

May 23, 2019

Garrett Fountain, P.E. G.E.
West Area Engineer
Tensar Corporation
10755 Scripps Poway Pkwy, Suite 236
San Diego, CA 92131
Cell: 858-287-3068
GFountain@tensarcorp.com

Re: In Situ Performance Verification of Geogrid-Stabilized Aggregate Layer
Using Automated Plate Load Testing
Scott Road, Riverside County, CA

Dear Garrett,

At the request of Tensar Corporation personnel, Ingios Geotechnics, Inc. conducted Automated Plate Load Tests (APLTs) on Scott Road Test Sections in City of Menifee in Riverside County, CA. Testing was performed May 14, 2018. In situ testing included cyclic APLTs on the aggregate base layer to determine composite, base layer, and subgrade layer resilient modulus (M_r) values. Dynamic cone penetrometer tests were performed to determine penetration resistance profile with depth at each APLT location. Tests were conducted on two test sections. The pavement foundation in one section comprised of nominal 4 in. of Class 2 recycled aggregate base course (ABC) stabilized with TX7 geogrid over compacted subgrade. The other section comprised of nominal 8 in. of ABC placed over compacted subgrade and served as a control section. The TX7 geogrid was a multi-axial geogrid with hexagonal structure and triangular apertures. The ABC layer material is classified as poorly graded sand with silt and gravel (SP-SM) and A-1-a.

Three cyclic APLTs were conducted in each of the two sections with six different applied cyclic stresses for each test. Deflection basin measurements were obtained at three positions extending away from the plate (2r, 3r, and 4r).

Results from cyclic APLTs conducted at six different stress levels were used to determine the in situ "universal" model (AASHTO 2015), the k_1^* , k_2^* , and k_3^* model parameters for the composite (M_{r-comp}) and stabilized aggregate base (M_{r-Base}) and subgrade layers ($M_{r-Subgrade}$). Summaries of each individual test result are attached. Results from extended cyclic APLTs were used to determine power model parameters and predict number of cycles to achieve a near-linear elastic condition.

The layered analysis performed in determining M_{r-Base} and $M_{r-Sugrade}$ was based on Odemark's method of equivalent thickness and Boussinesq's elastic solution for linear-elastic materials. The applied cyclic stresses at the subgrade/base layer interface were calculated using the KENLAYER elastic layer analysis program.

The following assumptions were made in calculating the M_r values:

1. Shape factor, $f = 8/3$ for a rigid plate on granular material.
2. Poisson's ratio, $\nu = 0.40$ for aggregate base material and 0.40 for subgrade material.
3. Plate bending correction, $F_{Bending} = 1$ (No correction). The 12 in. diameter plate used in this study is 1 in. thick and has a 6 in. diameter steel loading pedestal centered on the plate.
4. Future saturation correction, $F_{Saturation} = 1$ (No correction). Laboratory testing is needed to determine this correction factor, else field saturation is required in situ.

The results presented herein represent a selected number of measurements per sample group that was requested by Tensar. Statistical determination of the minimum number of measurements requires knowledge of the coefficient of variation within a sample group and the difference between mean values of the selected sample groups. Determination of statistical input parameters needed for calculating statistical sample sizes was beyond the scope of this study. As a result, these test results are applicable to the specific testing point locations.

We appreciate the opportunity to provide Automated Plate Load Testing on your project. If you have any questions, please do not hesitate to contact us.

Sincerely,

Pavana Vennapusa, Ph.D., P.E.
Registered in AZ, IA, NM, NV, TX
Lead Engineer

David White, Ph.D., P.E.
Registered in CO, IA, KY, MN, TN
President and Chief Engineer

Attachments:

Aerial Image with In Situ Test Locations and Pictures
Particle-size Analysis Results (ABC material)
Composite Resilient Modulus Test Results
Layered Resilient Modulus Test Results
DCP Test Results

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Project Location and Test Locations



Test Locations

Project Name: Scott Road Test Sections
Project ID: TIC-00048
Location: City of Menifee, Riverside County, CA



Site Conditions and Pictures



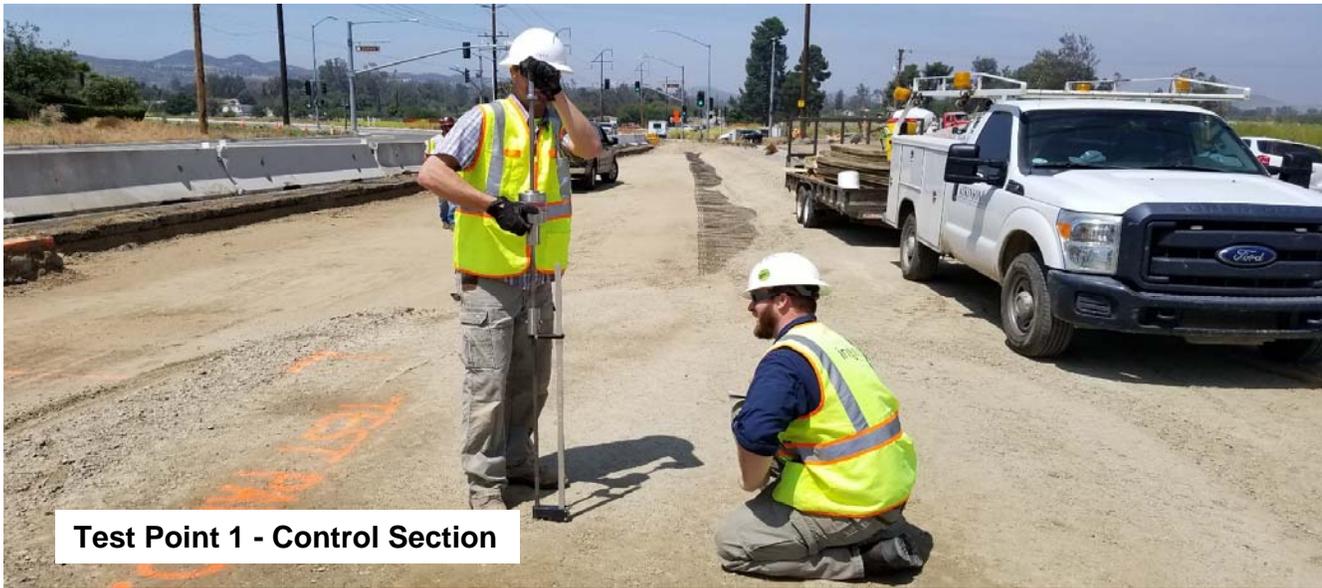
Pictures

Project Name: Scott Road Test Sections
Project ID: TIC-00048
Location: City of Menifee, Riverside County, CA

Site Conditions and Pictures



Test Point 1 - Control Section



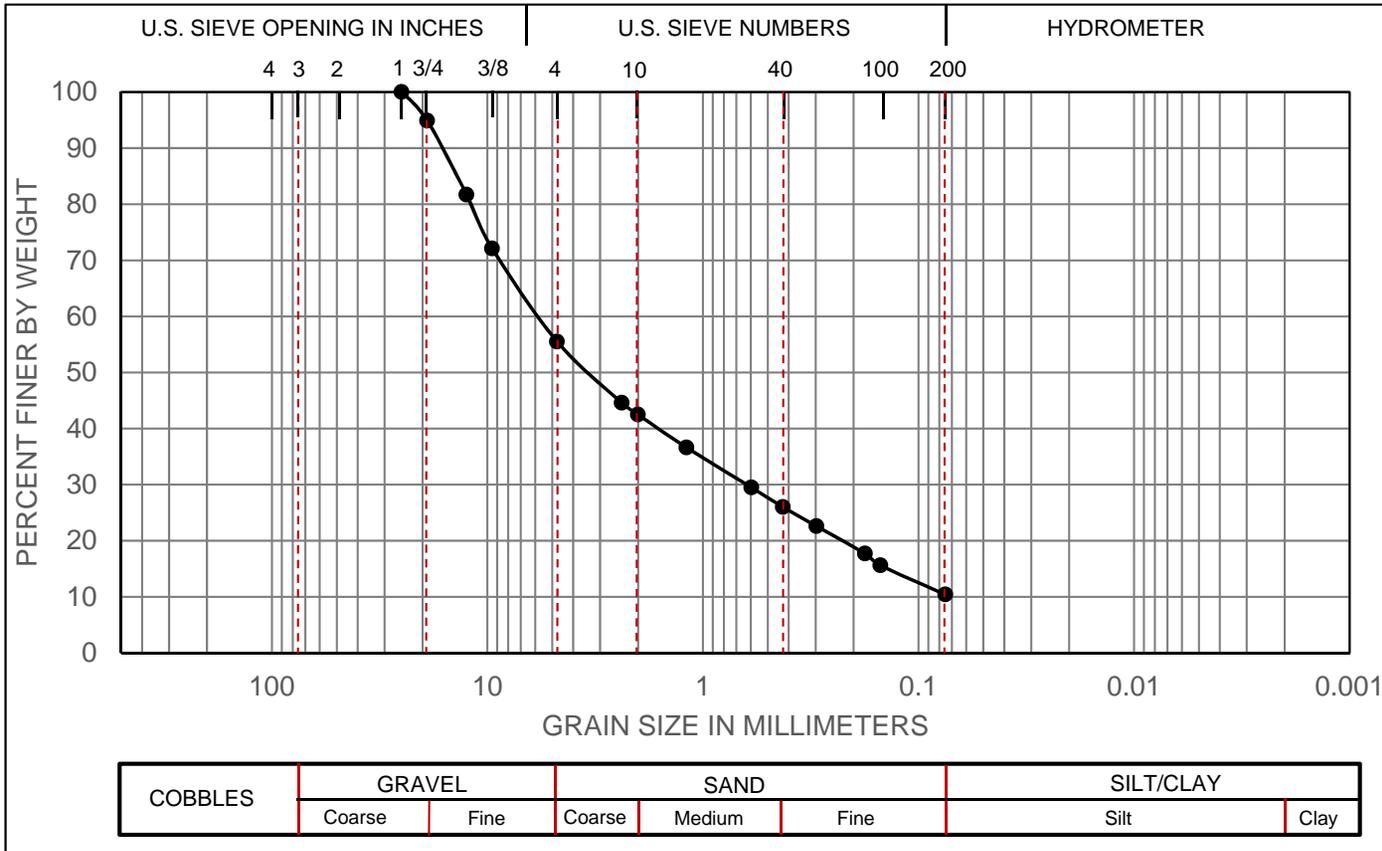
Test Point 1 - Control Section



Pictures

Project Name: Scott Road Test Sections
Project ID: TIC-00048
Location: City of Menifee, Riverside County, CA

**GRAIN SIZE DISTRIBUTION
ASTM D422/C136**



Gradation Summary

% Gravel	44.5
% Sand	45.1
% Fines	10.4
D ₁₀ (mm)	0.07
D ₃₀ (mm)	0.64
D ₅₀ (mm)	3.55
D ₆₀ (mm)	6.04
D ₈₅ (mm)	14.13
C _u	87.2
C _c	0.97

Atterberg Limits

LL	NP
PL	NP
PI	NP

Classification

AASHTO:	A-1-a
USCS:	SP-SM

MATERIAL: Class 2 Recycled Aggregate Base Course
LOCATION: Scott Rd Test Sections **TESTED BY:** T
SAMPLE DATE: 5/14/2019 **TEST DATE:** 5/20/2019

Gradation and Soil Classification Test Results

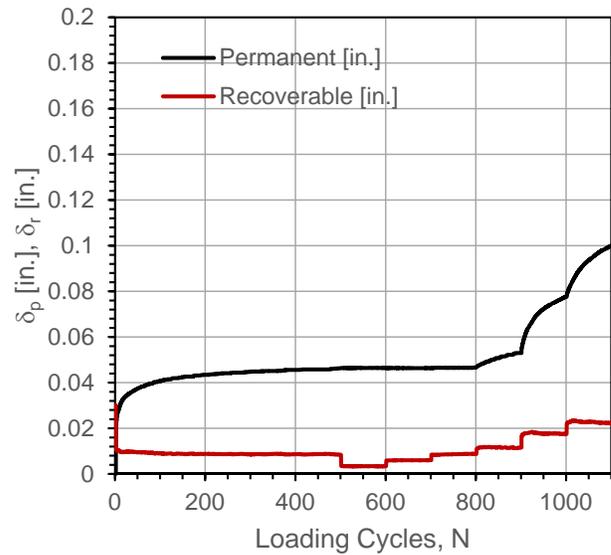
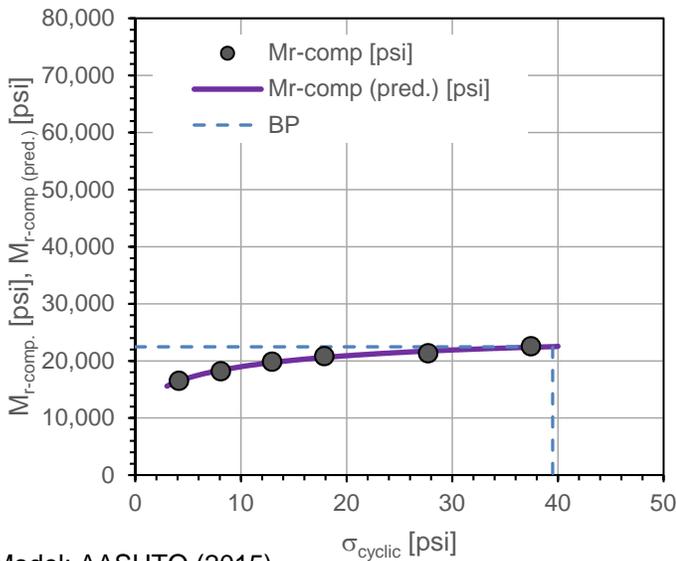
Project Name: Scott Road Test Sections
 Project ID: TIC-00048
 Location: City of Menifee, Riverside County, CA



Automated Plate Load Test [APLT]

Test:	In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent (5, 10, 15, 20, 30, 40)				
Date:	5/14/2019	Time:	8:33:17 AM	Test ID:	CTRL_PT1
Tested By:	PV, HG, CV	Location:	Scott Rd Test Sections	Sta.:	NA
Latitude,N:	33.641701	Longitude,W:	117.174510	Elev. (ft):	NA
Comments:	9.7 in. Class 2 recycled aggregate base course over subgrade.				

