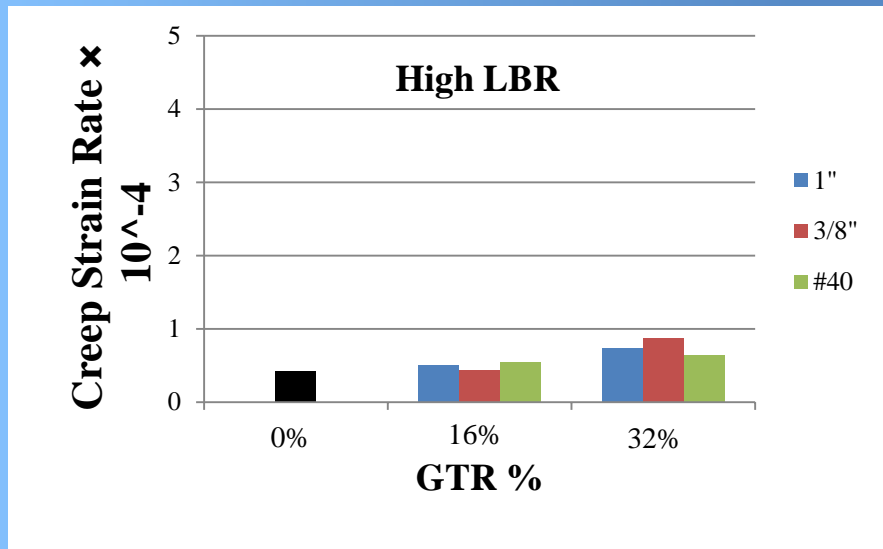


## 30-Year Deflection Projection for Low LBR Material





# Strain Rate vs. GTR % for each Soil Type

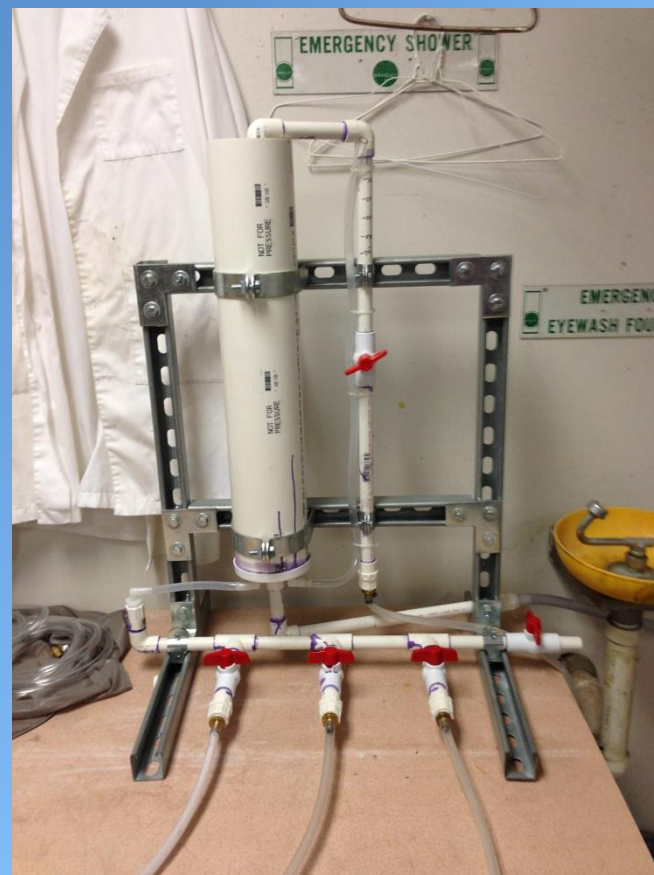


- Creep not a concern
- All relatively acceptable if  $10^{-4}$
- #40 with Low Material will produce 0.3 % strain over 30 years



# Permeability

## Constant Head Permeability Test Set-up





# Test Results: Constant Head Permeability

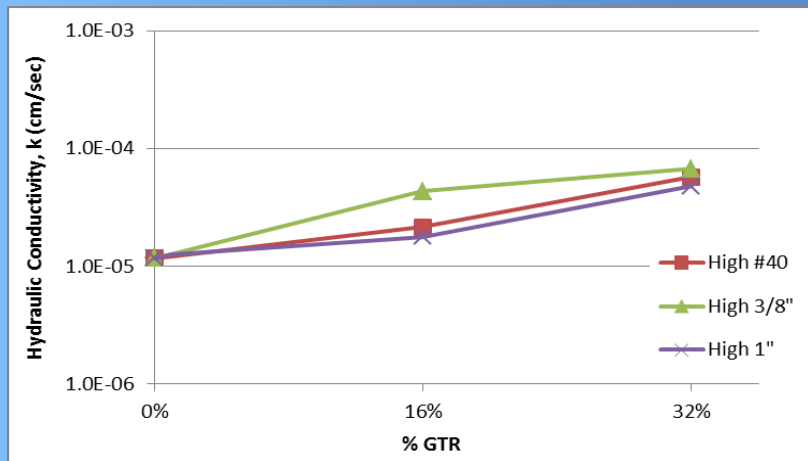
- Virgin Material
  - One Order of Magnitude Differences

