Memorandum

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To: SERGIO ACEVES, STATE PAVEMENT ENGINEER
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Date: November 15, 2019

File: 11-SD-5
11-2T1724
PM R37.4/R46.4
11-2T1714
PM R39.8/R44.1
11-2T2114
PM R43.4/R47.5
11-2T2124
PM R47.3/R51.3

From: DAVID EVANS
District Pavement Engineer
Division of Engineering
District 11 Materials Lab

Subject: **CONSTRUCTION EVALUATED WORK PLAN (CEWP) RESULTS FOR TRIAX GEOGRID ON SD-5 NORTH COAST CORRIDOR IN SAN DIEGO COUNTY**

Herein is the final report for the Construction Evaluated Work Plan (CEWP) for the North Coast Corridor project. The District 11 CMGC design team selected the Tensar TriAx Geogrid to help solve various project challenges. In summary, the contractor installed the geogrid on the project successfully using rubber-tired vehicles to bottom dump base. Caltrans District 11 representatives have not observed any delays in construction or other issues about the geogrid to date. The geogrid is easy to install, and no issues that could result in any Contract Change Orders (CCO) are foreseen. Additionally, no product deficiencies are known. Another benefit realized was the ability to quickly address yielding subgrades. When the contractor encountered yielding subgrade along the alignment, this condition was addressed using the TriAx geogrid without delay or significant cost increase.

Tensar commissioned Ingios Geotechnics to perform testing at the site. The purpose of testing during construction was to verify the planned pavement section (control section and Tensar Stabilized Section) met or exceeded the section stiffness and constructability.

The testing consisted of:

- Collecting a sample of the aggregate base for grain size distribution
- Performing Dynamic Cone Penetrometer tests at the site
- Measuring the resilient modulus and surface deformation of the aggregate base using Automated Plate Load Tests

The test sections consisted of:

- Flexible Pavement
  - Control: 0.15 Feet RHMA/ 0.45 Feet HMA/ 2.25 Feet AB CL2
  - TriAx Section: 0.15 Feet RHMA/ 0.45 Feet HMA/ 0.85 Feet AB CL2/ TriAx TX5

- Rigid Pavement
  - Control: 0.85 Feet JPCP/ 0.25 Feet HMA/ 0.70 Feet AB CL2
  - TriAx Section 1: 0.85 Feet JPCP/ 0.25 Feet HMA/ 0.35 Feet AB CL2/ TriAx TX5
  - TriAx Section 2: 0.85 Feet JPCP/ 0.20 Feet HMA/ 0.35 Feet AB CL2/ TriAx TX5

<u>Summary</u>

- The 0.85 Feet of Cl2 AB underlain by TriAx geogrid supporting the flexible pavement performed better compared to the control section of 2.25 feet Cl2 AB. The TriAx section reduced the CL2 AB by 62%. The TriAx section had less surface deformation and nearly equivalent composite resilient moduli values.
- The 0.35 Feet AB underlain by TriAx geogrid supporting the rigid pavement performed better compared to the control section of 0.70 Feet AB. The TriAx section reduced the AB by 50%. The TriAx section had less surface deformation and improved composite resilient moduli values. These results

validate how the overlying HMA layer may be reduced from 0.25 Feet to 0.20 Feet, as demonstrated in the TriAx test section.

- The TriAx Geogrid designs on the North Coast Corridor met the needs of the project challenges discussed in the CEWP, reduced cost, improved sustainability, and expedited the construction schedule. Based on the results of this CEWP, I am recommending that District 11 continues to implement the TriAx geogrid designs of 50% aggregate base reduction on future projects within the allowable use of post-bid value engineering of Design Bid Build, Design Bid Build, and CMGC projects.
- The results from this project (TriAx geogrid provides 50% reduction of the aggregate layer) are consistent with the District's experience, pavement monitoring over the past 10 years, and several other Caltrans TriAx research studies throughout the state. Additionally, many research studies demonstrate TriAx Geogrid is superior to Biaxial Geogrid.

David Evans,
District 11 Pavement Engineer
District 11 Materials Lab

Appendices:

Appendix I: CEWP Test Section Locations

Appendix II: Research summary of the I-5 North Coast Corridor Testing for both flexible and rigid pavements

Appendix III: Ingios Consultants report on the Automated Plate Load Tests.

Appendix IV: Summary of Caltrans Statewide Rigid Pavement Research, demonstrating 0.35 Feet aggregate placed on TriAx is superior to 0.70 Feet aggregate control sections.

Appendix V: Summary of research and Caltrans experience comparing TriAx Geogrid performance to Biaxial Geogrid

Appendix VI: TriAx Geogrid Caltrans Example Project List (500+ Lane Miles)

Appendix VII: Summary letter of District 11 project and research experience with Tensar TrIAx geogrid for the last 10 years and how District 11 will continue to use TriAx geogrid to provide value on future pavement designs.

Appendix VIII: Example TriAx Geogrid nSSP

Appendix I: CEWP Test Section Locations

NOTE:

1. FOR ACCURATE RIGHT OF WAY DATA, CONTACT RIGHT OF WAY ENGINEERING AT THE DISTRICT OFFICE.

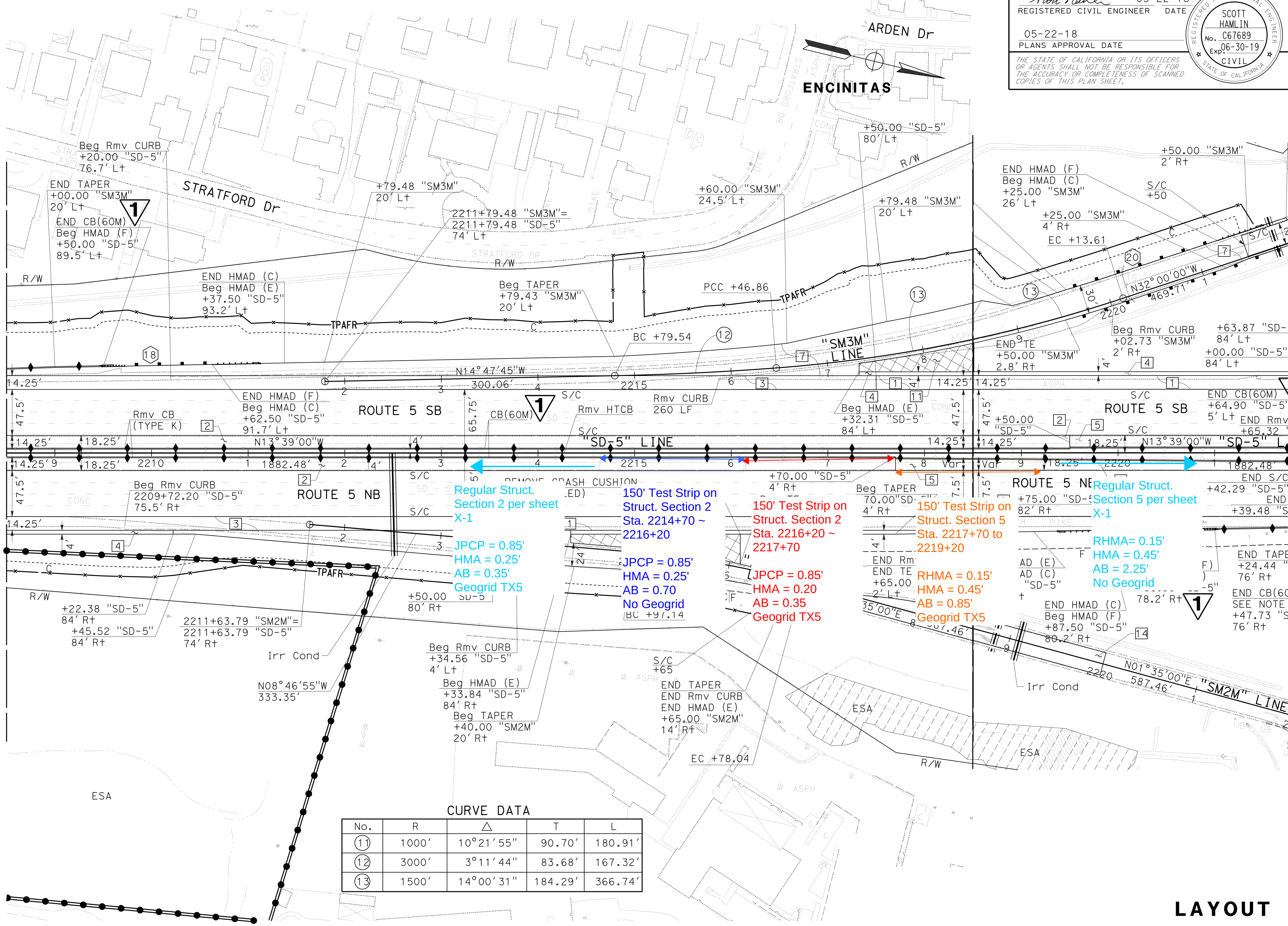
1 REPLACED PER ADDENDUM No. 1 DATED JULY 20, 2018

Dist	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No.	TOTAL SHEETS
11	SD	5	R38.4/R47.3	74	2117

REGISTERED CIVIL ENGINEER 05-22-18 DATE

05-22-18 PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER SCOTT HAMLIN No. C67689 Exp. 06-30-19 CIVIL STATE OF CALIFORNIA



CURVE DATA

No.	R	Δ	T	L
11	1000'	10°21'55"	90.70'	180.91'
12	3000'	3°11'44"	83.68'	167.32'
13	1500'	14°00'31"	184.29'	366.74'

LAYOUT L-12

SCALE 1"=50'

STATE OF CALIFORNIA - DEPARTMENT OF TRANSPORTATION

Caltrans PROJECT DEVELOPMENT

FUNCTIONAL SUPERVISOR: CHRISTOPHER SCOTT

CALCULATED-DESIGNED BY: SCOTT HAMLIN — CHECKED BY: WAMEEDH TOZY

REVISED BY / DATE REVISED

LAST REVISION 05-22-18 — DATE PLOTTED => 24-JUL-2018 TIME PLOTTED => 15:25

Appendix II: Research summary of the I-5 North Coast Corridor Testing for both flexible and rigid pavements

Research Summary Enhanced Pavement Design Using Tensar Stabilization Technology

Topic: Evaluation of using TriAx geogrids for Permanent Pavements
Caltrans Contract No.: 11-2T1714
Location: I-5, North Coast Corridor, San Diego, California

Application:

Permanent Pavements

Type:

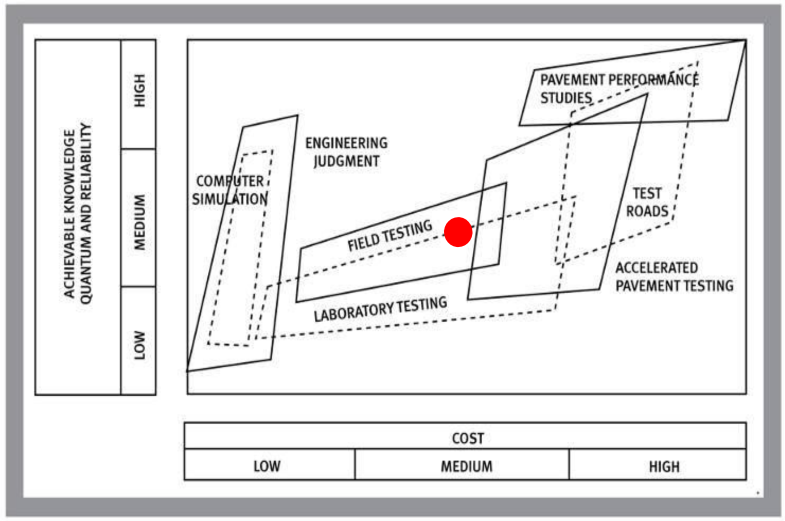
Field Structural Performance Study

Geogrid Products Tested:

- Tensar TriAx

Section Profiles:

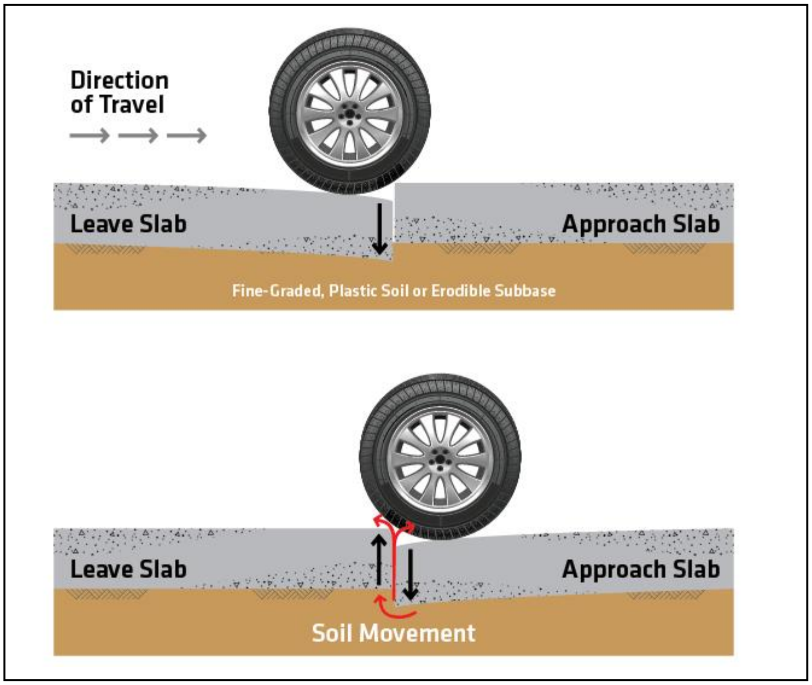
- Enhanced Section 1: 0.25 feet HMA placed on 0.35 feet AB placed on TriAx Geogrid.
- Enhanced Section 2: 0.20 feet HMA placed on 0.35 feet AB placed on TriAx Geogrid.
- Control Section: 0.25 feet HMA placed on 0.70 feet AB
- All sections constructed over a subgrade with Type II Soils (Subgrade R-Value between 10 and 40)



Background:

A concrete pavement structure distributes load stresses through multiple layers. The concrete layer provides most of the support for the traffic loading and the concrete s strength minimizes the stresses on the foundation structure below the rigid wearing surface. However, the performance is dependent on the foundation structure below the rigid pavement to provide:

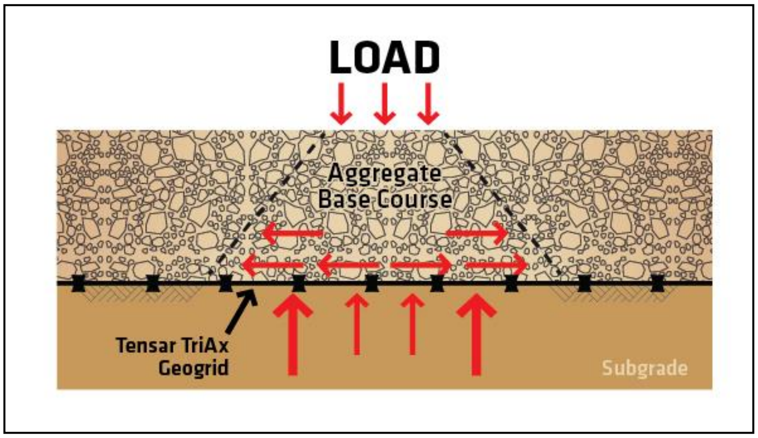
- Uniform support
- Additional load distribution; and
- Drainage



Most performance problems with concrete pavement are a result of poorly performing joints (ACPA, 2001). Poor load transfer creates high slab stresses, which contribute heavily to distresses such as faulting, pumping and corner breaks.

“Load transfer” is a term used to describe the transfer (or distribution) load across discontinuities such as joints or cracks (AASHTO, 1993). When a wheel load is applied at a joint or crack, both the loaded slab and adjacent unloaded slab deflect. The amount the unloaded slab deflects is directly related to joint performance. If a joint is performing perfectly, both the loaded and unloaded slabs deflect equally.

Benefits of the Geogrid Mechanically Stabilized Layer (MSL)

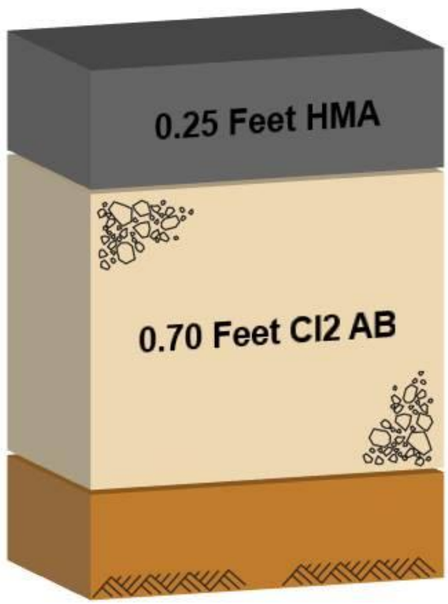


Incorporating geogrids into the roadway section is an effective method of creating a stiffer and more uniform foundation that will maintain integrity over time improving the Load Transfer. The geogrid enhancement results in less deformation during construction, and during the pavement s life. The geogrid achieves this by interlocking with and confining the aggregate base. The confinement reduces the potential for contamination of the aggregate base with the subgrade soil. The geogrid and aggregate base together create a mechanically stabilized layer (MSL). The MSL provides a resilient layer that minimizes the potential for differential movements of the concrete surface that initiate faulting and corner breaks.

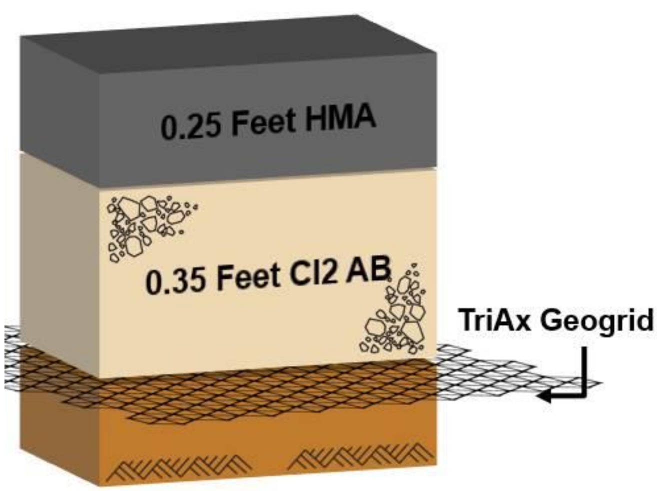
Field Test

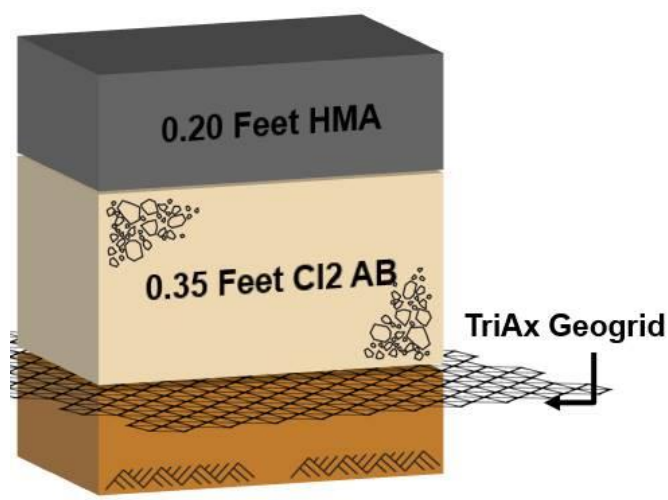
The test was located along Interstate 5 in Encinitas, California. A contractor constructed the test section within the limits of project area. The diagrams below present the test sections. All sections were constructed over similar subgrade strengths (Type II Soils).

Control Section:



TriAx Enhanced Sections:





Purpose/Objective:

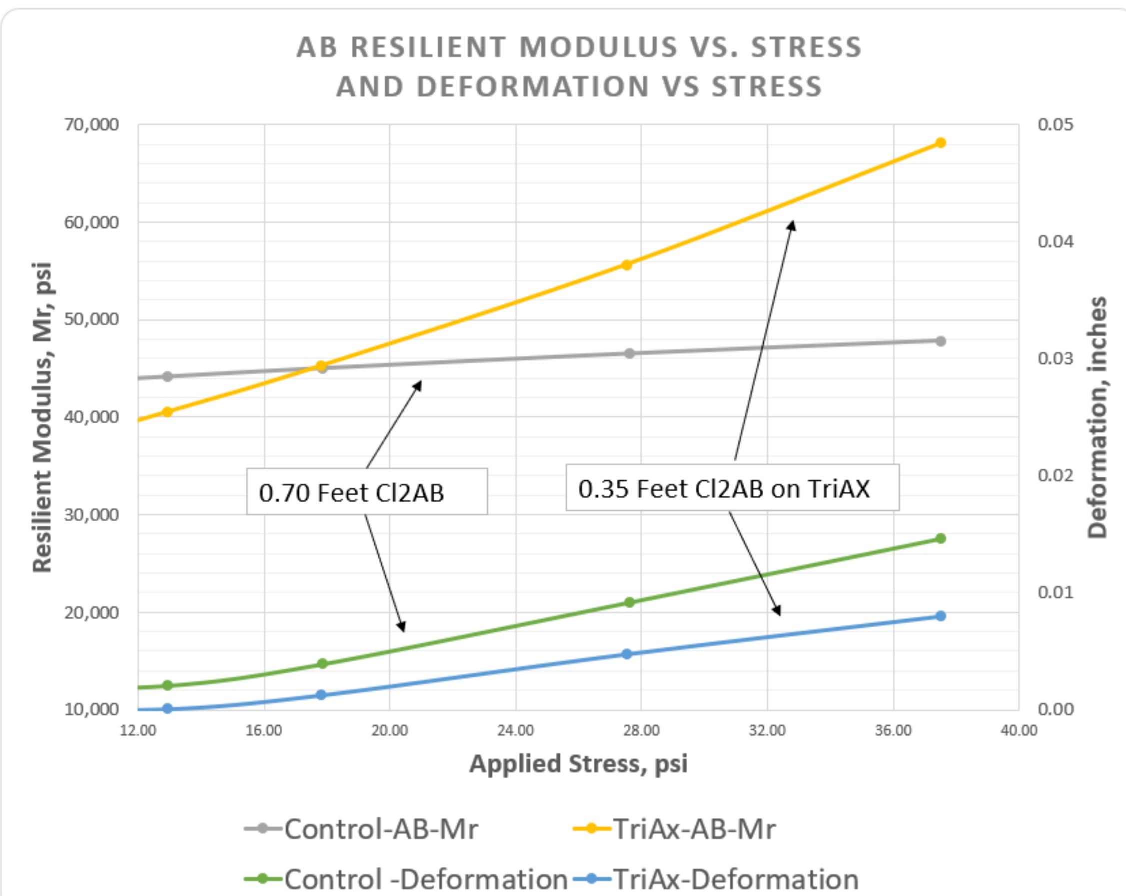
The purpose of the testing was to demonstrate that an MSL below a rigid pavement will reduce deformation better than a thicker aggregate base section creating more uniform support. Additionally, the MSL will create a more resilient foundation section and not lose strength over time.