Step	N	σ_{cyclic} [psi]	M_{r-comp} [psi]	M_{r-comp} (pred.) [psi]	δ_p [in.]	$\Delta\delta_p$ [in.]	$d = \Delta\log(\delta_p) / \Delta\log(N)$	Near-linear Elastic
Conditioning	500	12.95	---	---	0.0463	---	0.182	---
1	100	4.14	16,507	16,471	0.0465	0.0002	0.092	Y
2	100	8.10	18,199	18,377	0.0464	0.0001	-0.007	Y
3	100	12.95	19,850	19,718	0.0466	0.0003	0.185	Y
4	100	17.89	20,847	20,611	0.0529	0.0067	0.751	N
5	100	27.72	21,337	21,727	0.0776	0.0314	0.654	N
6	100	37.45	22,563	22,392	0.0998	0.0536	0.771	N



Model: AASHTO (2015)

$$M_{r-comp} = k_1^* P_a \left(\frac{\theta}{P_a}\right)^{k_2^*} \left(1 + \frac{\tau_{oct}}{P_a}\right)^{k_3^*}$$

Parameter	Value	P-Value
k_1^*	1,226.3	3.04E-08
k_2^*	0.182	9.45E-03
k_3^*	-0.318	2.50E-01
Adj. R ²	0.985	
Std. Error [psi]	266	

M_{r-comp} (pred.)-BP [psi]	22,474
$\sigma_{cyclic-BP}$ [psi]	39.5



In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent

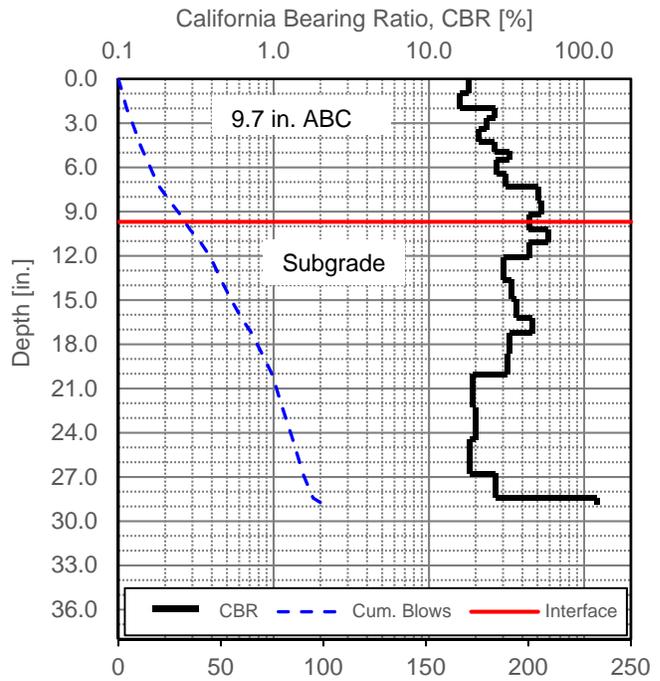
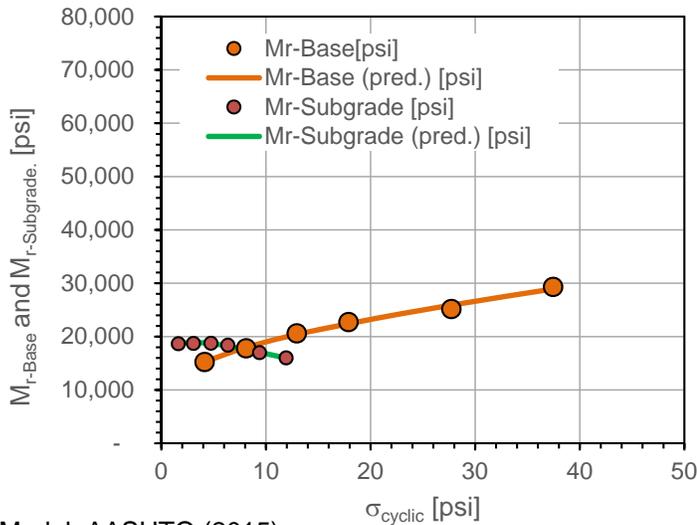
Project Name: Scott Road Test Sections
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Automated Plate Load Test [APLT]

Test:	In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent (5, 10, 15, 20, 30, 40)				
Date:	5/14/2019	Time:	8:33:17 AM	Test ID:	CTRL_PT1
Tested By:	PV, HG, CV	Location:	Scott Rd Test Sections	Sta.:	NA
Latitude, N:	33.641701	Longitude, W:	117.174510	Elev. (ft):	NA
Comments:	9.7 in. Class 2 recycled aggregate base course over subgrade.				

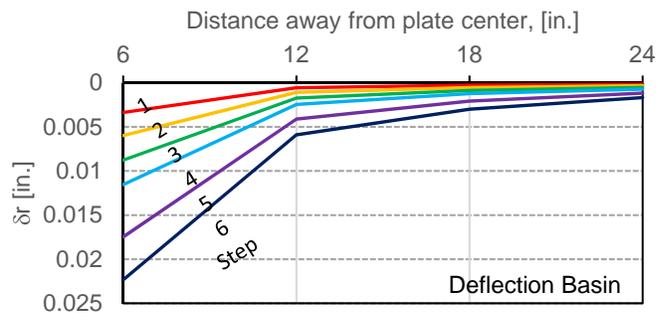
Step	N	$\sigma_{cyclic_surface}$ [psi]	M_{r-Base} [psi]	M_{r-Base} (pred.) [psi]	$\sigma_{cyclic_Int.}$ [psi]	$M_{r-Subgrade}$ [psi]	$M_{r-Subgrade}$ (pred.) [psi]	Modulus Ratio
Conditioning	500	12.95	---	---	---	---	---	---
1	100	4.14	15,235	15,225	1.64	18,641	18,567	0.82
2	100	8.10	17,807	17,962	3.09	18,705	18,896	0.95
3	100	12.95	20,600	20,390	4.75	18,735	18,690	1.10
4	100	17.89	22,722	22,433	6.37	18,362	18,220	1.24
5	100	27.72	25,172	25,894	9.39	16,971	17,048	1.48
6	100	37.45	29,297	28,911	11.94	15,978	15,970	1.83



Model: AASHTO (2015)

$$M_r = k_1^* P_a \left(\frac{\theta}{P_a} \right)^{k_2^*} \left(1 + \frac{\tau_{oct}}{P_a} \right)^{k_3^*}$$

Parameter	Value	P-Value
k_1^* (Base)	1101.9	8.99E-08
k_2^* (Base)	0.210	1.66E-02
k_3^* (Base)	0.609	1.50E-01
Adj. R^2	0.992	
Std. Error [psi]	451	
k_1^* (Subgrade)	1721.5	2.61E-07
k_2^* (Subgrade)	0.181	7.34E-03
k_3^* (Subgrade)	-3.283	2.16E-03
Adj. R^2	0.987	
Std. Error [psi]	132	



In-situ Resilient Modulus [Mr]: Cyclic Loading, Layered Analysis, Stress-Dependent

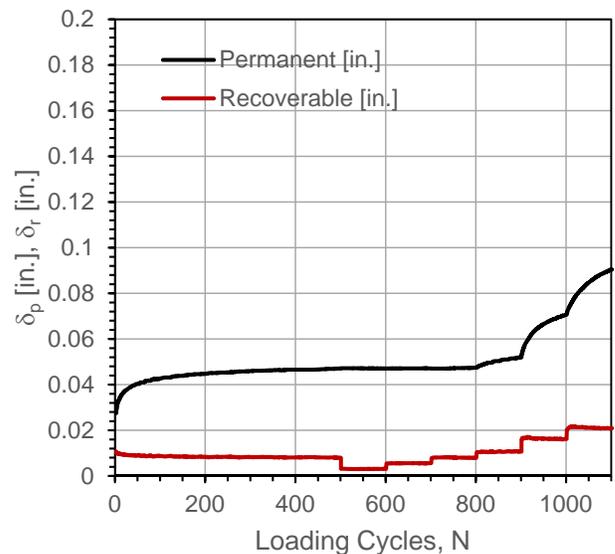
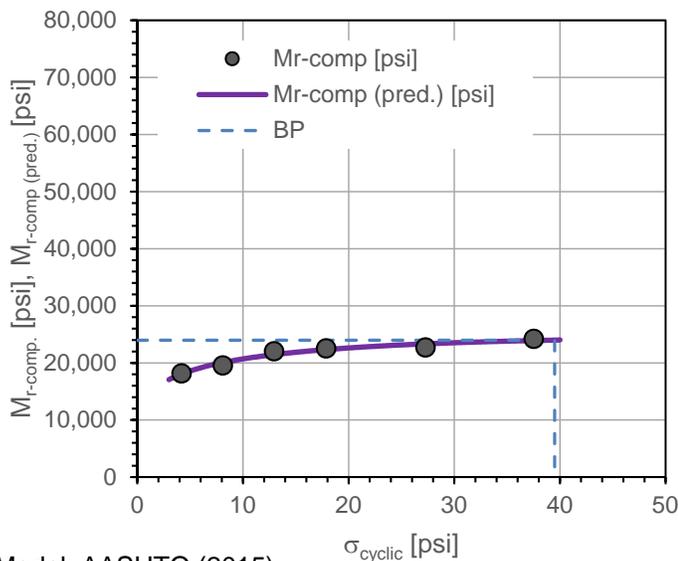
Project Name: Scott Road Test Sections
 Project ID: TIC-00048
 Location: City of Menifee, Riverside County, CA



Automated Plate Load Test [APLT]

Test:	In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent (5, 10, 15, 20, 30, 40)				
Date:	5/14/2019	Time:	9:08:21 AM	Test ID:	CTRL_PT2
Tested By:	PV, HG, CV	Location:	Scott Rd Test Sections	Sta.:	NA
Latitude,N:	33.641701	Longitude,W:	117.174490	Elev. (ft):	NA
Comments:	9.25 in. Class 2 recycled aggregate base course over subgrade.				