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

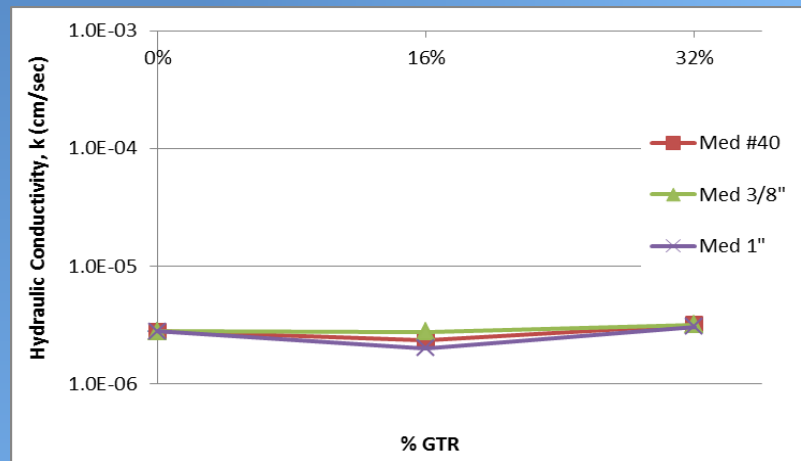


# Constant Head Permeability

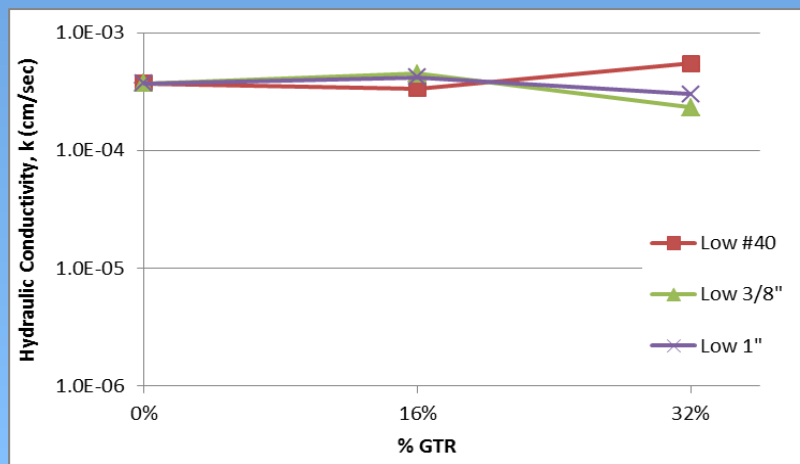
## High LBR Blends



## Medium LBR Blends



## Low LBR Blends

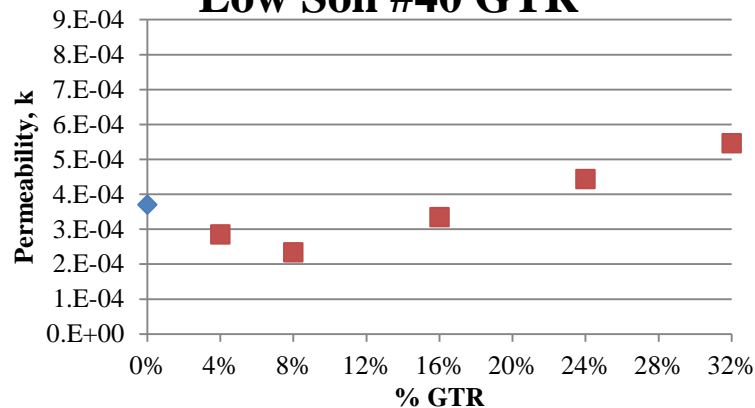


Very little change for all cases



# Low LBR Material

### Low Soil #40 GTR



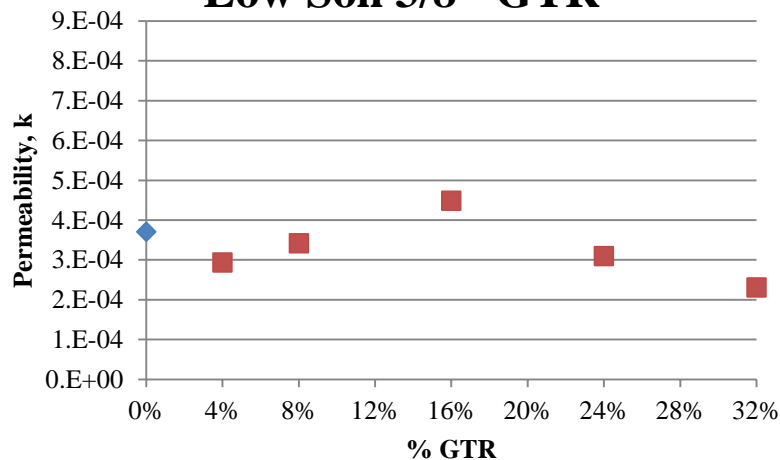
Typical results



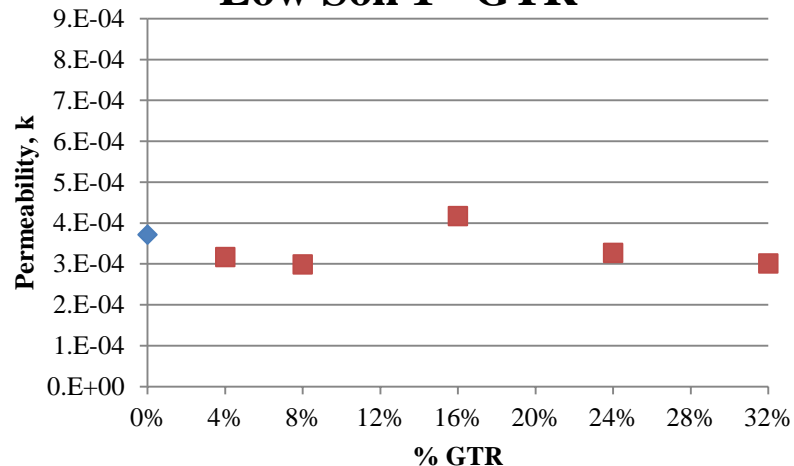