Test Procedure:

Ingios® performed a series of Automated Plate Load Test s (APLTs) at the subject site. APLT is a system developed to perform fully automated static and repetitive/cyclic plate load tests, per AASHTO and ASTM test methods. To evaluate the stress dependent resilient modulus a 12-inch diameter plate was cycled 100 times at stress increments between about 5 pounds per square inch and 40 pounds per square inch.

Results / Key Findings:

The chart below shows the resilient modulus of the aggregate base versus the applied stress using the 12-inch diameter plate. The results demonstrate how the resilient modulus of the 0.35 feet Class 2 AB section underlain by TriAx geogrid is more resilient as the stress and loading increments increase as compared to the control section with 0.70 feet Class 2 AB. The 0.35 feet Class 2 AB on TriAx section increased the AB resilient modulus by 15% and reduced AB surface deformation by 40% compared to the 0.70 feet Class 2 AB section.



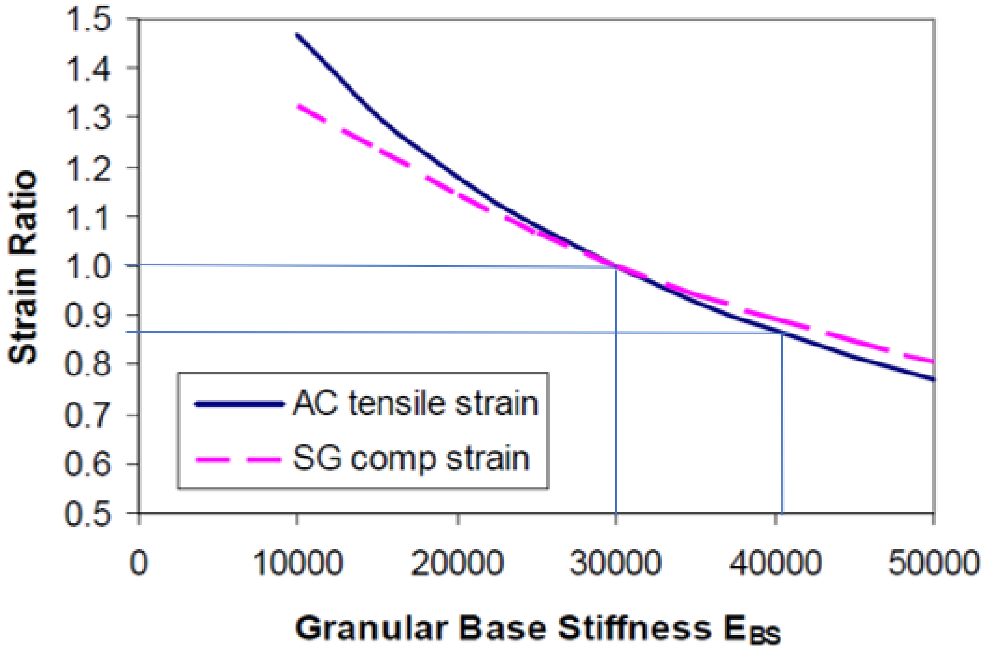
Why is this concept significant to the rigid pavement design?

The aggregate base within a rigid pavement section is a construction platform. Because the 0.35 feet AB on TriAx section increased the AB resilient modulus by 15% and reduced AB surface deformation by 40% compared to the 0.70 AB section, the 0.35 feet on TriAx layer creates a more uniform layer for the overlying wearing surfaces consisting of asphalt concrete or Portland cement concrete. During construction, the aggregate base layer will be trafficked by typical construction equipment. Without geogrid the aggregate base layer will become intermixed with the underlying subgrade. This intermixing results in non-uniform support characteristics and added maintenance during construction to maintain a surface that can be paved on. Additionally, the aggregate base will sometimes move and rut under the traffic loading.

The results demonstrate the intermixing at the aggregate/subgrade interface as well as the benefits of the TriAx geogrid. As the applied stress increases there is only a slight increase in the resilient modulus of the aggregate base for the control section. This is a result of aggregate/subgrade intermixing. Placing a geogrid on the subgrade creates an MSL. The geogrid within the MSL prevents intermixing of the aggregate base and subgrade material. As the applied stress increases the resilient modulus of the aggregate base increases significantly. This occurs because the geogrid interlocks with and confines the aggregate base preventing movement.

Why is this concept significant to the HMA below the rigid pavement?

The HMA below the rigid pavement is a construction platform that is a non-erodible surface. The addition of TriAx increases the Mr of the aggregate base as well as reduces the potential for deformation. The graph below demonstrates how the Strain Ratio of the Subgrade and AC tensile strain could potentially decrease by approximately 15% from a 25% increase in the aggregate base resilient modulus. This is why the planned 0.25 feet of HMA below the rigid pavement can be reduce to 0.20 feet of HMA.



*Strain Ratio benefit dependent on AC layer thickness, AC Resilient Modulus and Aggregate Base thickness.

Why does a TriAx geogrid improve performance?

A geogrid s performance is based on the materials ability to interlock with the aggregate base and confine the aggregate from moving laterally. Triangle apertures with high ribs create a hexagonal structure of aggregate creating stiffer structures. Initial lateral and vertical confinement during construction is clear as aggregate locks into geogrid and “soil-arching” begins. Performance is dependent on a geogrids rib shape, rib height, confinement ring geometry, aperture size, geogrid stiffness, and junction efficiency. Performance is dependent on the efficiency and stability of the confinement ring geometry, less potential for movement equals less surface deformation and better performing pavements.

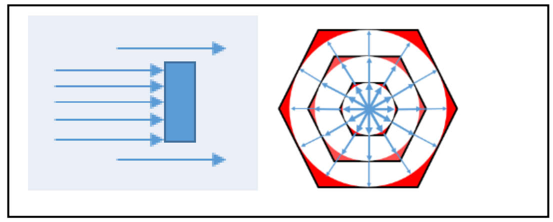


Figure 2 summarizes these benefits.

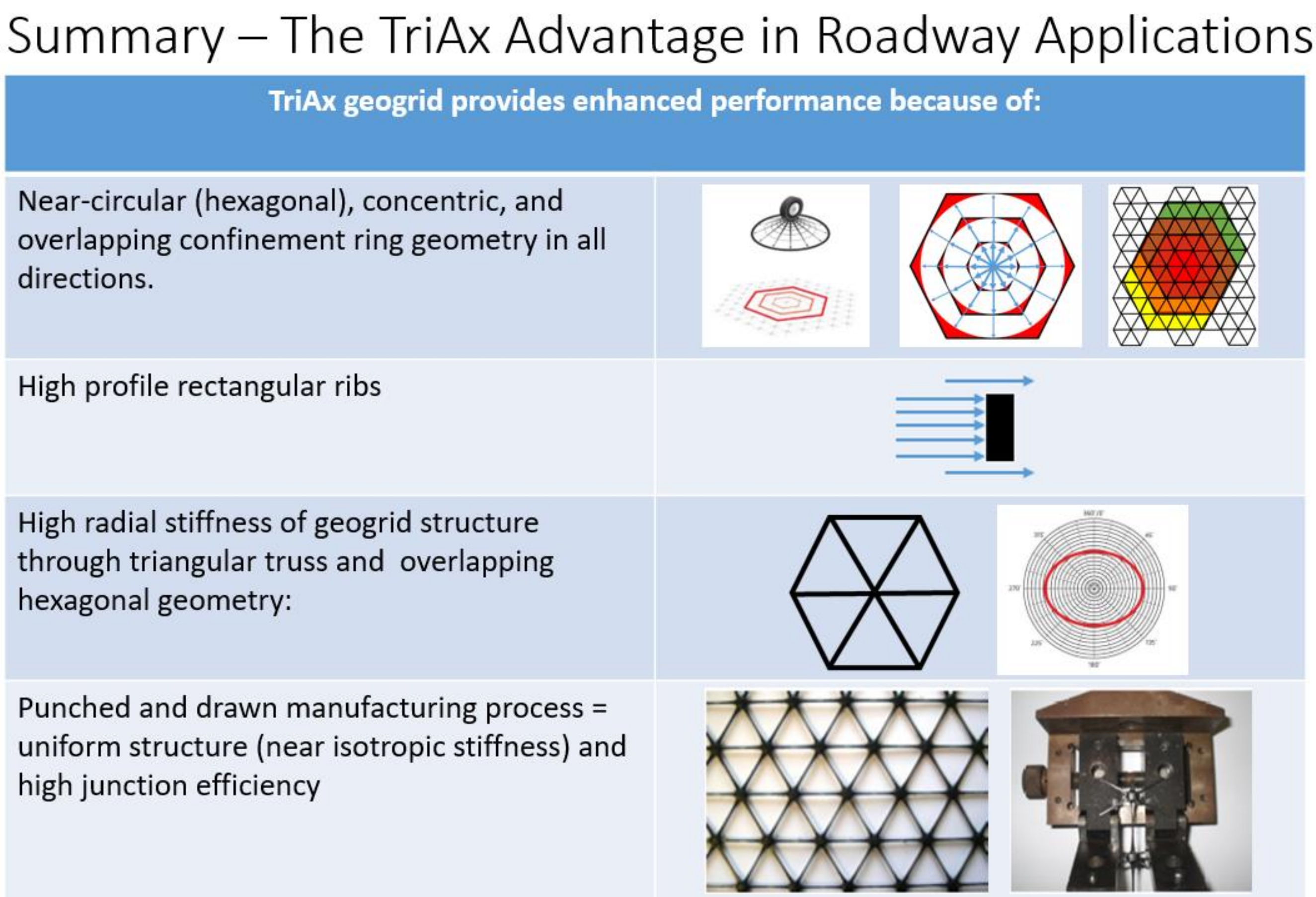


Figure 2

Conclusions

The testing here shows that 0.35 feet aggregate base placed on TriAx Geogrid improves performance compared to the control section of 0.70 feet aggregate base by:

- Reducing deformation as compared to thicker aggregate base sections
- Providing more uniform support characteristics improving pavement performance
- Improving the performance of the aggregate base through confinement and less subgrade soil contamination. This will maintain drainage properties of the aggregate base over time.

The results of the testing are consistent with the findings of the Accelerated Pavement Testing and over 150 APLT s performed on sections enhanced with TriAx geogrid. Results can vary depending on the quality of the aggregate, type of geogrid and subgrade strength.