Step	N	σ_{cyclic} [psi]	M_{r-comp} [psi]	M_{r-comp} (pred.) [psi]	δ_p [in.]	$\Delta\delta_p$ [in.]	$d = \frac{\Delta\log(\delta_p)}{\Delta\log(N)}$	Near-linear Elastic
Conditioning	500	12.95	---	---	0.0470	---	0.079	---
1	100	4.19	18,170	18,067	0.0471	0.0000	-0.133	Y
2	100	8.10	19,562	20,064	0.0471	0.0001	0.153	Y
3	100	12.95	22,040	21,453	0.0475	0.0004	0.471	Y
4	100	17.87	22,533	22,337	0.0520	0.0049	0.692	N
5	100	27.28	22,700	23,338	0.0705	0.0235	0.651	N
6	100	37.52	24,197	23,918	0.0904	0.0433	0.778	N



Model: AASHTO (2015)

$$M_{r-comp} = k_1^* P_a \left(\frac{\theta}{P_a} \right)^{k_2^*} \left(1 + \frac{\tau_{oct}}{P_a} \right)^{k_3^*}$$

Parameter	Value	P-Value
k_1^*	1,349.5	2.00E-07
k_2^*	0.184	5.13E-02
k_3^*	-0.421	3.98E-01
Adj. R ²	0.943	
Std. Error [psi]	520	

M_{r-comp} (pred.)-BP [psi]	23,975
$\sigma_{cyclic-BP}$ [psi]	39.5



In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent

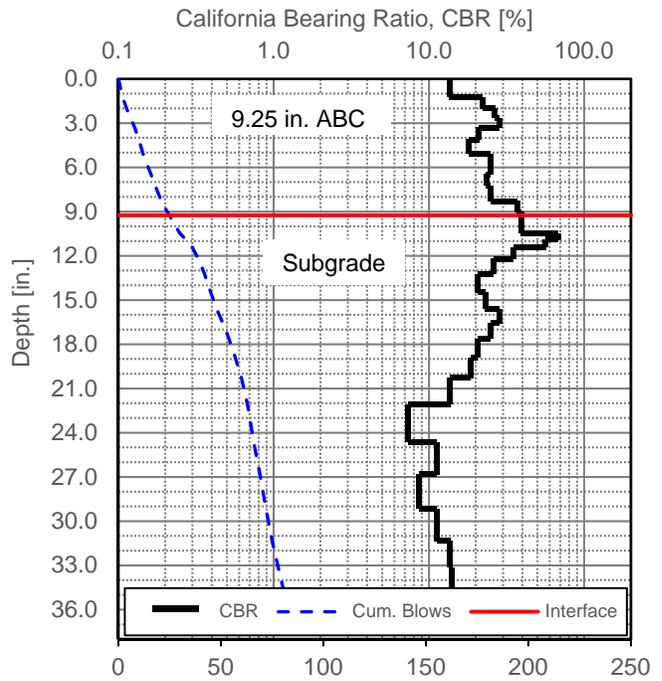
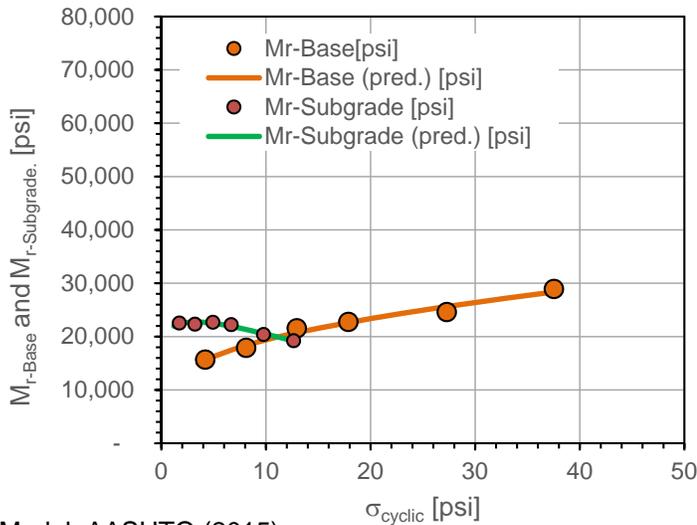
Project Name: Scott Road Test Sections
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 Location: City of Menifee, Riverside County, CA



Automated Plate Load Test [APLT]

Test:	In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent (5, 10, 15, 20, 30, 40)				
Date:	5/14/2019	Time:	9:08:21 AM	Test ID:	CTRL_PT2
Tested By:	PV, HG, CV	Location:	Scott Rd Test Sections	Sta.:	NA
Latitude, N:	33.641701	Longitude, W:	117.174490	Elev. (ft):	NA
Comments:	9.25 in. Class 2 recycled aggregate base course over subgrade.				

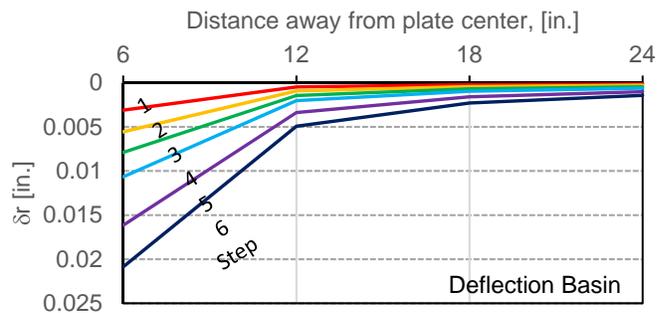
Step	N	$\sigma_{cyclic_surface}$ [psi]	M_{r-Base} [psi]	M_{r-Base} (pred.) [psi]	$\sigma_{cyclic_Int.}$ [psi]	$M_{r-Subgrade}$ [psi]	$M_{r-Subgrade}$ (pred.) [psi]	Modulus Ratio
Conditioning	500	12.95	---	---	---	---	---	---
1	100	4.19	15,691	15,637	1.72	22,514	22,350	0.70
2	100	8.10	17,883	18,355	3.22	22,302	22,739	0.80
3	100	12.95	21,566	20,725	4.93	22,647	22,501	0.95
4	100	17.87	22,739	22,639	6.69	22,219	21,920	1.02
5	100	27.28	24,595	25,630	9.78	20,365	20,560	1.21
6	100	37.52	28,920	28,357	12.66	19,206	19,176	1.51



Model: AASHTO (2015)

$$M_r = k_1^* P_a \left(\frac{\theta}{P_a} \right)^{k_2^*} \left(1 + \frac{\tau_{oct}}{P_a} \right)^{k_3^*}$$

Parameter	Value	P-Value
k_1^* (Base)	1144.8	5.31E-07
k_2^* (Base)	0.221	6.84E-02
k_3^* (Base)	0.377	5.63E-01
Adj. R^2	0.974	
Std. Error [psi]	754	
k_1^* (Subgrade)	2040.5	1.41E-06
k_2^* (Subgrade)	0.174	4.22E-02
k_3^* (Subgrade)	-3.086	1.34E-02
Adj. R^2	0.954	
Std. Error [psi]	298	



In-situ Resilient Modulus [Mr]: Cyclic Loading, Layered Analysis, Stress-Dependent

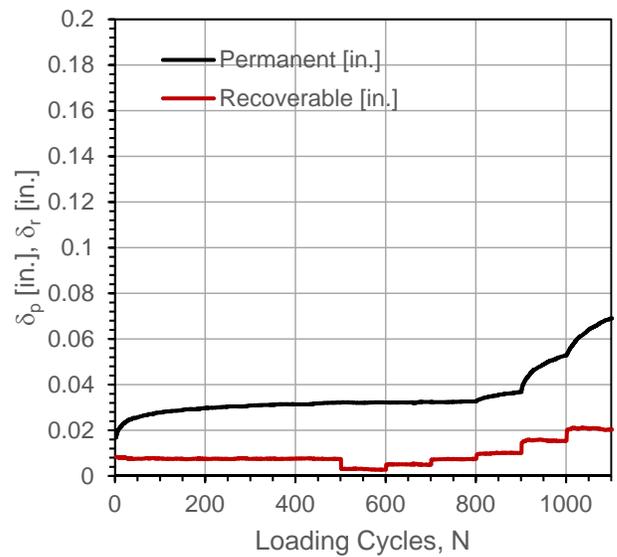
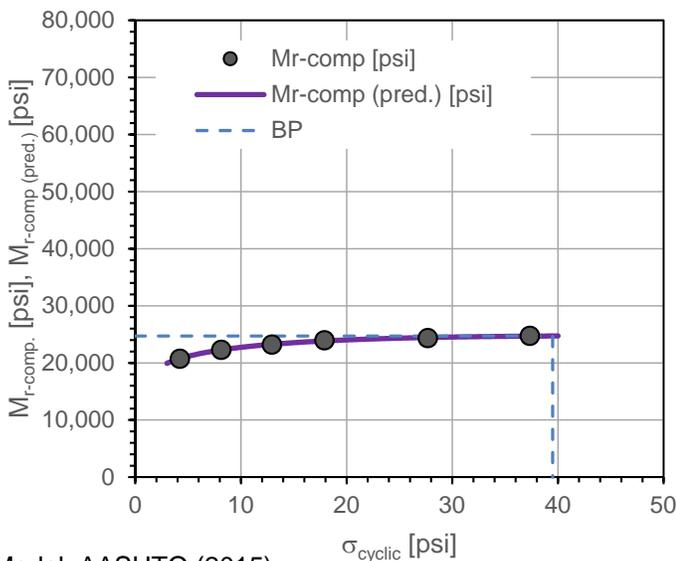
Project Name: Scott Road Test Sections
 Project ID: TIC-00048
 Location: City of Menifee, Riverside County, CA



Automated Plate Load Test [APLT]

Test:	In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent (5, 10, 15, 20, 30, 40)				
Date:	5/14/2019	Time:	10:14:25 AM	Test ID:	CTRL_PT3
Tested By:	PV, HG, CV	Location:	Scott Rd Test Sections	Sta.:	NA
Latitude,N:	33.641697	Longitude,W:	117.174470	Elev. (ft):	NA
Comments:	9.1 in. Class 2 recycled aggregate base course over subgrade.				

Step	N	σ_{cyclic} [psi]	M_{r-comp} [psi]	M_{r-comp} (pred.) [psi]	δ_p [in.]	$\Delta\delta_p$ [in.]	$d = \Delta\log(\delta_p) / \Delta\log(N)$	Near-linear Elastic
Conditioning	500	12.93	---	---	0.0321	---	0.105	---
1	100	4.22	20,740	20,745	0.0322	0.0001	-0.023	Y
2	100	8.15	22,296	22,282	0.0324	0.0003	0.112	Y
3	100	12.93	23,209	23,262	0.0326	0.0005	0.281	Y
4	100	17.90	23,964	23,854	0.0368	0.0047	0.608	N
5	100	27.69	24,337	24,453	0.0528	0.0207	0.632	N
6	100	37.34	24,741	24,692	0.0690	0.0369	0.809	N



Model: AASHTO (2015)

$$M_{r-comp} = k_1^* P_a \left(\frac{\theta}{P_a} \right)^{k_2^*} \left(1 + \frac{\tau_{oct}}{P_a} \right)^{k_3^*}$$

Parameter	Value	P-Value
k_1^*	1,513.5	6.52E-10
k_2^*	0.132	6.65E-04
k_3^*	-0.387	9.40E-03
Adj. R ²	0.996	
Std. Error [psi]	88	

M_{r-comp} (pred.)-BP [psi]	24,713
$\sigma_{cyclic-BP}$ [psi]	39.5



In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent

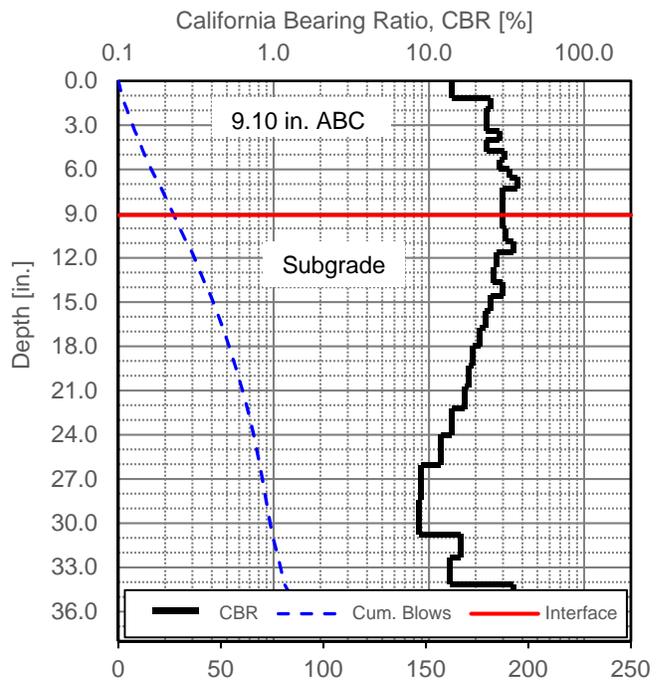
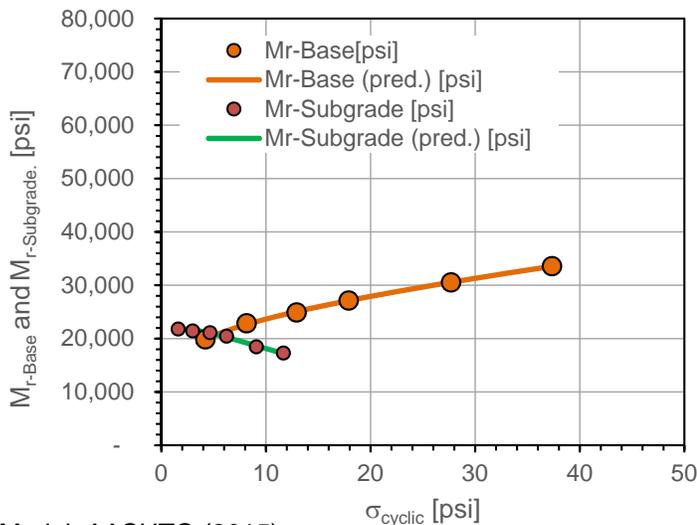
Project Name: Scott Road Test Sections
 Project ID: TIC-00048
 Location: City of Menifee, Riverside County, CA



Automated Plate Load Test [APLT]

Test:	In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent (5, 10, 15, 20, 30, 40)				
Date:	5/14/2019	Time:	10:14:25 AM	Test ID:	CTRL_PT3
Tested By:	PV, HG, CV	Location:	Scott Rd Test Sections	Sta.:	NA
Latitude, N:	33.641697	Longitude, W:	117.174470	Elev. (ft):	NA
Comments:	9.1 in. Class 2 recycled aggregate base course over subgrade.				