No significant change

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

### Low Soil 3/8" GTR



### Low Soil 1" GTR





# Consolidation



Custom 4-inch Consolidation Molds





# Consolidation

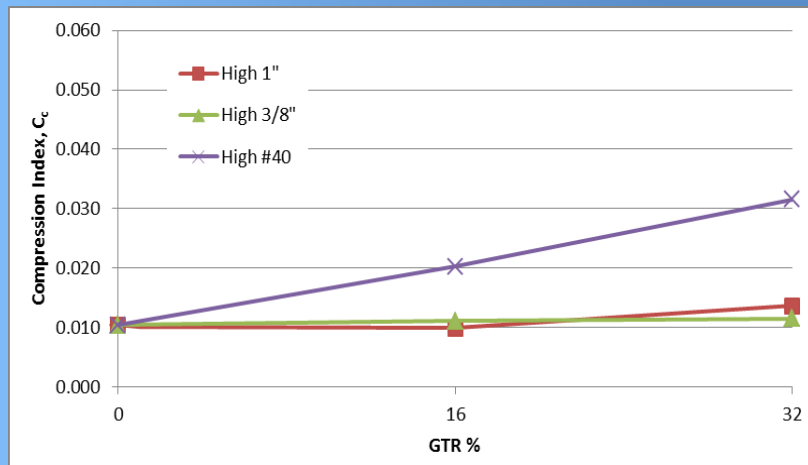
- Virgin Material Slope

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

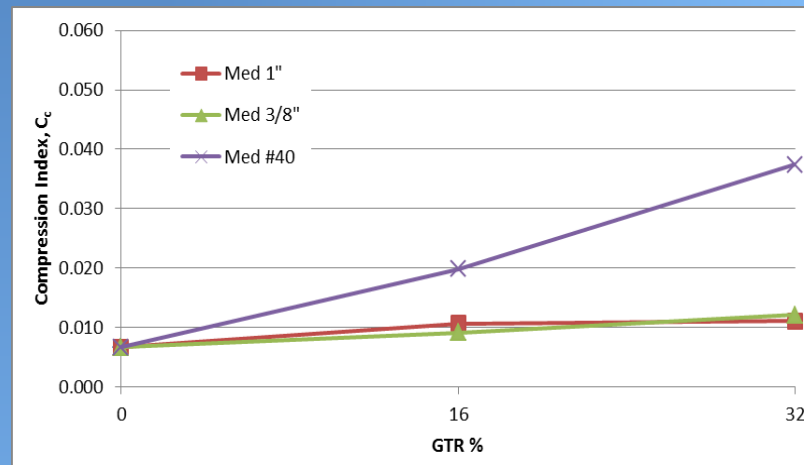


# Consolidation Results

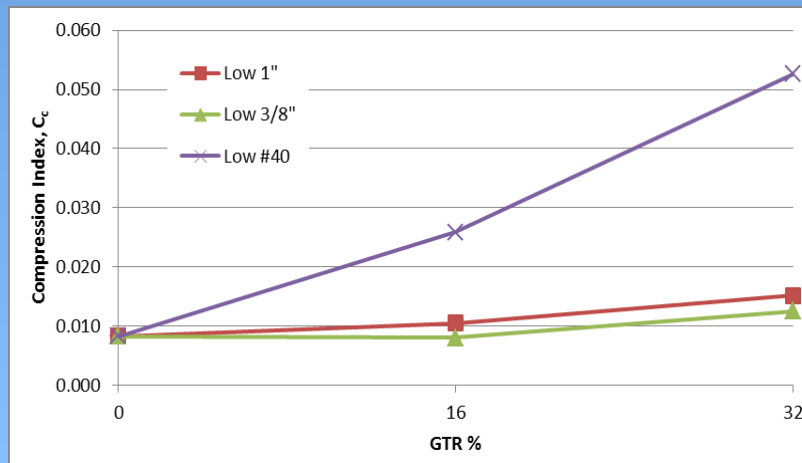