References:

1. *"In Situ Performance Verification of Geogrid-Stabilized Aggregate Layer and Control Test Sections Using Automated Plate Load Testing, Interstate 5 Test Sections, Encinitas, California" prepared by David J. White, Ph.D., P. E. dated August 12, 2019.*
2. *AASHTO, MEPDG, 2015*
3. *Concrete Pavement Joints, Technical Advisory T 5040.30. Federal Highway Administration. Washington, D.C. http://www.fhwa.dot.gov/legsregs/directives/techadvs/t504030.htm.*
4. *Concrete Pavement Design Details & Construction Practices. Course No. 131060. CD-ROM course companion including technical digest, instructor's guide, participant's workbook and visual aids. Federal Highway Administration. Washington, D.C.*
5. *Concrete Types. Web page on the American Concrete Pavement Association's web site. http://www.pavement.com/PavTech/Tech/Fundamentals/fundtypes.html. Accessed 18 January 2002.*
6. *Load Transfer Design on the Pavement Interactive web site.* http://www.pavementinteractive.org/article/joint-design/
7. *"State of California, Department of Transportation, Concrete Pavement Guide" prepared by Division of Maintenance Pavement Program, 5900 Folsom Boulevard, MS-5, Sacramento, California 95819, dated January 2015.*
8. *"Full-Scale Evaluation of Geogrid Reinforced Thin Flexible Pavements"* prepared by U.S Army Engineer Research and Development Center, dated August 2, 2011.
9. *"Performance of Geogrid-Stabilized Flexible Pavements"* prepared by U.S Army Engineer Research and Development Center, dated July 2014.
10. *"Full-scale accelerated testing of multi-axial geogrid stabilized flexible pavements," Geotechnical and structures laboratory, Engineering research and development center, June 2017,report can be obtained at https://erdc-library.erdc.dren.mil/xmlui/handle/11681/22653*
11. *Christopher B.R., Schwartz C., and Boudreau R. (2006). Geotechnical Aspects of Pavements. REPORT NO. FHWA NHI-05-037. National Highway Institute Federal Highway Administration, 598 p.*

Research Summary Enhanced Pavement Design Using Tensar Stabilization Technology

Topic: Evaluation of using TriAx geogrids for Flexible Pavements
Caltrans Contract No.: 11-2T1714
Location: I-5, North Coast Corridor, San Diego, California

Application:

Flexible Pavements

Type:

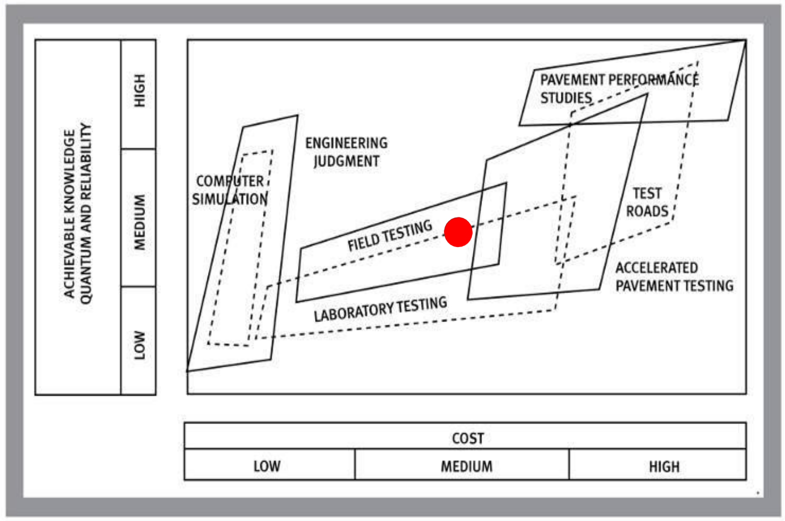
Field Structural Performance Study

Geogrid Products Tested:

- Tensar TriAx

Section Profiles:

- TriAx Enhanced Section: 0.15 Feet RHMA/ 0.45 Feet HMA/ 0.85 Feet AB CL2 stabilized with TriAx Geogrid/ Subgrade
- Control Section: 0.15 Feet RHMA/ 0.45 Feet HMA/ 2.25 Feet AB/ Subgrade
- Both sections constructed over a Subgrade R-Value = 10 with a Design TI = 12.0.



Importance of the Aggregate Base Layer

The aggregate base layer s initial resilient modulus and maintaining that modulus for the pavement s design life are essential for an enhanced pavements long term performance. The goal of a pavement agency is to construct pavements that provide service over an extended period with minimal repair beyond regular preservation activities. This goal includes supplying a comfortable ride for the public that minimizes traffic interruption because of construction lane closures. This will also maximize taxpayer s dollars and preserve the environment by selecting lifecycle cost effective and sustainable pavement solutions.

The aggregate base layers are critical components of a flexible pavement system. A poorly performing aggregate base layer below a flexible pavement can be detrimental to the pavement s performance. The purpose of unbound material layers (aggregate base and aggregate subbase) is to structurally improve the load supporting ability of the pavement section and help the surface structural layer (asphalt concrete) in carrying the traffic load. The increased ability to carry traffic loads reduces the potential for structural related distresses. Other benefits provided by the aggregate base include frost control and drainage.

Many structural distresses seen at the pavement s surface are the result of aggregate base failure. Typically, aggregate base failure consists of the loss of the in-situ material stiffness (Resilient Modulus

Degradation). Many factors contribute to the in-situ aggregate base resilient modulus degradation including:

- Fines from the subgrade contaminating the aggregate base
- Subgrade shear failure, and
- Moisture saturation

The resilient modulus, Mr is the measure of the applied cyclic stress to the recoverable elastic strain after many cycles of repeated loading. The resilient modulus is the most important unbound material property input in most pavement design procedures (Christopher et al. 2006). Mechanistic empirical procedures rely on the Mr of the layered materials to evaluate the stresses, strains, and deformations induced in the pavement layers by the applied traffic loads.

The resilient modulus of geomaterials is stress-dependent:

- Increasing with increasing confining stress for coarse grained materials (such as the aggregate base and subbase), and
- Decreasing with increasing shear stress for fine-grained soils.

The aggregate base layer stiffness (strength) can control the development of structural distresses in flexible pavements. The influence of an insufficient base stiffness on the pavement overall performance accelerates the initiation and progression of several distresses including fatigue cracking, rutting, corrugations, bumps, depressions, potholes, and roughness (Christopher et al. 2006).

Permanent deformation (rutting), depressions and roughness are examples of distress that create poor ride quality. Base stiffness affects fatigue cracking and rutting of flexible pavements. The lateral tensile strain at the bottom of the asphalt concrete layer affects the fatigue cracking along the surface. The vertical compressive strain at the top of the subgrade can affect the development of rutting that occurs along the pavement surface. The importance of the aggregate base layer in flexible pavement is assessed by the aggregate base layer stiffness (resilient modulus) that affects the strains within the asphalt concrete.

Figure 1 shows the effect of the granular base stiffness (EBS) on the AC tensile strain and subgrade vertical compressive strain (that control cracking and rutting, respectively). The strain ratio in Figure 1 shows the strain that would result for a given aggregate base resilient modulus divided by the strain that develops for a base layer with a 30,000-psi resilient modulus. The simulations are based on (Multi-Layer Elastic Theory) MLET with a three-layer system consisting of

- 6 inches of AC (500,000 psi modulus), over
- 18 inches of AB (30,000 modulus), over
- Subgrade (3000 psi modulus)

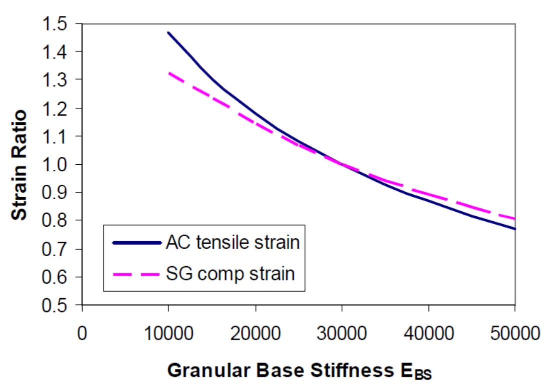
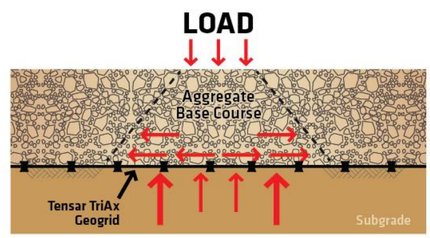


Figure 1. Effect of granular base stiffness on strains (Christopher et al. 2006).

The system was trafficked with a 10-kip load and 100 psi tire pressure. The results show that aggregate base stiffness over a wide range of values affects both the tensile strain that controls fatigue cracking in asphalt concrete and compressive strain that controls rutting. The tensile strains can increase by 50% and the compressive strain by 30% when resilient modulus of the base drops from 30,000 psi to 10,000 psi. Similarly, the strains decrease by ~20% when the base modulus increases from 30,000 psi to 50,000 psi. This has a significant effect on fatigue cracking and rutting.

Benefits of the Geogrid Mechanically Stabilized Layer (MSL)



Incorporating geogrids into the roadway section is an effective method of creating a stiffer and more uniform foundation that will maintain integrity over time improving the Load Transfer. The geogrid enhancement results in less deformation during construction, and during the pavement s life. The geogrid achieves this by interlocking with and confining the aggregate base. The confinement reduces the potential for contamination of the aggregate base with the subgrade soil. The geogrid and aggregate base together create a mechanically stabilized layer (MSL). The MSL is a resilient layer that minimizes the potential for differential movements of the concrete surface that initiate faulting and corner breaks.

Purpose/Objective of Field Testing:

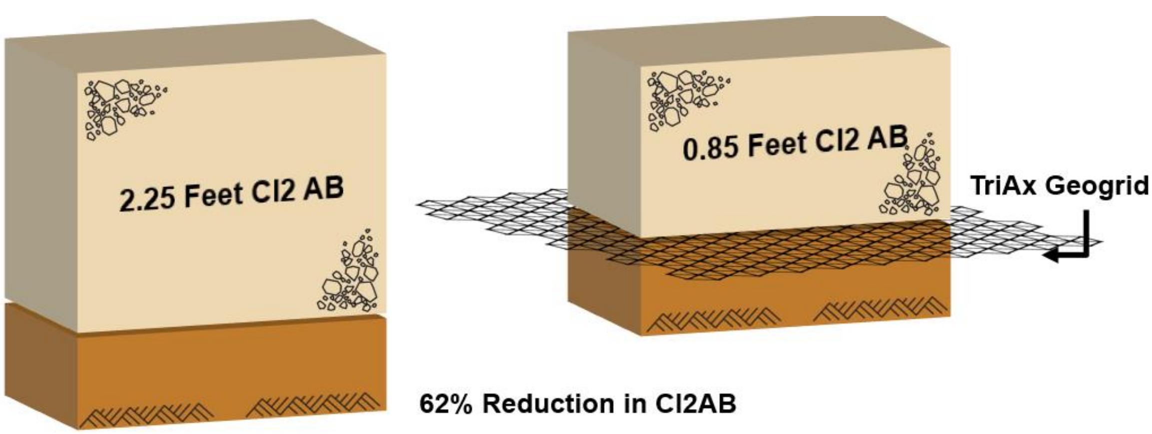
The purpose of the testing was to show that an MSL below a flexible pavement will reduce deformation better than a thicker aggregate base section creating more uniform support and reduce the stress on the underlying subgrade. Additionally, the MSL will create a more resilient foundation section and not lose strength over time.

Test Procedure:

Ingios® performed a series of Automated Plate Load Test s (APLTs) at the subject site. APLT is a system developed to perform fully automated static and repetitive/cyclic plate load tests, per AASHTO and ASTM test methods. To evaluate the stress dependent resilient modulus a 12-inch diameter plate cycles 100 times at each stress level at increments between about 5 pounds per square inch and 40 pounds per square inch.