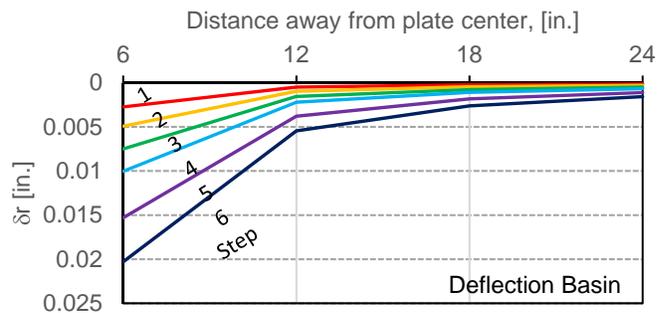
Step	N	$\sigma_{cyclic_surface}$ [psi]	M_{r-Base} [psi]	M_{r-Base} (pred.) [psi]	$\sigma_{cyclic_Int.}$ [psi]	$M_{r-Subgrade}$ [psi]	$M_{r-Subgrade}$ (pred.) [psi]	Modulus Ratio
Conditioning	500	12.93	---	---	---	---	---	---
1	100	4.22	19,852	19,921	1.62	21,771	21,702	0.91
2	100	8.15	22,883	22,656	3.01	21,416	21,622	1.07
3	100	12.93	24,889	25,065	4.66	21,092	21,019	1.18
4	100	17.90	27,129	27,122	6.25	20,433	20,223	1.33
5	100	27.69	30,523	30,560	9.09	18,429	18,639	1.66
6	100	37.34	33,588	33,538	11.69	17,252	17,184	1.95



Model: AASHTO (2015)

$$M_r = k_1^* P_a \left(\frac{\theta}{P_a} \right)^{k_2^*} \left(1 + \frac{\tau_{oct}}{P_a} \right)^{k_3^*}$$

Parameter	Value	P-Value
k_1^* (Base)	1408.2	3.62E-09
k_2^* (Base)	0.160	1.96E-03
k_3^* (Base)	0.588	1.40E-02
Adj. R^2	0.999	
Std. Error [psi]	151	
k_1^* (Subgrade)	1935.2	6.11E-07
k_2^* (Subgrade)	0.139	3.27E-02
k_3^* (Subgrade)	-3.448	4.54E-03
Adj. R^2	0.989	
Std. Error [psi]	190	



In-situ Resilient Modulus [Mr]: Cyclic Loading, Layered Analysis, Stress-Dependent

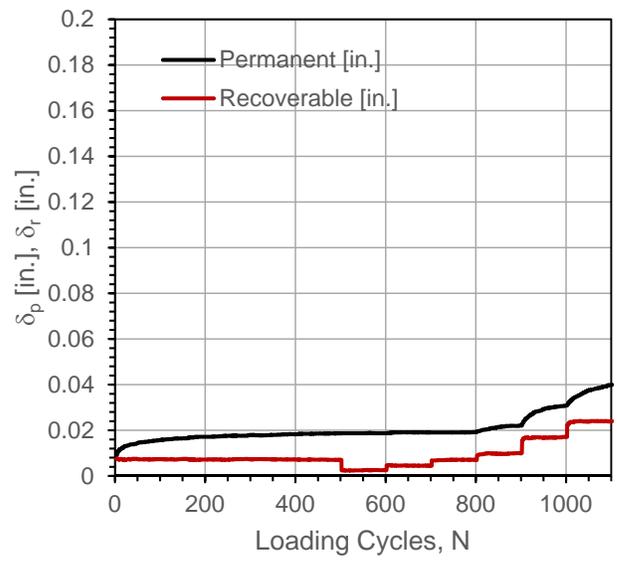
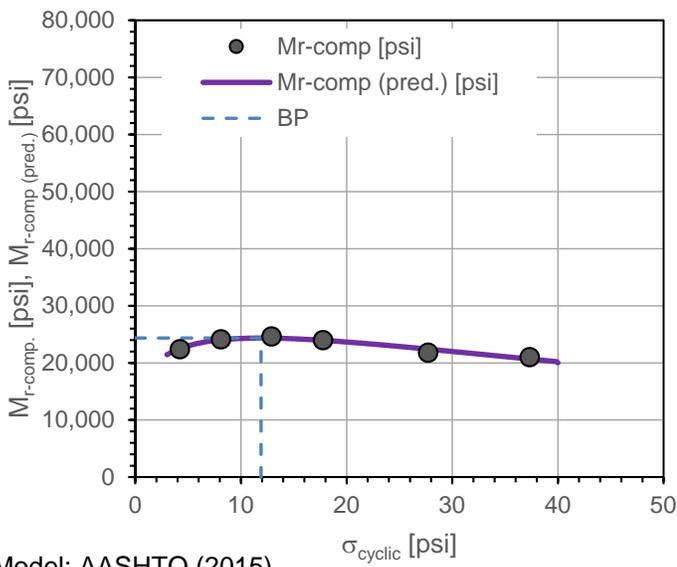
Project Name: Scott Road Test Sections
 Project ID: TIC-00048
 Location: City of Menifee, Riverside County, CA



Automated Plate Load Test [APLT]

Test:	In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent (5, 10, 15, 20, 30, 40)				
Date:	5/14/2019	Time:	10:48:07 AM	Test ID:	TX_PT4
Tested By:	PV, HG, CV	Location:	Scott Rd Test Sections	Sta.:	NA
Latitude,N:	33.641693	Longitude,W:	117.174420	Elev. (ft):	NA
Comments:	5.0 in. TX7 geogrid stabilized Class 2 recycled aggregate base course over subgrade.				

Step	N	σ_{cyclic} [psi]	M_{r-comp} [psi]	M_{r-comp} (pred.) [psi]	δ_p [in.]	$\Delta\delta_p$ [in.]	$d = \frac{\Delta\log(\delta_p)}{\Delta\log(N)}$	Near-linear Elastic
Conditioning	500	12.90	---	---	0.0186	---	0.123	---
1	100	4.22	22,395	22,508	0.0187	0.0001	0.065	Y
2	100	8.11	24,136	24,043	0.0191	0.0005	0.290	Y
3	100	12.90	24,626	24,340	0.0192	0.0006	0.068	Y
4	100	17.77	23,988	23,954	0.0221	0.0035	0.677	N
5	100	27.71	21,788	22,411	0.0308	0.0122	0.697	N
6	100	37.33	21,018	20,679	0.0399	0.0213	0.803	N



Model: AASHTO (2015)

$$M_{r-comp} = k_1^* P_a \left(\frac{\theta}{P_a}\right)^{k_2^*} \left(1 + \frac{\tau_{oct}}{P_a}\right)^{k_3^*}$$

Parameter	Value	P-Value
k_1^*	1,813.1	6.71E-08
k_2^*	0.214	1.53E-02
k_3^*	-1.888	9.02E-03
Adj. R ²	0.929	
Std. Error [psi]	372	

M_{r-comp} (pred.)-BP [psi]	24,355
$\sigma_{cyclic-BP}$ [psi]	11.9



In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent

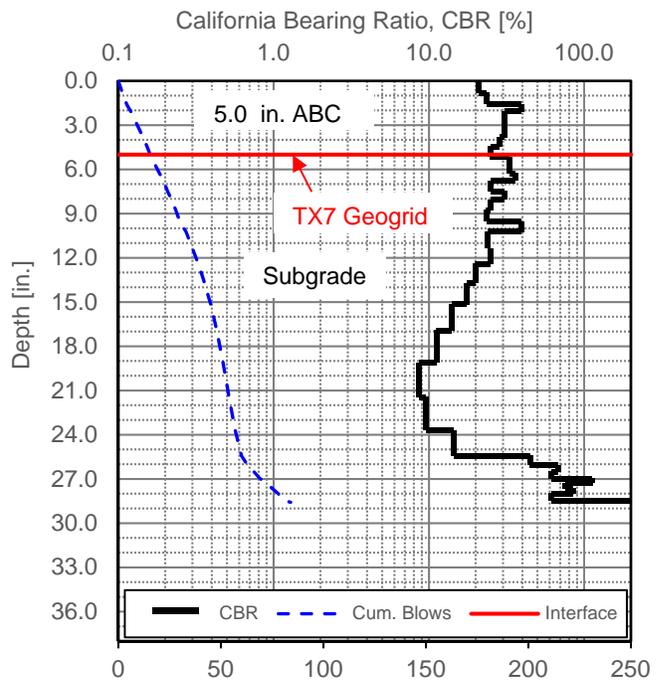
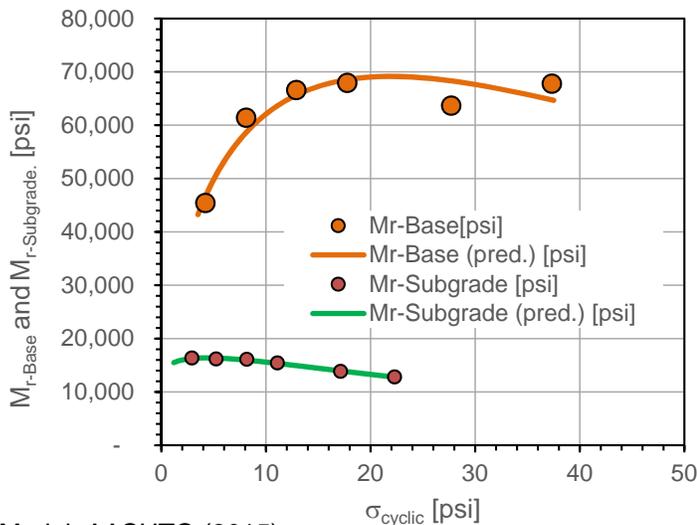
Project Name: Scott Road Test Sections
 Project ID: TIC-00048
 Location: City of Menifee, Riverside County, CA



Automated Plate Load Test [APLT]

Test:	In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent (5, 10, 15, 20, 30, 40)				
Date:	5/14/2019	Time:	10:48:07 AM	Test ID:	TX_PT4
Tested By:	PV, HG, CV	Location:	Scott Rd Test Sections	Sta.:	NA
Latitude, N:	33.641693	Longitude, W:	117.174420	Elev. (ft):	NA
Comments:	5.0 in. TX7 geogrid stabilized Class 2 recycled aggregate base course over subgrade.				