## High LBR Blends



## Medium LBR Blends



## Low LBR Blends



1" and 3/8" produce no change

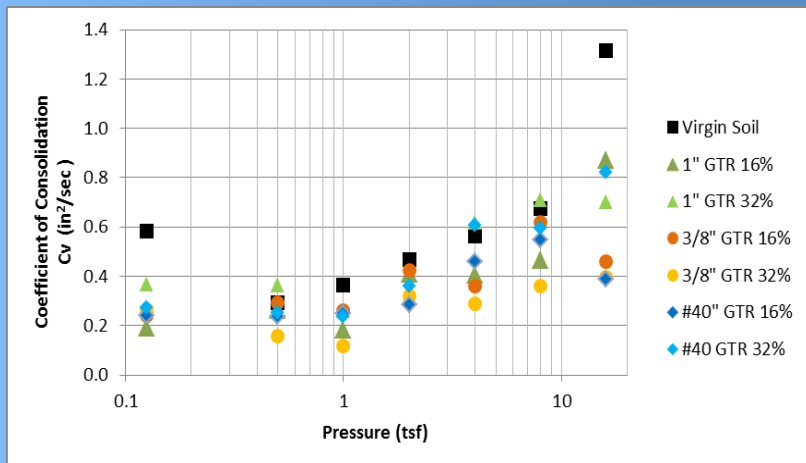


#40 blend causes change

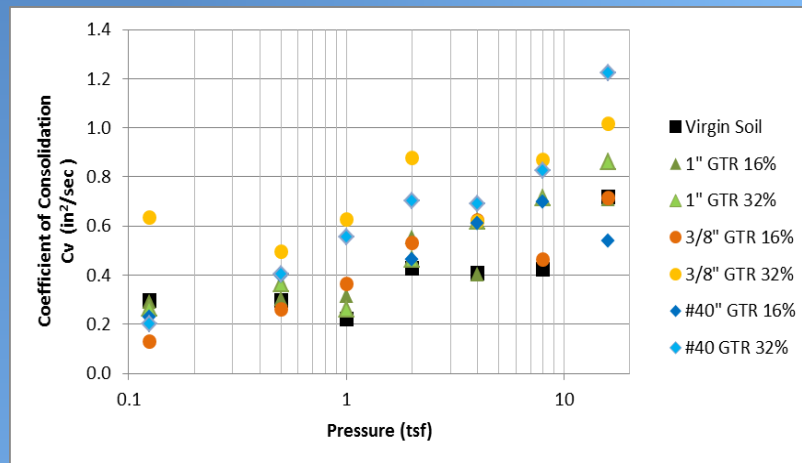


# Consolidation Results

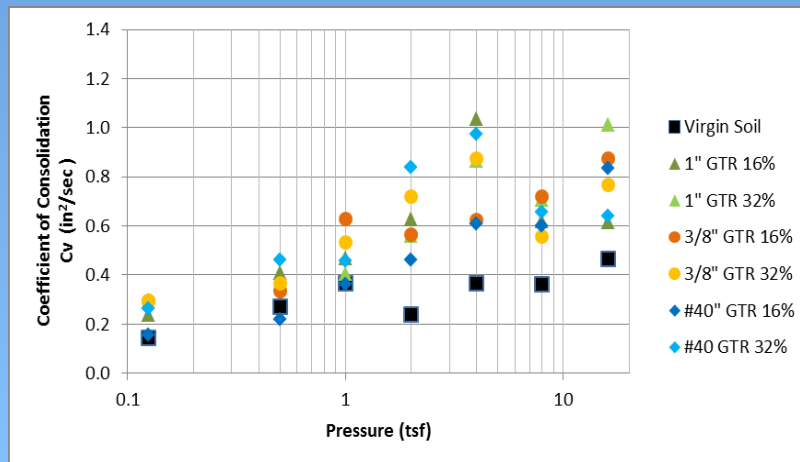
## High LBR Blends



## 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




# 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






# 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



# Questions ?