Test Location and Section Description

The test was located along Interstate 5 in Encinitas, California. A contractor constructed the test section within the limits of project area. Figure 2 presents the test sections:



Results / Key Findings:

Figure 3 shows the composite resilient modulus of the aggregate base versus the applied stress using the 12-inch diameter plate. The results show how the composite resilient moduli of the 0.85 feet of Cl2AB underlain by TriAx is essentially equivalent to the 2.25 feet of Class 2 AB section. However, the TriAx section performed better by decreasing the deformation by about 20%.

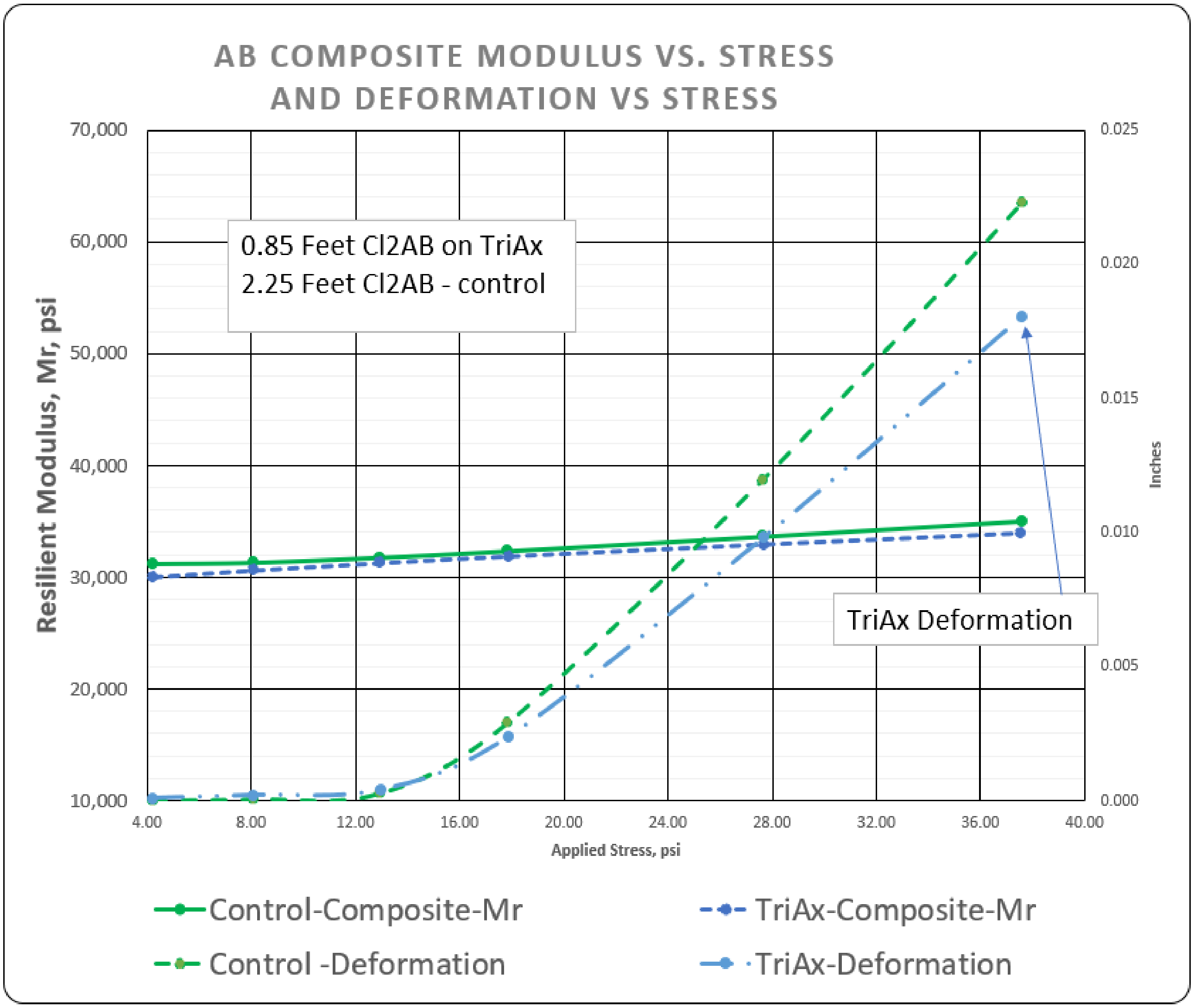


Figure 3

Why is this concept significant to flexible pavement design?

The aggregate base within a flexible pavement section is the foundation that supports the flexible wearing surface. As discussed above a poorly performing aggregate base layer below a flexible pavement can be detrimental to the pavement s performance. The purpose of unbound material layers (aggregate base and aggregate subbase) is to structurally improve the load supporting ability of the pavement section and help the surface structural layer (asphalt concrete) in carrying the traffic load. The increased ability to carry traffic loads reduces the potential for structural related distresses. Tensar representatives performed a MLET to evaluate the structural mechanics of the TriAx Section compared to the Control Section using WinJulea®. The model used the APLT results with a three-layer system consisting of:

- 0.60 Feet of HMA (300,000 psi modulus), over
- 0.85 Feet of Cl2 AB/TriAx (56,000 psi modulus), and a 2.25 Feet of Cl2 AB (46,000 psi modulus) over
- Subgrade (3500 psi modulus)

The analysis assumed a 100 pound per square inch (PSI) tire pressure applied on the surface of the HMA layer to evaluate the structural mechanics of the TriAx Section compared to the Control Section. Figure 4 presents the findings. The stresses at the bottom of the HMA layer are nearly equivalent but drops significantly within the TriAx Enhanced 0.85-foot AB layer. Comparing the stress at the subgrade elevation of the TriAx section to the control section at the same depth still within the AB section, the stress in the TriAx section is 1/3 of that in the control section. This reduction in stress creates more uniform support characteristics and reduces the potential for non-uniformities in the subgrade soil to cause pavement distress.

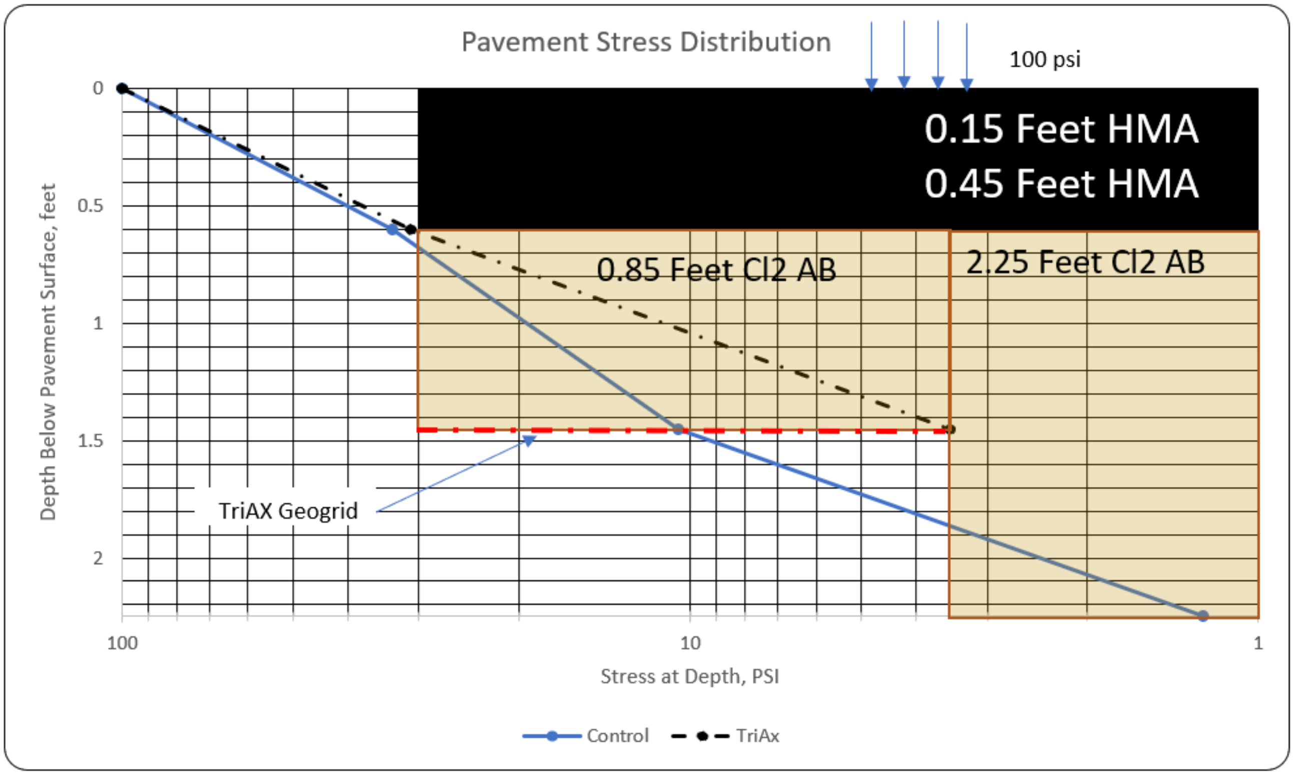


Figure 4 Mechanistic Analysis Results

<u>How does this apply to the Caltrans Design Method?</u>

Based on the mechanistic analyses above approximately 1.3 feet of Cl2 AB without TriAx would achieve the same subgrade pressure of about 3½ psi as 0.85 feet of CL2 AB with TriAx. Using the Gravel Equivalency method, the composite TriAx/Cl2AB gravel factor would be about 2.85 to achieve the required Gravel Equivalent for the design Traffic Index of 12 and R-Value of 10. This is significantly higher than the 1.1 gravel factor prescribed. This equates to about a 62% reduction in aggregate base using the typical Caltrans Gravel Equivalency Methods. Figure 5 below shows an example of the calculations to evaluate and compare the sections with the Gravel Equivalency Method.

Design Parameters	
Traffic Index	12.0
Subgrade R-value	10

Design Calculations - Non-Stabilized Control Section

Pavement Layer	Gravel Factor	Required Gravel Equivalent (feet)	Layer GE (feet)	Actual GE (feet)	Thickness (feet)	**Non-Stabilized Pavement Profile**
HMA (Feet)	1.70	3.46	1.02	3.50	0.60	**0.60 Feet HMA**
Cl 2 AB (Feet)	1.10		2.48		2.25	**2.25 Feet Cl2 AB**
			Total Thickness:		2.85	**Subgrade**

Design Calculations - TriAx Stabilized Section

Pavement Layer	Gravel Factor	Required Gravel Equivalent (feet)	Layer GE (feet)	Actual GE (feet)	Thickness (feet)	**TriAx Pavement Profile**
HMA (Feet)	1.70	3.46	1.02	3.45	0.60	**0.60 Feet HMA**
Cl 2 AB (Feet)	2.85		2.42		0.85	**0.85 Feet Cl2 AB**
			Total Thickness:		1.45	**Subgrade**

FIGURE 5

<u>Why does a TriAx geogrid improve performance?</u>

A geogrid s performance is based on the materials ability to interlock with the aggregate base and confine the aggregate from moving laterally. Triangle apertures with high ribs create a hexagonal structure of aggregate creating stiffer structures. Initial lateral and vertical confinement during construction is clear as aggregate locks into geogrid and "soil-arching" begins. Performance is dependent on a geogrids rib shape, rib height, confinement ring geometry, aperture size, geogrid stiffness, and junction efficiency. Performance is dependent on the efficiency and stability of the confinement ring geometry, less potential for movement equals less surface deformation and better performing pavements.