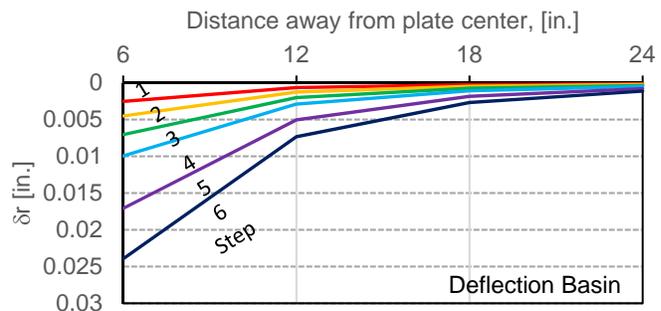
Step	N	$\sigma_{cyclic_surface}$ [psi]	M_{r-Base} [psi]	M_{r-Base} (pred.) [psi]	$\sigma_{cyclic_Int.}$ [psi]	$M_{r-Subgrade}$ [psi]	$M_{r-Subgrade}$ (pred.) [psi]	Modulus Ratio
Conditioning	500	12.90	---	---	---	---	---	---
1	100	4.22	45,412	46,631	2.93	16,335	16,267	2.78
2	100	8.11	61,397	58,624	5.25	16,144	16,353	3.80
3	100	12.90	66,585	65,654	8.19	16,098	15,952	4.14
4	100	17.77	67,922	68,546	11.10	15,414	15,349	4.41
5	100	27.71	63,660	68,312	17.14	13,842	13,942	4.60
6	100	37.33	67,796	64,757	22.31	12,802	12,769	5.30



Model: AASHTO (2015)

$$M_r = k_1^* P_a \left(\frac{\theta}{P_a} \right)^{k_2^*} \left(1 + \frac{\tau_{oct}}{P_a} \right)^{k_3^*}$$

Parameter	Value	P-Value
k_1^* (Base)	4386.0	1.13E-06
k_2^* (Base)	0.511	2.50E-02
k_3^* (Base)	-2.695	5.70E-02
Adj. R^2	0.861	
Std. Error [psi]	3123	
k_1^* (Subgrade)	1357.9	1.08E-07
k_2^* (Subgrade)	0.138	1.68E-02
k_3^* (Subgrade)	-2.096	2.50E-03
Adj. R^2	0.990	
Std. Error [psi]	145	



In-situ Resilient Modulus [Mr]: Cyclic Loading, Layered Analysis, Stress-Dependent

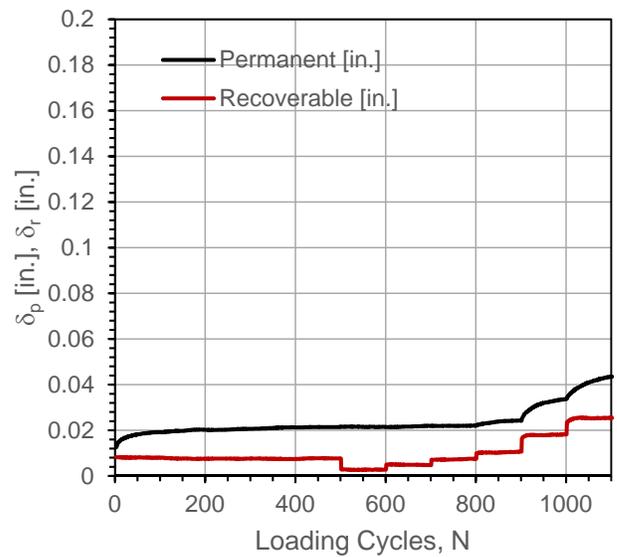
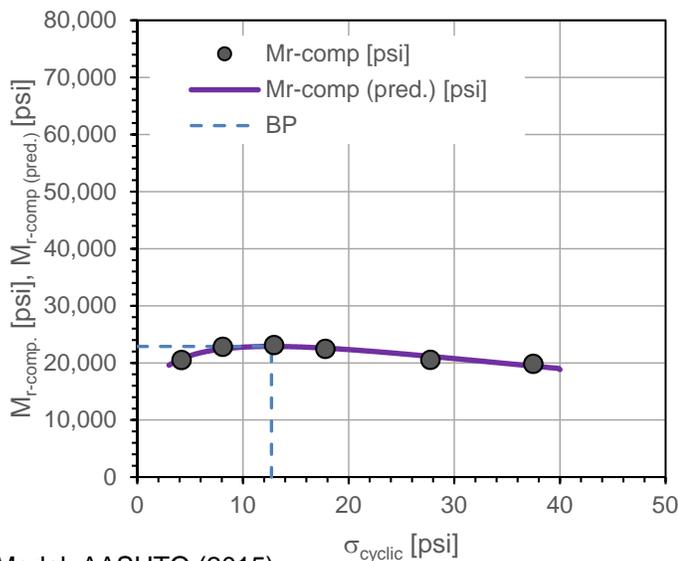
Project Name: Scott Road Test Sections
 Project ID: TIC-00048
 Location: City of Menifee, Riverside County, CA



Automated Plate Load Test [APLT]

Test:	In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent (5, 10, 15, 20, 30, 40)				
Date:	5/14/2019	Time:	11:19:12 AM	Test ID:	TX_PT5
Tested By:	PV, HG, CV	Location:	Scott Rd Test Sections	Sta.:	NA
Latitude,N:	33.641689	Longitude,W:	117.174390	Elev. (ft):	NA
Comments:	4.4 in. TX7 geogrid stabilized Class 2 recycled aggregate base course over subgrade.				

Step	N	σ_{cyclic} [psi]	M_{r-comp} [psi]	M_{r-comp} (pred.) [psi]	δ_p [in.]	$\Delta\delta_p$ [in.]	$d = \Delta\log(\delta_p) / \Delta\log(N)$	Near-linear Elastic
Conditioning	500	12.95	---	---	0.0215	---	0.083	---
1	100	4.19	20,510	20,721	0.0214	0.0000	-0.129	Y
2	100	8.09	22,814	22,451	0.0220	0.0005	0.509	Y
3	100	12.95	23,135	22,890	0.0221	0.0006	0.136	Y
4	100	17.80	22,450	22,590	0.0243	0.0028	0.573	Y
5	100	27.74	20,536	21,147	0.0337	0.0123	0.593	N
6	100	37.48	19,822	19,447	0.0434	0.0220	0.700	N



Model: AASHTO (2015)

$$M_{r-comp} = k_1^* P_a \left(\frac{\theta}{P_a}\right)^{k_2^*} \left(1 + \frac{\tau_{oct}}{P_a}\right)^{k_3^*}$$

Parameter	Value	P-Value
k_1^*	1,701.0	1.13E-07
k_2^*	0.243	1.68E-02
k_3^*	-2.032	1.15E-02
Adj. R ²	0.904	
Std. Error [psi]	414	

M_{r-comp} (pred.)-BP [psi]	22,891
$\sigma_{cyclic-BP}$ [psi]	12.7



In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent

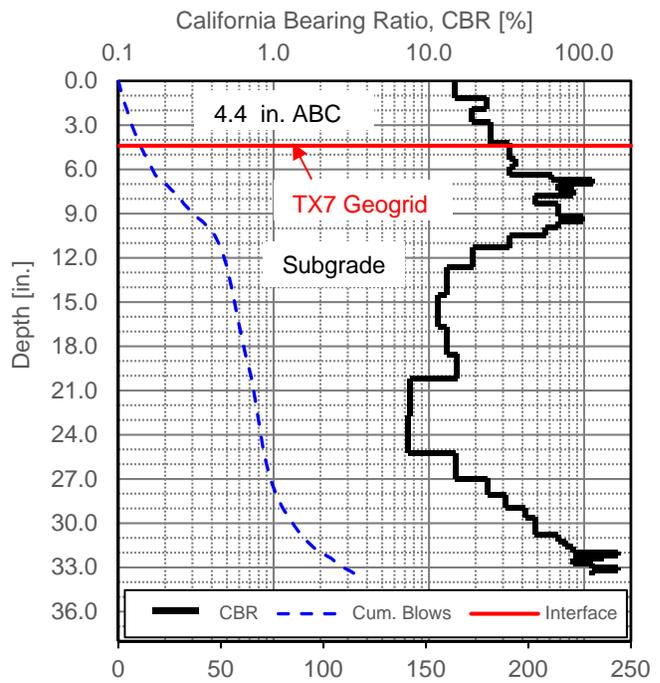
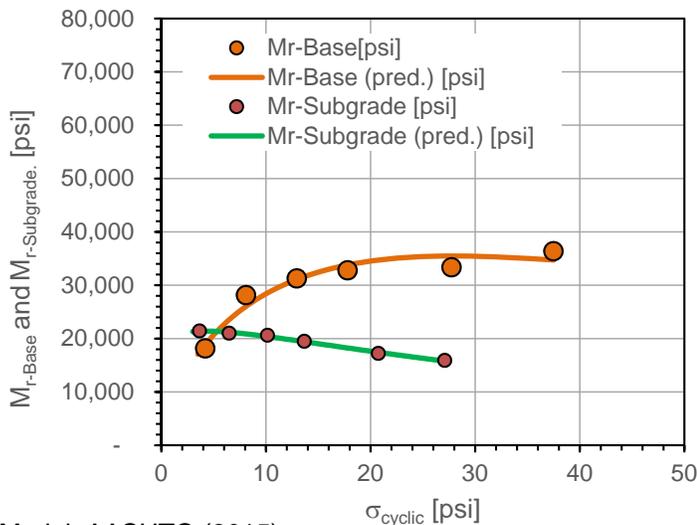
Project Name: Scott Road Test Sections
 Project ID: TIC-00048
 Location: City of Menifee, Riverside County, CA



Automated Plate Load Test [APLT]

Test:	In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent (5, 10, 15, 20, 30, 40)				
Date:	5/14/2019	Time:	11:19:12 AM	Test ID:	TX_PT5
Tested By:	PV, HG, CV	Location:	Scott Rd Test Sections	Sta.:	NA
Latitude, N:	33.641689	Longitude, W:	117.174390	Elev. (ft):	NA
Comments:	4.4 in. TX7 geogrid stabilized Class 2 recycled aggregate base course over subgrade.				

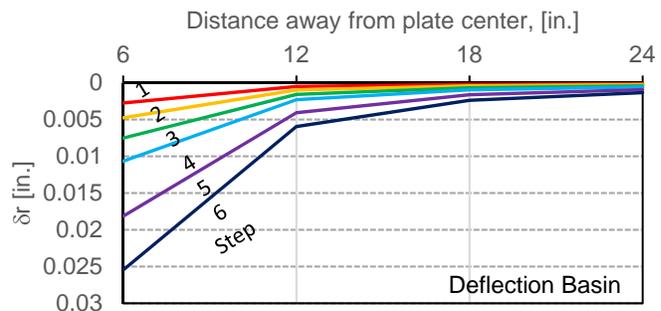
Step	N	$\sigma_{cyclic_surface}$ [psi]	M_{r-Base} [psi]	M_{r-Base} (pred.) [psi]	$\sigma_{cyclic_Int.}$ [psi]	$M_{r-Subgrade}$ [psi]	$M_{r-Subgrade}$ (pred.) [psi]	Modulus Ratio
Conditioning	500	12.95	---	---	---	---	---	---
1	100	4.19	18,143	18,856	3.66	21,420	21,383	0.85
2	100	8.09	28,154	26,046	6.50	21,004	21,191	1.34
3	100	12.95	31,271	31,101	10.16	20,604	20,378	1.52
4	100	17.80	32,809	33,796	13.68	19,469	19,411	1.69
5	100	27.74	33,358	35,486	20.75	17,197	17,429	1.94
6	100	37.48	36,375	34,713	27.10	15,891	15,786	2.29



Model: AASHTO (2015)

$$M_r = k_1^* P_a \left(\frac{\theta}{P_a} \right)^{k_2^*} \left(1 + \frac{\tau_{oct}}{P_a} \right)^{k_3^*}$$

Parameter	Value	P-Value
k_1^* (Base)	1903.9	2.59E-06
k_2^* (Base)	0.662	1.96E-02
k_3^* (Base)	-2.864	7.30E-02
Adj. R^2	0.921	
Std. Error [psi]	1810	
k_1^* (Subgrade)	1736.9	8.46E-08
k_2^* (Subgrade)	0.120	3.46E-02
k_3^* (Subgrade)	-1.889	3.22E-03
Adj. R^2	0.992	
Std. Error [psi]	196	



In-situ Resilient Modulus [Mr]: Cyclic Loading, Layered Analysis, Stress-Dependent