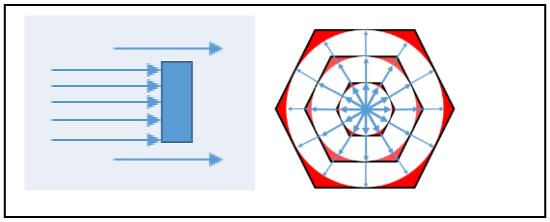


Figure 2 summarizes these benefits.

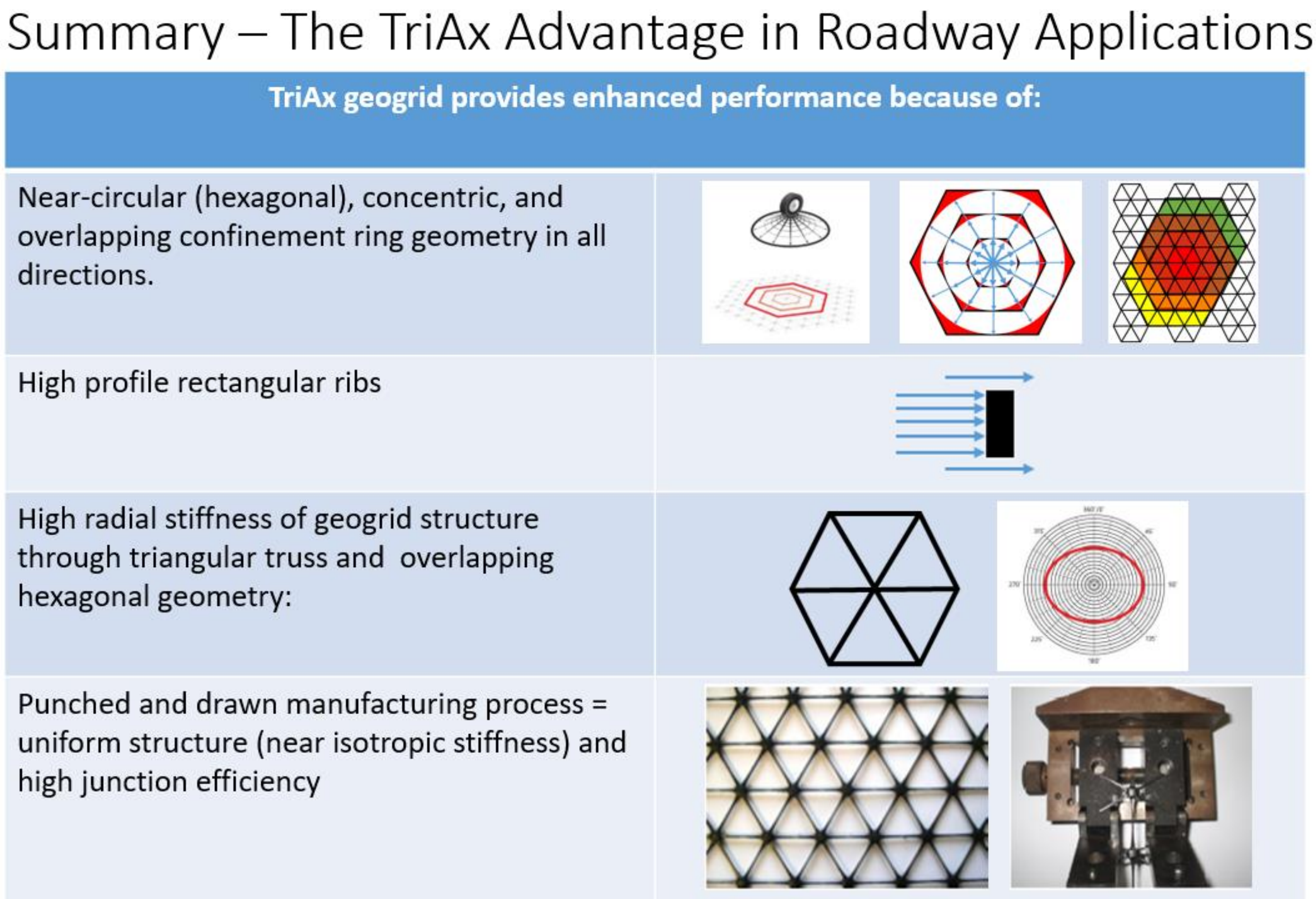


Figure 2

Conclusions

The testing here shows how TriAx geogrids improve the performance of the aggregate base and thereby creating better performing pavement sections. Additionally, it demonstrates:

- The TriAx geogrid stabilized AB CL2 of 0.85 Feet had less surface deformation and nearly equivalent composite resilient moduli values compared to the AB CL2 of 2.25 Feet. This resulted in a 62% AB CL2 reduction.
- HMA thickness reduction based on the reduced deformation of the aggregate base experienced with TriAx is reasonable.

The results of the testing are consistent with the findings of the Accelerated Pavement Testing and over 200 APLT s performed on sections enhanced with TriAx geogrid. Results can vary depending on the quality of the aggregate, type of geogrid and subgrade strength.

References:

1. *"In Situ Performance Verification of Geogrid-Stabilized Aggregate Layer and Control Test Sections Using Automated Plate Load Testing, Interstate 5 Test Sections, Encinitas, California" prepared by David J. White, Ph.D., P. E. dated August 12, 2019.*
2. *AASHTO, MEPDG, 2015*
3. *Concrete Pavement Joints, Technical Advisory T 5040.30. Federal Highway Administration. Washington, D.C. http://www.fhwa.dot.gov/legsregs/directives/techadvs/t504030.htm.*
4. *Concrete Pavement Design Details & Construction Practices. Course No. 131060. CD-ROM course companion including technical digest, instructor's guide, participant's workbook, and visual aids. Federal Highway Administration. Washington, D.C.*
5. *Concrete Types. Web page on the American Concrete Pavement Association's web site. http://www.pavement.com/PavTech/Tech/Fundamentals/fundtypes.html. Accessed 18 January 2002.*
6. *Load Transfer Design on the Pavement Interactive web site.* http://www.pavementinteractive.org/article/joint-design/
7. *"State of California, Department of Transportation, Concrete Pavement Guide" prepared by Division of Maintenance Pavement Program, 5900 Folsom Boulevard, MS-5, Sacramento, California 95819, dated January 2015.*
8. *"Full-Scale Evaluation of Geogrid Reinforced Thin Flexible Pavements"* prepared by U.S Army Engineer Research and Development Center, dated August 2, 2011.
9. *"Performance of Geogrid-Stabilized Flexible Pavements"* prepared by U.S Army Engineer Research and Development Center, dated July 2014.
10. *"Full-scale accelerated testing of multi-axial geogrid stabilized flexible pavements," Geotechnical and structures laboratory, Engineering research and development center, June 2017,report can be obtained at https://erdc-library.erdc.dren.mil/xmlui/handle/11681/22653*
11. *Christopher B.R., Schwartz C., and Boudreau R. (2006). Geotechnical Aspects of Pavements. REPORT NO. FHWA NHI-05-037. National Highway Institute Federal Highway Administration, 598 p.*

Appendix III: Ingios Consultants report on the Automated Plate Load Tests.

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NORTHFIELD, MN 55057

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August 12, 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 Base Layer and Control Test Sections Using Automated Plate Load Testing
I-5, North County Coastal, Encinitas, CA

Dear Garrett,

At the request of Tensar Corporation personnel, Ingios Geotechnics, Inc. conducted Automated Plate Load Tests (APLTs) on four test sections on Interstate Highway 5 (I-5) near Encinitas, CA. Testing was performed August 1, 2019. In situ testing included cyclic APLTs on the aggregate base course (ABC) 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. The location and pavement foundation cross-section details of the four test sections are as follows:

- Section 1 located south of Sta. 2214+70. The section is comprised of nominal 0.35 ft thick TX5 geogrid-stabilized ABC over subgrade.
- Section 2 located between Sta. 2214+70 and Sta. 2216+20. The section is comprised of nominal 0.70 ft thick ABC over subgrade (control).
- Section 3 located between Sta. 2217+70 and Sta. 2219+20. The section is comprised of nominal 0.85 ft thick TX5 geogrid-stabilized ABC over subgrade.
- Section 4 located north of Sta. 2219+20. The section is comprised of nominal 2.25 ft thick ABC over subgrade (control).

The TX5 geogrid was a multi-axial geogrid with hexagonal structure and triangular apertures. The ABC layer material is CalTrans Class 6 aggregate base course material with recycled aggregate.

Five cyclic APLTs were conducted in each of 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 ($M_{r\text{-comp}}$) and stabilized aggregate base ($M_{r\text{-Base}}$) and subgrade layers ($M_{r\text{-Subgrade}}$). 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 $M_{r\text{-Base}}$ and $M_{r\text{-Sugrade}}$ 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. Layered analysis was not performed for test results obtained from section 4 (control) because of the thickness of the top layer (2.25 ft) is greater than the estimated measurement influence depth (1.5 to 2 x's plate diameter) of the 12 in. diameter loading plate. Therefore, $M_{r\text{-comp}}$ equals $M_{r\text{-Base}}$ for the section 4 test points.

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, v = 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.

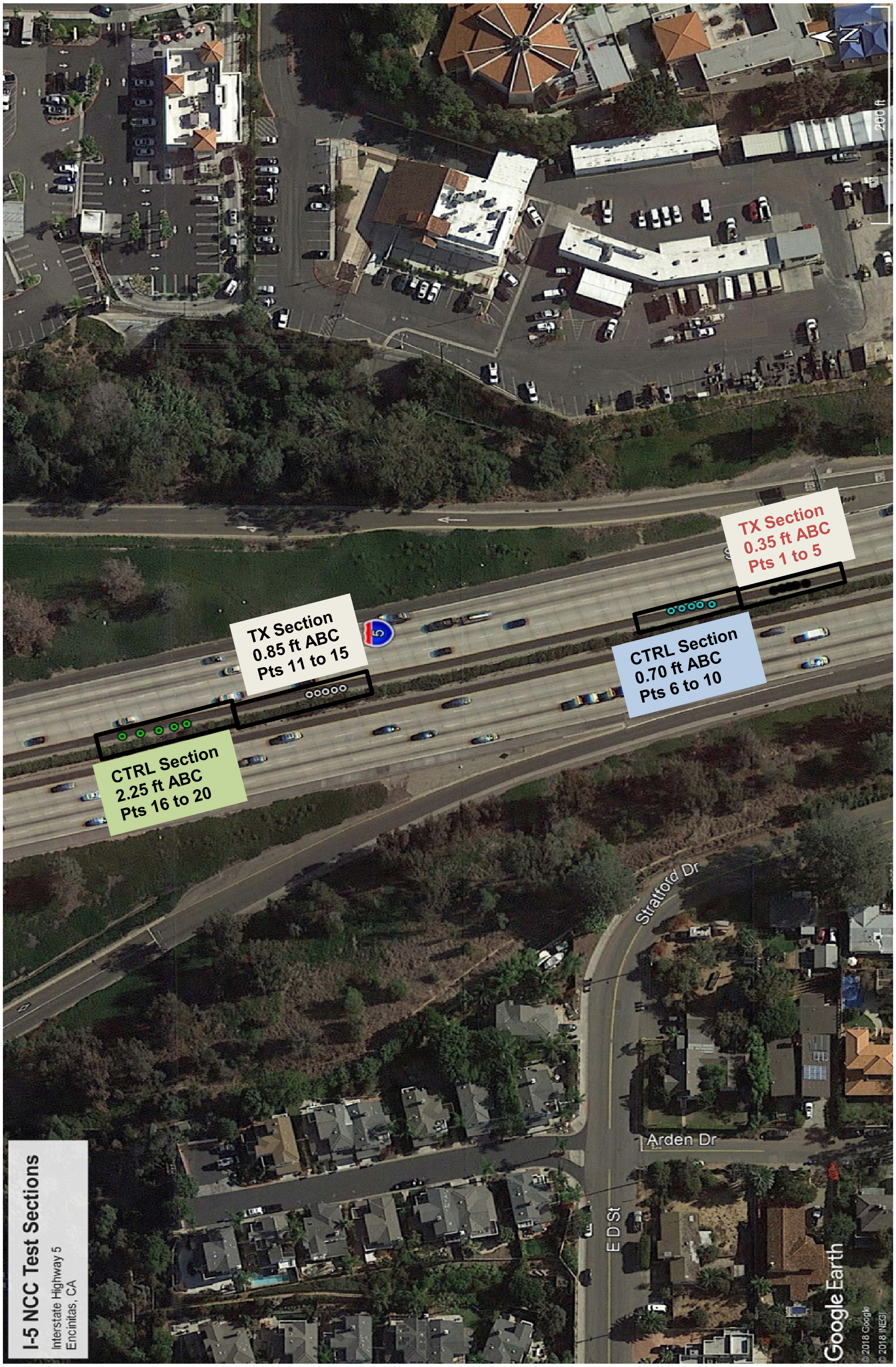
Sincerely,

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
Composite Resilient Modulus Test Results
Layered Resilient Modulus Test Results
DCP Test Results