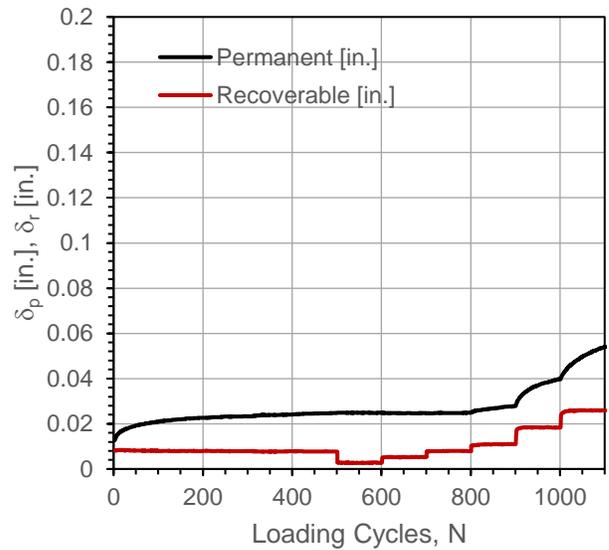
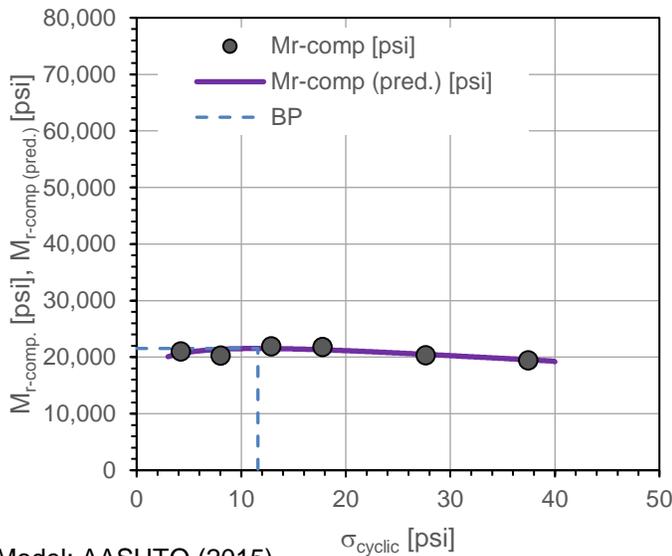
Project Name: Scott Road Test Sections
 Project ID: TIC-00048
 Location: City of Menifee, Riverside County, CA



Automated Plate Load Test [APLT]

Test:	In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent (5, 10, 15, 20, 30, 40)				
Date:	5/14/2019	Time:	11:54:32 AM	Test ID:	TX_PT6
Tested By:	PV, HG, CV	Location:	Scott Rd Test Sections	Sta.:	NA
Latitude, N:	33.641701	Longitude, W:	117.174380	Elev. (ft):	NA
Comments:	5.0 in. TX7 geogrid stabilized Class 2 recycled aggregate base course over subgrade.				

Step	N	σ_{cyclic} [psi]	M_{r-comp} [psi]	M_{r-comp} (pred.) [psi]	δ_p [in.]	$\Delta\delta_p$ [in.]	$d = \Delta\log(\delta_p) / \Delta\log(N)$	Near-linear Elastic
Conditioning	500	12.88	---	---	0.0247	---	0.116	---
1	100	4.22	21,051	20,645	0.0248	0.0001	-0.109	Y
2	100	8.02	20,323	21,388	0.0247	0.0000	-0.123	Y
3	100	12.88	21,955	21,517	0.0250	0.0003	0.193	Y
4	100	17.77	21,790	21,301	0.0279	0.0031	0.570	Y
5	100	27.64	20,333	20,488	0.0398	0.0151	0.549	N
6	100	37.47	19,461	19,533	0.0540	0.0293	0.766	N



Model: AASHTO (2015)

$$M_{r-comp} = k_1^* P_a \left(\frac{\theta}{P_a}\right)^{k_2^*} \left(1 + \frac{\tau_{oct}}{P_a}\right)^{k_3^*}$$

Parameter	Value	P-Value
k_1^*	1,544.7	4.09E-07
k_2^*	0.119	2.17E-01
k_3^*	-1.077	1.49E-01
Adj. R^2	0.524	
Std. Error [psi]	520	

M_{r-comp} (pred.)-BP [psi]	21,529
$\sigma_{cyclic-BP}$ [psi]	11.6



In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent

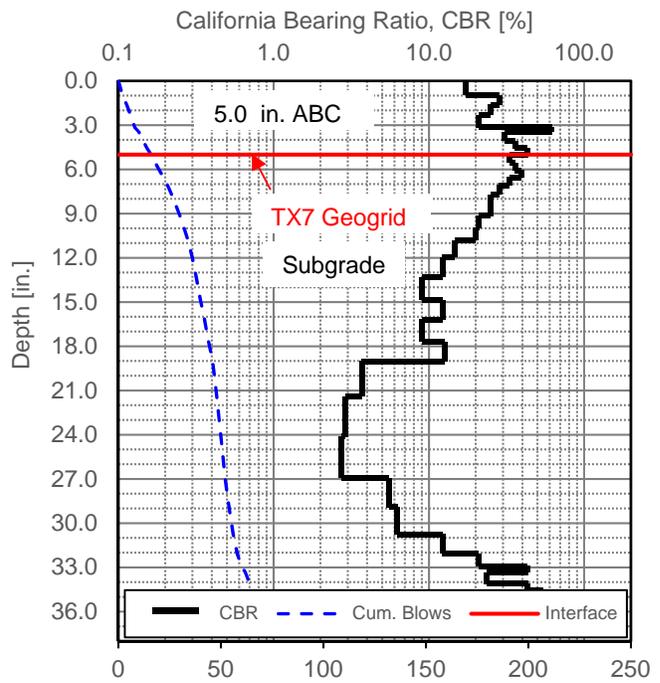
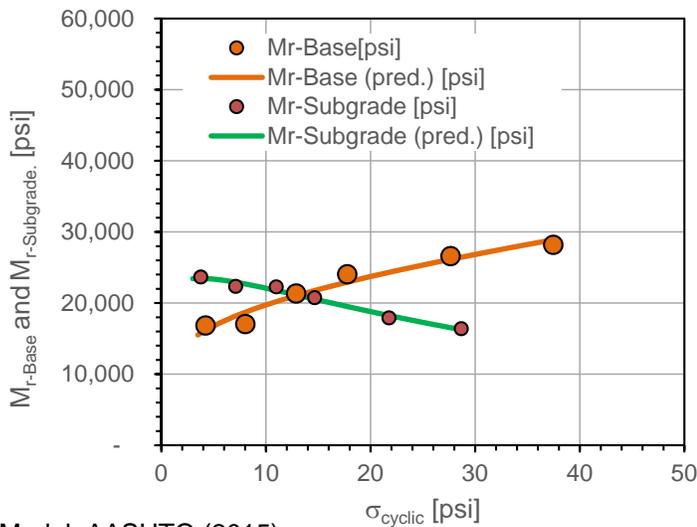
Project Name: Scott Road Test Sections
 Project ID: TIC-00048
 Location: City of Menifee, Riverside County, CA



Automated Plate Load Test [APLT]

Test:	In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent (5, 10, 15, 20, 30, 40)				
Date:	5/14/2019	Time:	11:54:32 AM	Test ID	TX_PT6
Tested By	PV, HG, CV	Location:	Scott Rd Test Sections	Sta.	NA
Latitude, N:	33.641701	Longitude, W:	117.174380	Elev. (ft):	NA
Comments:	5.0 in. TX7 geogrid stabilized Class 2 recycled aggregate base course over subgrade.				

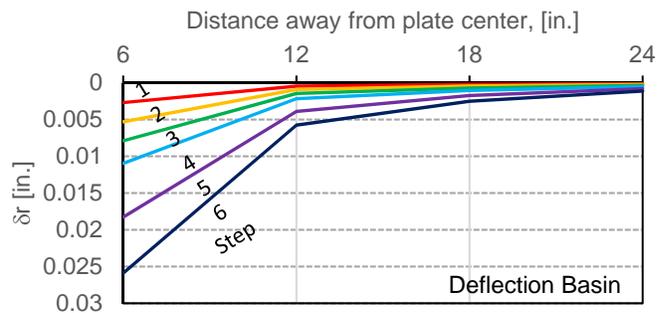
Step	N	$\sigma_{cyclic_surface}$ [psi]	M_{r-Base} [psi]	M_{r-Base} (pred.) [psi]	$\sigma_{cyclic_Int.}$ [psi]	$M_{r-Subgrade}$ [psi]	$M_{r-Subgrade}$ (pred.) [psi]	Modulus Ratio
Conditioning	500	12.88	---	---	---	---	---	---
1	100	4.22	16,828	16,161	3.79	23,635	23,459	0.71
2	100	8.02	17,050	18,707	7.12	22,316	22,922	0.76
3	100	12.88	21,327	21,036	10.99	22,247	21,762	0.96
4	100	17.77	24,032	22,939	14.66	20,739	20,539	1.16
5	100	27.64	26,589	26,142	21.77	17,893	18,240	1.49
6	100	37.47	28,178	28,891	28.68	16,365	16,253	1.72



Model: AASHTO (2015)

$$M_r = k_1^* P_a \left(\frac{\theta}{P_a} \right)^{k_2^*} \left(1 + \frac{\tau_{oct}}{P_a} \right)^{k_3^*}$$

Parameter	Value	P-Value
k_1^* (Base)	1163.1	2.88E-06
k_2^* (Base)	0.197	2.56E-01
k_3^* (Base)	0.513	6.52E-01
Adj. R^2	0.944	
Std. Error [psi]	1119	
k_1^* (Subgrade)	1906.3	5.43E-07
k_2^* (Subgrade)	0.113	1.80E-01
k_3^* (Subgrade)	-1.968	1.78E-02
Adj. R^2	0.975	
Std. Error [psi]	445	



In-situ Resilient Modulus [Mr]: Cyclic Loading, Layered Analysis, Stress-Dependent

Project Name: Scott Road Test Sections
 Project ID: TIC-00048
 Location: City of Menifee, Riverside County, CA



Date of Test	5/14/2019	Test ID	CTRL_PT1	Operator	JV, HG	ASTM	D6951
Latitude, N	33.64170	Longitude, W	117.174510	Elevation (ft)	NA		
Location	Scott Rd Test Sections	Station	NA				
Comments	9.7 in. Class 2 recycled aggregate base course over subgrade.						

Parameter	DPI (mm/blow)	CBR (%)	E _{CBR} , Elastic Modulus (ksi) (non stress-dependent)	S _{u-CBR} , Bearing Capacity (psf)
Avg. Top Layer [0-9.7 in.]	7.4	30.9	22.9	5,331
Avg. Bottom Layer [9.7-24 in.]	7.2	31.9	23.4	5,445
Ratio of Avg.0-9.7 in./9.7-24 in.	1.0	1.0	1.0	1.0
Stdev Top Layer [0-9.7 in.]	2.8	12.2	12.7	2,879
Stdev. Bottom Layer [9.7-24 in.]	2.3	11.9	12.5	2,832

NOTES:

Subgrade is assumed as CL

¹CBR = 292/DPI^{1.12}

¹CBR = 1/(0.002871*DPI)

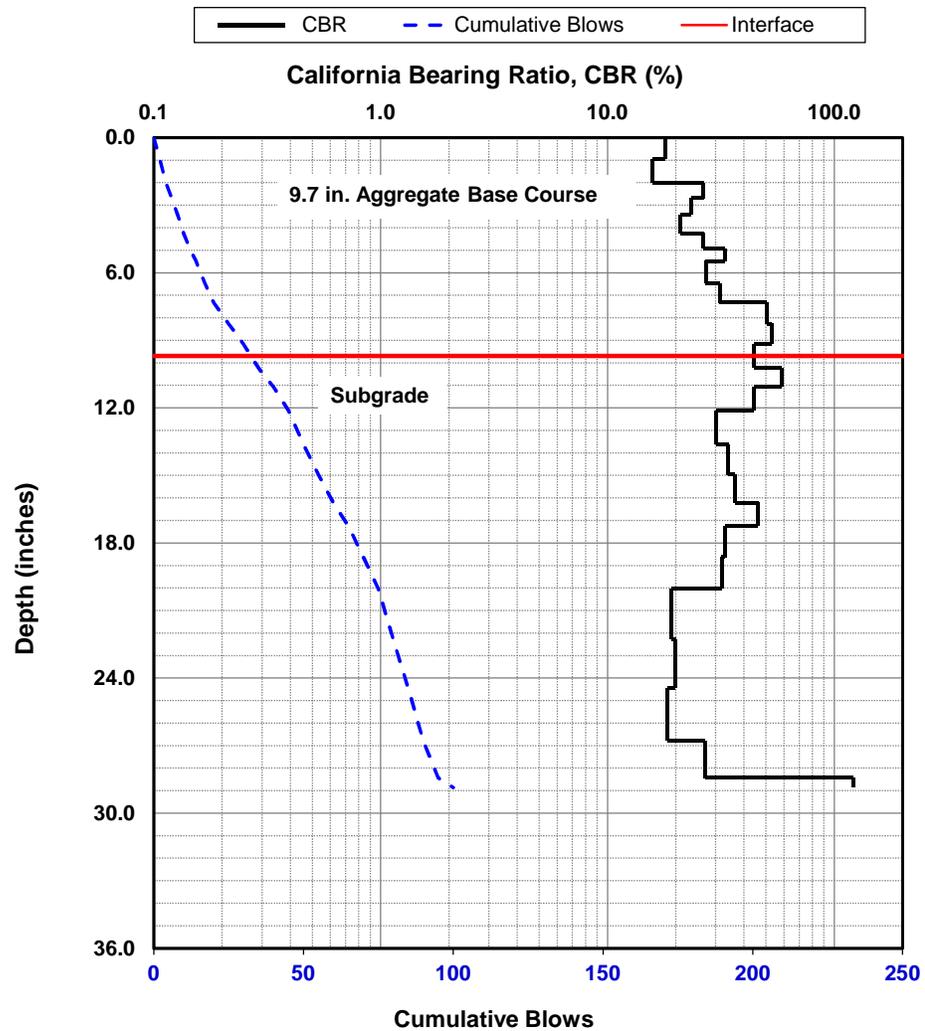
²E (ksi) = (17.6 CBR^{0.64}) x 0.1450377

³S_u (psf) =(3.794 x CBR^{0.664}) x 144

¹ASTM D6951-03

²Powell et al. (1986)

³Portland Cement Assoc. (1955)



Dynamic Cone Penetrometer (DCP) Test Results

Project Name: Scott Road Test Sections
 Project ID: TIC-00048
 Location: City of Menifee, Riverside County, CA



Date of Test	5/14/2019	Test ID	CTRL_PT2	Operator	JV, HG	ASTM	D6951
Latitude, N	33.64170	Longitude, W		117.174490		Elevation (ft)	NA
Location	Scott Rd Test Sections	Station		NA			
Comments	9.25 in. Class 2 recycled aggregate base course over subgrade.						

Parameter	DPI (mm/blow)	CBR (%)	E _{CBR} , Elastic Modulus (ksi) (non stress-dependent)	S _{u-CBR} , Bearing Capacity (psf)
Avg. Top Layer [0-9.25 in.]	9.6	23.2	19.1	4,411
Avg. Bottom Layer [9.25-24 in.]	9.4	23.7	19.3	4,465
Ratio of Avg.0-9.25 in./9.25-24 in.	1.0	1.0	1.0	1.0
Stdev Top Layer [0-9.25 in.]	2.8	6.4	8.4	1,880
Stdev. Bottom Layer [9.25-24 in.]	4.7	16.5	15.3	3,511

NOTES:

Subgrade is assumed as CL

¹CBR = 292/DPI^{1.12}

¹CBR = 1/(0.002871*DPI)

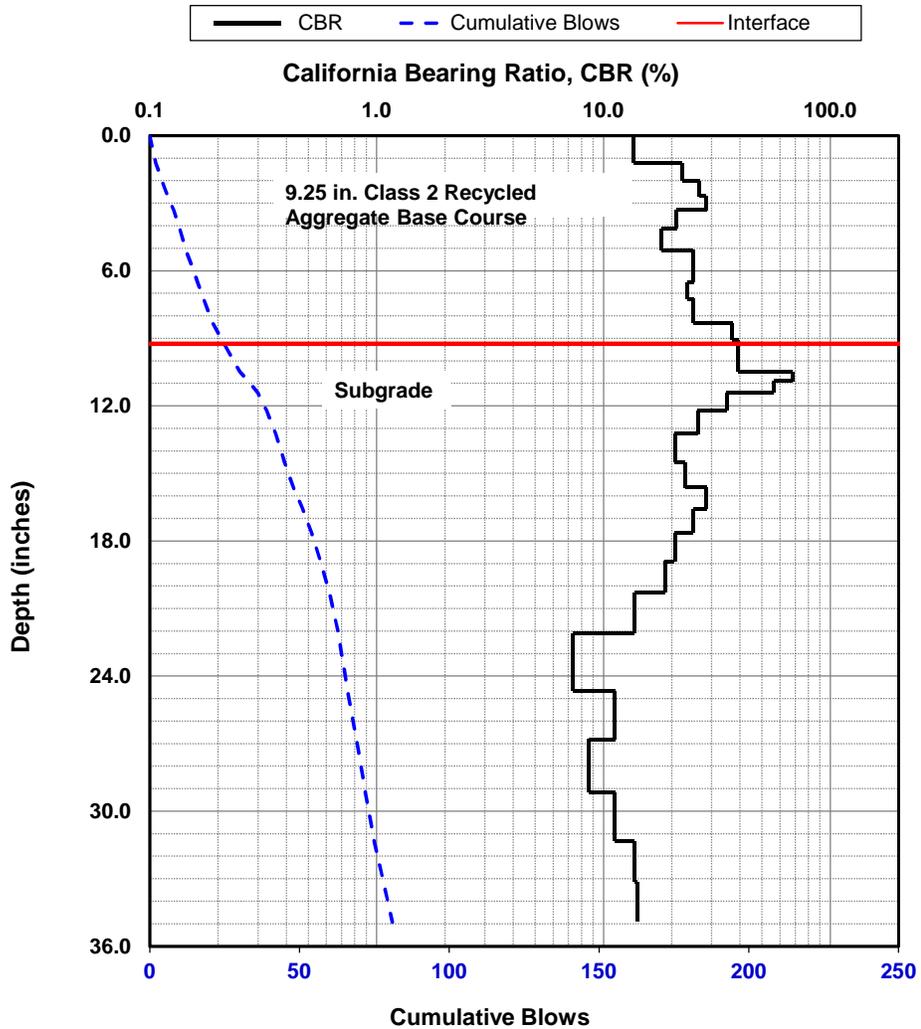
²E (ksi) = (17.6 CBR^{0.664}) x 0.1450377

³S_u (psf) = (3.794 x CBR^{0.664}) x 144

¹ASTM D6951-03

²Powell et al. (1986)

³Portland Cement Assoc. (1955)



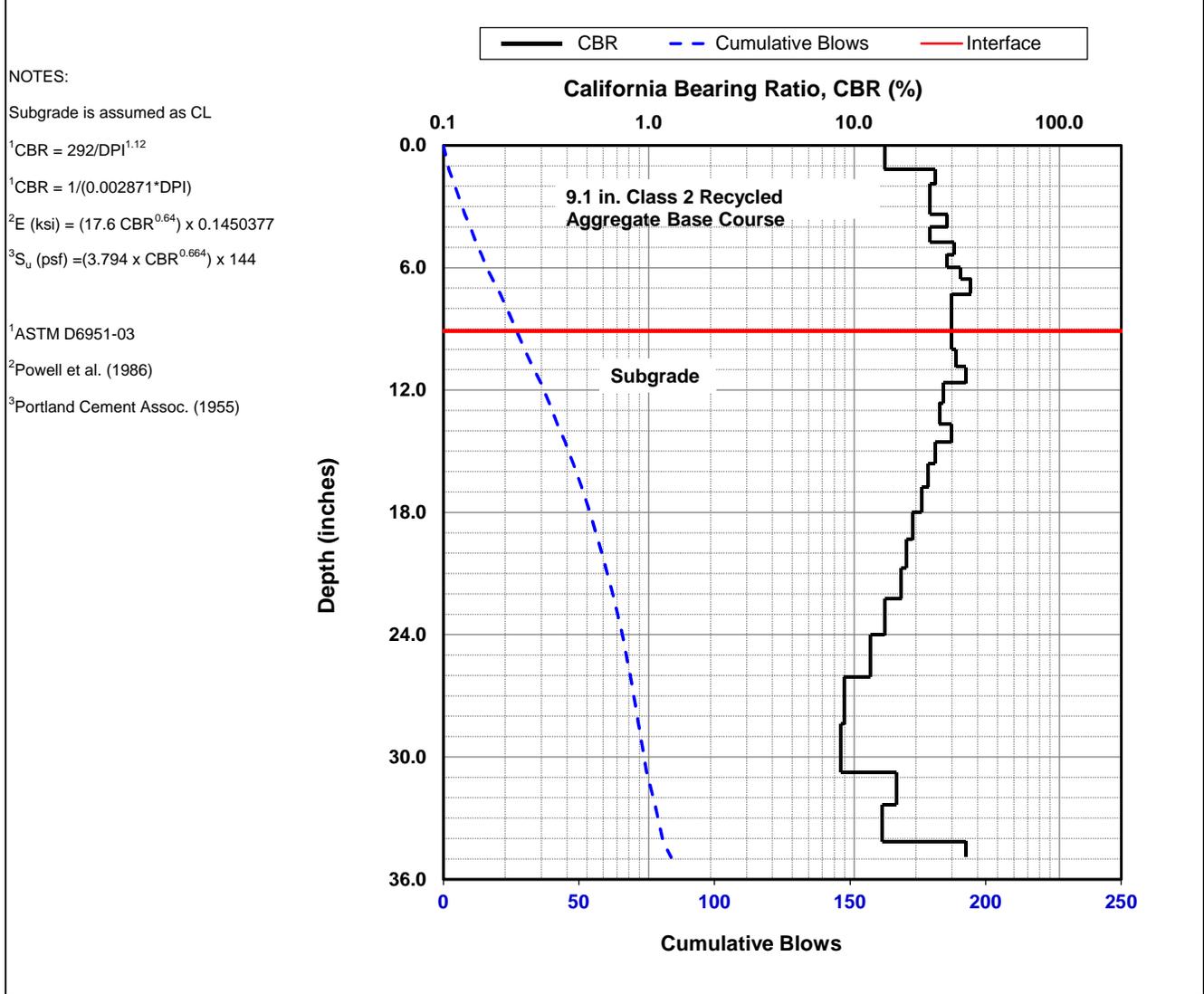
Dynamic Cone Penetrometer (DCP) Test Results

Project Name: Scott Road Test Sections
 Project ID: TIC-00048
 Location: City of Menifee, Riverside County, CA



Date of Test	5/14/2019	Test ID	CTRL_PT3	Operator	JV, HG	ASTM	D6951
Latitude, N	33.64170	Longitude, W	117.174470	Elevation (ft)	NA		
Location	Scott Rd Test Sections	Station	NA				
Comments	9.1 in. Class 2 recycled aggregate base course over subgrade.						

Parameter	DPI (mm/blow)	CBR (%)	E _{CBR} , Elastic Modulus (ksi) (non stress-dependent)	S _{u-CBR} , Bearing Capacity (psf)
Avg. Top Layer [0-9.1 in.]	8.6	26.4	20.7	4,799
Avg. Bottom Layer [9.1-24 in.]	9.7	22.9	18.9	4,366
Ratio of Avg.0-9.1 in./9.1-24 in.	0.9	1.2	1.1	1.1
Stdev Top Layer [0-9.1 in.]	2.8	6.7	8.6	1,929
Stdev. Bottom Layer [9.1-24 in.]	2.4	6.2	8.2	1,843



Dynamic Cone Penetrometer (DCP) Test Results		
Project Name:	Scott Road Test Sections	
Project ID:	TIC-00048	
Location:	City of Menifee, Riverside County, CA	

Date of Test	5/14/2019	Test ID	TX_PT4	Operator	JV, HG	ASTM	D6951
Latitude, N	33.64169		Longitude, W	117.174420		Elevation (ft)	NA
Location	Scott Rd Test Sections		Station	NA			
Comments	5.0 in. TX7 geogrid stabilized Class 2 recycled aggregate base course over subgrade.						