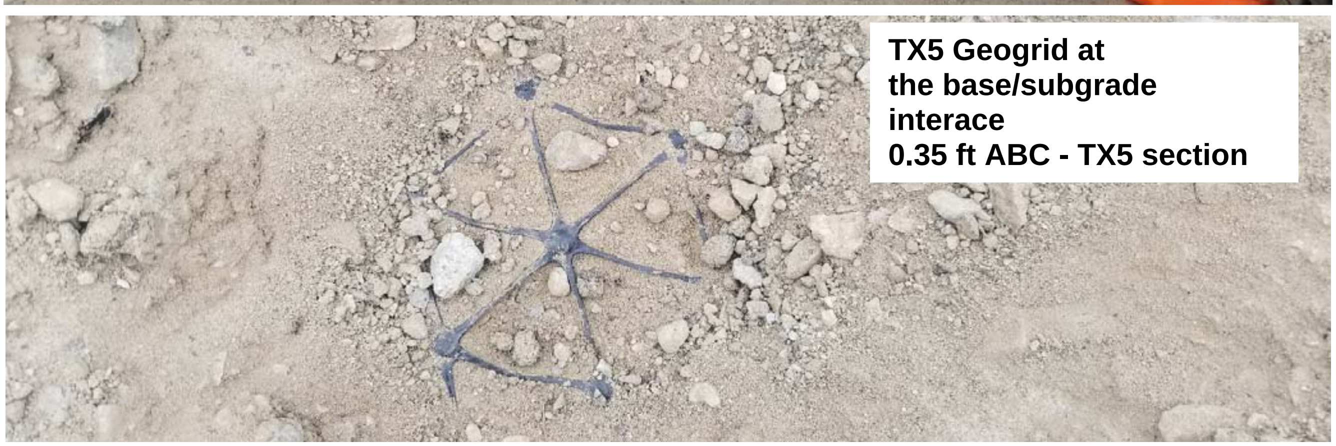
Project Location and Test Locations



Test Locations

Project Name:	Interstate 5: North County Coastal Test Sections
Project ID:	TIC-00050
Location:	Encinitas, California

Site Conditions and Pictures



TX5 Geogrid at the base/subgrade interace
0.35 ft ABC - TX5 section

Pictures	
Project Name:	Interstate 5: North County Coastal Test Sections
Project ID:	TIC-00050
Location:	Encinitas, California

Site Conditions and Pictures

ABC surace
0.85 ft ABC - TX5 section

Test point locations on
ABC surace
0.85 ft ABC - TX5 section

TX5 Geogrid at
the base/subgrade
interace
0.85 ft ABC - TX5 section

Pictures	
Project Name:	Interstate 5: North County Coastal Test Sections
Project ID:	TIC-00050
Location:	Encinitas, California

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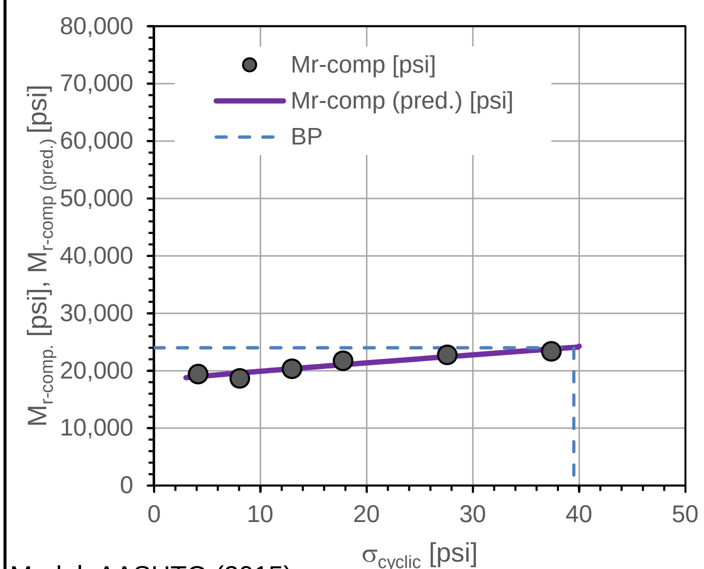
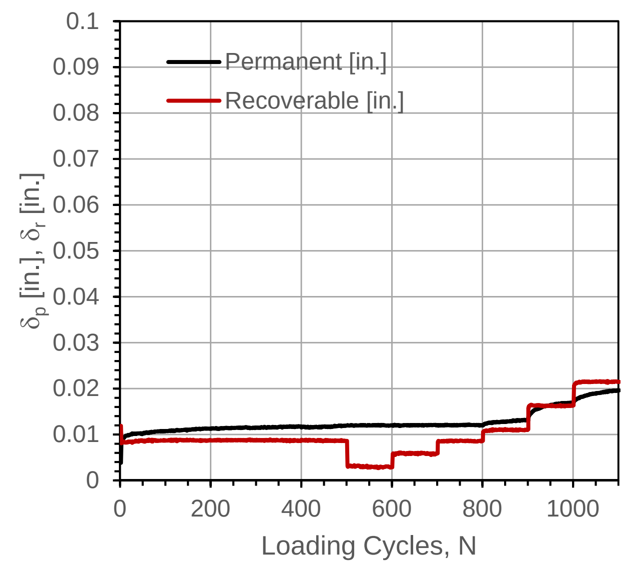
Automated Plate Load Test [APLT]

Test:	In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent (5, 10, 15, 20, 30, 40)				
Date:	8/1/2019	Time:	5:36:15 AM	Test ID	**I5_NCC_TX5_pt1**
Tested By	PV, LC, HG	Location:	I-5_NCC Test Sections	Sta.	NA
Latitude, N:	33.045910	Longitude,W:	117.286450	Elev. (ft):	NA
Comments:	Nominal 0.35 ft thick recycled aggregate base course layer over subgrade, with TX5 multiaxial geogrid at the base and subgrade interface. Measured base layer thickness = 4 in.				

Step	N	σ_{cyclic} [psi]	$M_{r\text{-}comp}$ [psi]	$M_{r\text{-}comp\ (pred.)}$ [psi]	δ_p [in.]	$\Delta\delta_p$ [in.]	d = $\Delta\log(\delta_p)/\Delta\log(N)$	Near-linear Elastic
Conditioning	500	12.98	---	---	0.0119	---	0.067	---
1	100	4.14	19,427	18,993	0.0120	0.0001	0.043	Y
2	100	8.07	18,660	19,618	0.0121	0.0002	0.078	Y
3	100	12.98	20,345	20,355	0.0120	0.0001	0.070	Y
4	100	17.79	21,725	21,054	0.0131	0.0012	0.403	Y
5	100	27.60	22,757	22,441	0.0169	0.0050	0.423	Y
6	100	37.38	23,374	23,784	0.0196	0.0077	0.521	Y





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	1,254.9	5.39E-07
k^*_2	0.005	9.49E-01
k^*_3	0.727	3.03E-01
Adj. R^2	0.871	
Std. Error [psi]	647	

$M_{r\text{-}comp\ (pred.)\text{-}BP}$ [psi]	24,002
$\sigma_{cyclic\text{-}BP}$ [psi]	39.5

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

Project Name:	Interstate 5: North County Coastal Test Sections
Project ID:	TIC-00050
Location:	Encinitas, California

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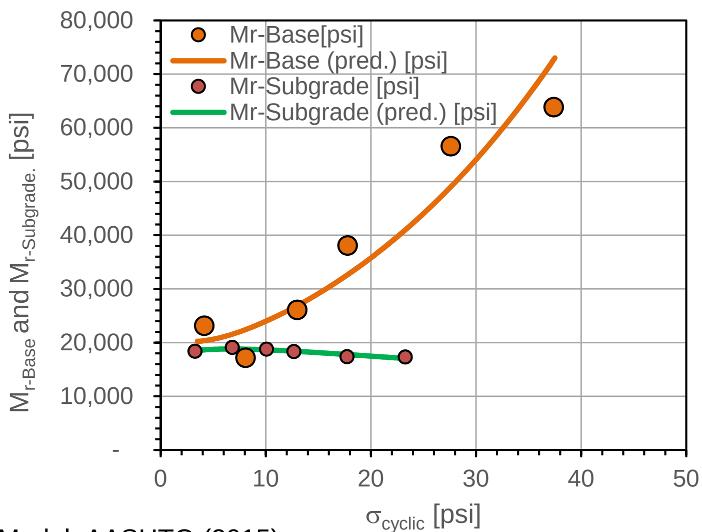
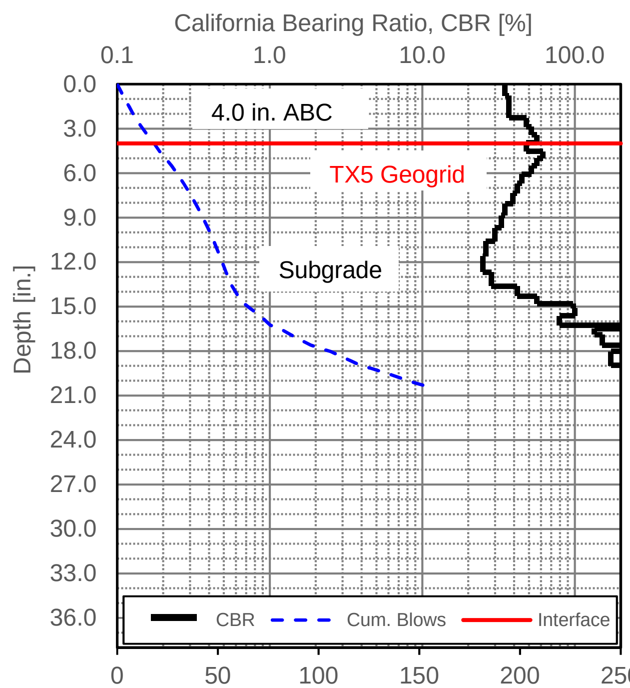
Automated Plate Load Test [APLT]

Test:	In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent (5, 10, 15, 20, 30, 40)				
Date:	8/1/2019	Time:	5:36:15 AM	Test ID	**I5_NCC_TX5_pt1**
Tested By	PV, LC, HG	Location:	I-5_NCC Test Sections	Sta.	NA
Latitude, N:	33.045910	Longitude, W:	117.286450	Elev. (ft):	NA
Comments:	Nominal 0.35 ft thick recycled aggregate base course layer over subgrade, with TX5 multiaxial geogrid at the base and subgrade interface. Measured base layer thickness = 4 in.				