Parameter	DPI (mm/blow)	CBR (%)	E _{CBR} , Elastic Modulus (ksi) (non stress-dependent)	S _{u-CBR} , Bearing Capacity (psf)
Avg. Top Layer [0-4.25 in.]	8.1	28.2	21.6	5,012
Avg. Bottom Layer [4.25-24 in.]	11.4	19.2	16.9	3,884
Ratio of Avg. 0-4.25 in./4.25-24 in.	0.7	1.5	1.3	1.3
Stdev Top Layer [0-4.25 in.]	1.6	6.2	8.2	1,828
Stdev. Bottom Layer [4.25-24 in.]	4.5	9.2	10.5	2,379

NOTES:

Subgrade is assumed as CL

¹CBR = 292/DPI^{1.12}

¹CBR = 1/(0.002871 * DPI)

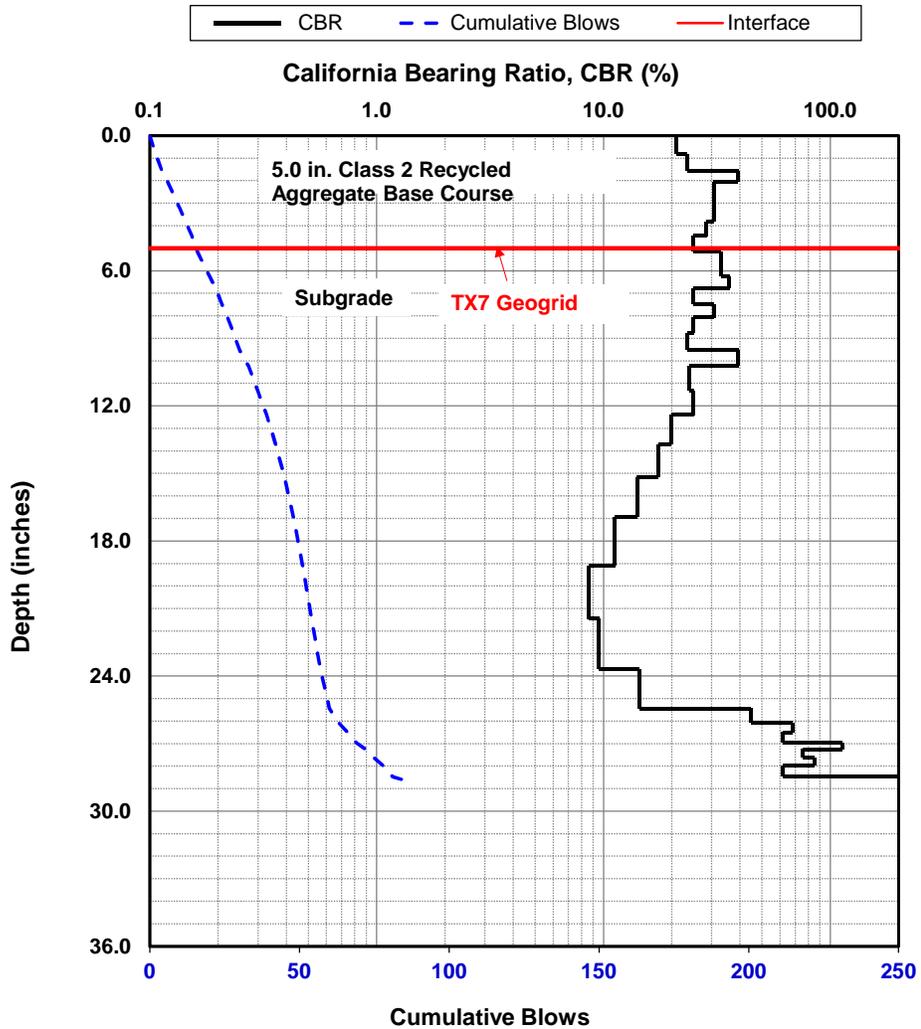
²E (ksi) = (17.6 CBR^{0.64}) x 0.1450377

³S_u (psf) = (3.794 x CBR^{0.664}) x 144

¹ASTM D6951-03

²Powell et al. (1986)

³Portland Cement Assoc. (1955)



Dynamic Cone Penetrometer (DCP) Test Results

Project Name: Scott Road Test Sections
 Project ID: TIC-00048
 Location: City of Menifee, Riverside County, CA



Date of Test	5/14/2019	Test ID	TX_PT5	Operator	JV, HG	ASTM	D6951
Latitude, N	33.64169		Longitude, W	117.174390		Elevation (ft)	NA
Location	Scott Rd Test Sections		Station	NA			
Comments	4.4 in. TX7 geogrid stabilized Class 2 recycled aggregate base course over subgrade.						

Parameter	DPI (mm/blow)	CBR (%)	E _{CBR} , Elastic Modulus (ksi) (non stress-dependent)	S _{u-CBR} , Bearing Capacity (psf)
Avg. Top Layer [0-4.4 in.]	10.7	20.5	17.7	4,064
Avg. Bottom Layer [4.4-24 in.]	8.8	25.7	20.4	4,712
Ratio of Avg.0-4.4 in./4.4-24 in.	1.2	0.8	0.9	0.9
Stdev Top Layer [0-4.4 in.]	2.6	4.9	7.0	1,566
Stdev. Bottom Layer [4.4-24 in.]	6.5	31.3	23.1	5,377

NOTES:

Subgrade is assumed as CL

¹CBR = 292/DPI^{1.12}

¹CBR = 1/(0.002871*DPI)

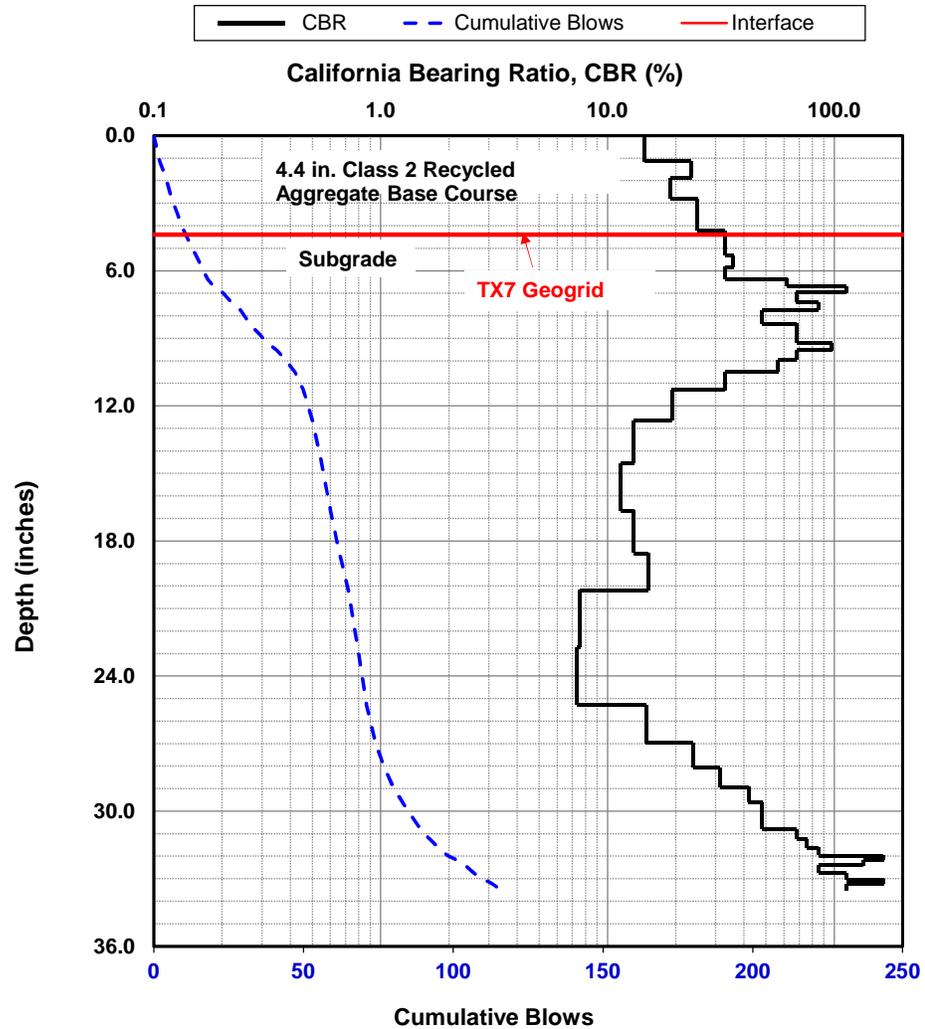
²E (ksi) = (17.6 CBR^{0.664}) x 0.1450377

³S_u (psf) = (3.794 x CBR^{0.664}) x 144

¹ASTM D6951-03

²Powell et al. (1986)

³Portland Cement Assoc. (1955)



Dynamic Cone Penetrometer (DCP) Test Results

Project Name: Scott Road Test Sections
 Project ID: TIC-00048
 Location: City of Menifee, Riverside County, CA



Date of Test	5/14/2019	Test ID	TX_PT6	Operator	JV, HG	ASTM	D6951
Latitude, N	33.64170	Longitude, W	117.174380	Elevation (ft)	NA		
Location	Scott Rd Test Sections	Station	NA				
Comments	5.0 in. TX7 geogrid stabilized Class 2 recycled aggregate base course over subgrade.						

Parameter	DPI (mm/blow)	CBR (%)	E _{CBR} , Elastic Modulus (ksi) (non stress-dependent)	S _{u-CBR} , Bearing Capacity (psf)
Avg. Top Layer [0-5.0 in.]	7.9	28.7	21.9	5,075
Avg. Bottom Layer [5.0-24 in.]	14.3	14.8	14.3	3,276
Ratio of Avg.0-5.0 in./5.0-24 in.	0.6	1.9	1.5	1.5
Stdev Top Layer [0-5.0 in.]	3.0	14.3	14.0	3,202
Stdev. Bottom Layer [5.0-24 in.]	8.3	12.4	12.8	2,903

NOTES:

Subgrade is assumed as CL

¹CBR = 292/DPI^{1.12}

¹CBR = 1/(0.002871*DPI)

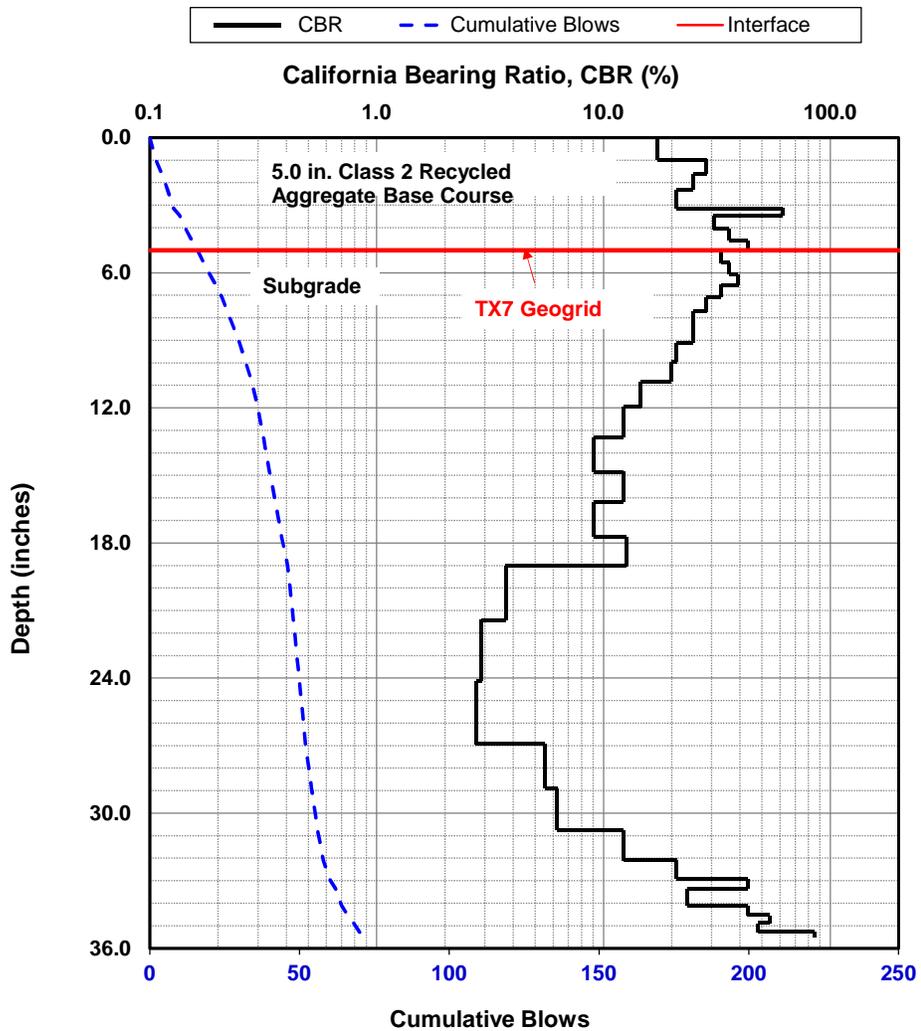
²E (ksi) = (17.6 CBR^{0.64}) x 0.1450377

³S_u (psf) = (3.794 x CBR^{0.664}) x 144

¹ASTM D6951-03

²Powell et al. (1986)

³Portland Cement Assoc. (1955)



Dynamic Cone Penetrometer (DCP) Test Results

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