Step	N	$\sigma_{cyclic\_surface}$ [psi]	$M_{r\text{-}Base}$[psi]	$M_{r\text{-}Base\ (pred.)}$ [psi]	$\sigma_{cyclic\_Int.}$ [psi]	$M_{r\text{-}Subgrade}$ [psi]	$M_{r\text{-}Subgrade\ (pred.)}$ [psi]	Modulus Ratio
Conditioning	500	12.98	---	---	---	---	---	---
1	100	4.14	23,124	20,346	3.28	18,361	18,487	1.26
2	100	8.07	17,171	22,415	6.83	19,091	18,807	0.90
3	100	12.98	26,081	26,859	10.09	18,745	18,645	1.39
4	100	17.79	38,076	32,643	12.69	18,300	18,395	2.08
5	100	27.60	56,563	49,005	17.73	17,364	17,780	3.26
6	100	37.38	63,846	72,676	23.29	17,302	17,038	3.69

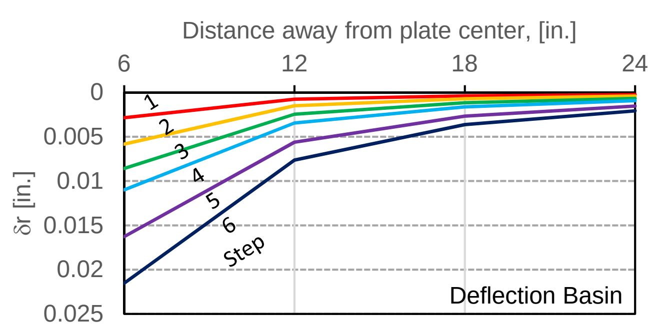




Model: AASHTO (2015)

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

Parameter	Value	P-Value
$k^*_{1\ (Base)}$	986.9	1.14E-04
$k^*_{2\ (Base)}$	-0.201	6.91E-01
$k^*_{3\ (Base)}$	5.859	1.81E-01
Adj. R^2	0.877	
Std. Error [psi]	7075	
$k^*_{1\ (Subgrade)}$	1431.4	5.56E-07
$k^*_{2\ (Subgrade)}$	0.105	1.38E-01
$k^*_{3\ (Subgrade)}$	-1.127	6.36E-02
Adj. R^2	0.830	
Std. Error [psi]	274	



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

Project Name: Interstate 5: North County Coastal Test Sections
Project ID: TIC-00050
Location: Encinitas, California

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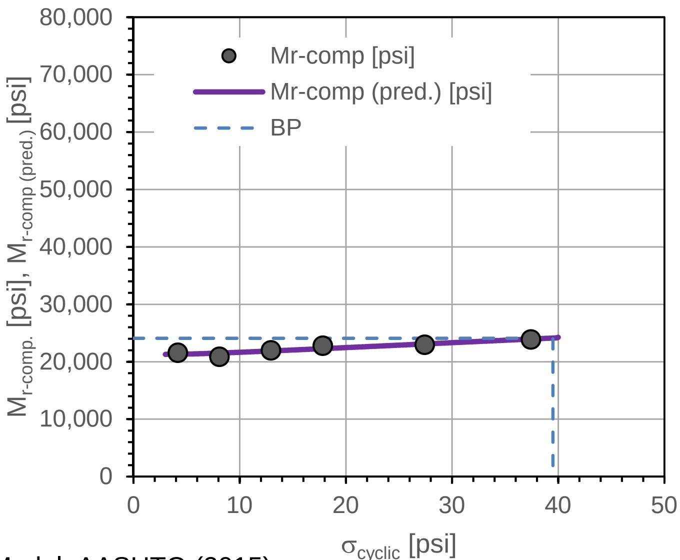
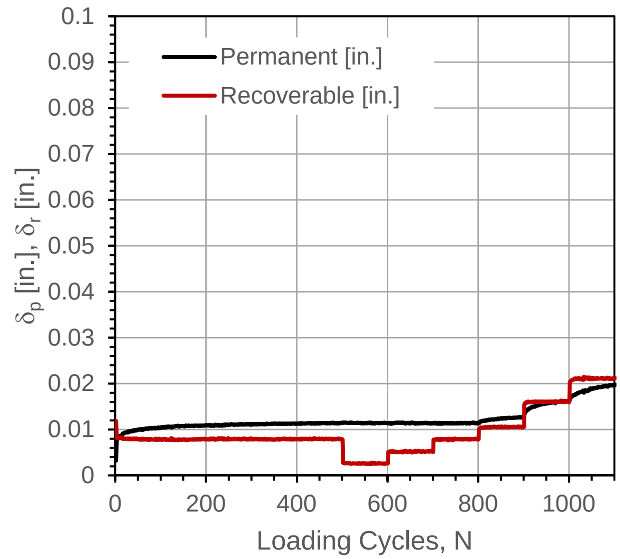
Automated Plate Load Test [APLT]

Test:	In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent (5, 10, 15, 20, 30, 40)				
Date:	8/1/2019	Time:	6:09:29 AM	Test ID	**I5_NCC_TX5_pt2**
Tested By	PV, LC, HG	Location:	I-5_NCC Test Sections	Sta.	NA
Latitude,N:	33.045921	Longitude,W:	117.286450	Elev. (ft):	NA
Comments:	Nominal 0.35 ft thick recycled aggregate base course layer over subgrade, with TX5 multiaxial georid at the base and subgrade interface. Measured base layer thickness = 4.2 in.				

Step	N	σ_{cyclic} [psi]	$M_{r\text{-}comp}$ [psi]	$M_{r\text{-}comp\ (pred.)}$ [psi]	δ_p [in.]	$\Delta\delta_p$ [in.]	d =$\Delta\log(\delta_p)$/ $\Delta\log(N)$	Near-linear Elastic
Conditioning	500	12.95	---	---	0.0114	---	0.078	---
1	100	4.18	21,572	21,307	0.0114	0.0000	-0.119	Y
2	100	8.10	20,866	21,518	0.0114	0.0000	-0.006	Y
3	100	12.95	21,992	21,881	0.0113	-0.0001	0.036	Y
4	100	17.83	22,788	22,282	0.0127	0.0013	0.441	Y
5	100	27.43	22,955	23,101	0.0163	0.0049	0.417	Y
6	100	37.43	23,889	23,955	0.0197	0.0083	0.517	Y





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	1,407.6	1.16E-07
k^*_2	-0.016	7.65E-01
k^*_3	0.520	2.44E-01
Adj. R^2	0.832	
Std. Error [psi]	416	

$M_{r\text{-}comp\ (pred.)\text{-}BP}$ [psi]	24,089
$\sigma_{cyclic\text{-}BP}$ [psi]	39.5

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

Project Name:	Interstate 5: North County Coastal Test Sections
Project ID:	TIC-00050
Location:	Encinitas, California

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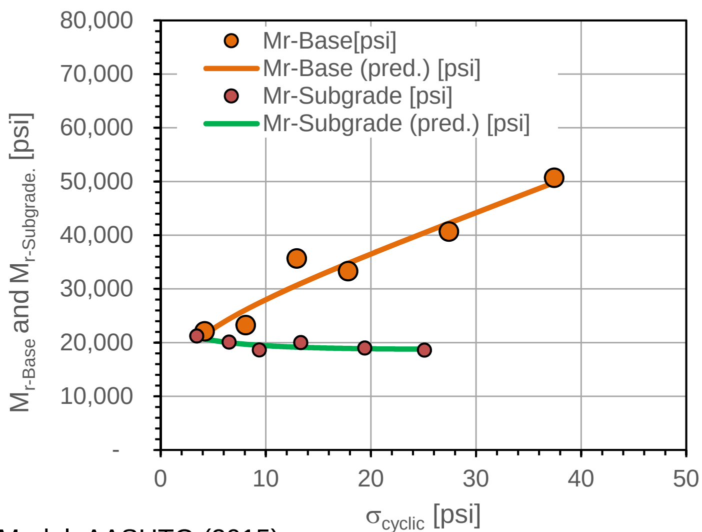
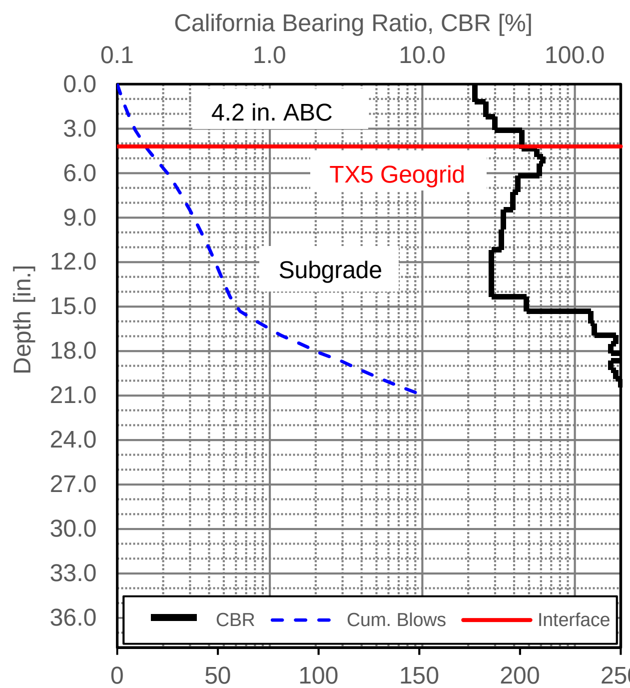
Automated Plate Load Test [APLT]

Test:	In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent (5, 10, 15, 20, 30, 40)				
Date:	8/1/2019	Time:	6:09:29 AM	Test ID	**I5_NCC_TX5_pt2**
Tested By	PV, LC, HG	Location:	I-5_NCC Test Sections	Sta.	NA
Latitude, N:	33.045921	Longitude, W:	117.286450	Elev. (ft):	NA
Comments:	Nominal 0.35 ft thick recycled aggregate base course layer over subgrade, with TX5 multiaxial georid				

at the base and subgrade interface. Measured base layer thickness = 4.2 in.

Step	N	$\sigma_{cyclic\_surface}$ [psi]	$M_{r\text{-}Base}$[psi]	$M_{r\text{-}Base\ (pred.)}$ [psi]	$\sigma_{cyclic\_Int.}$ [psi]	$M_{r\text{-}Subgrade}$ [psi]	$M_{r\text{-}Subgrade\ (pred.)}$ [psi]	Modulus Ratio
Conditioning	500	12.95	---	---	---	---	---	---
1	100	4.18	22,095	21,489	3.44	21,185	21,050	1.04
2	100	8.10	23,255	26,112	6.52	20,063	19,995	1.16
3	100	12.95	35,658	30,669	9.41	18,609	19,500	1.92
4	100	17.83	33,294	34,756	13.34	19,980	19,127	1.67
5	100	27.43	40,681	42,241	19.43	18,955	18,866	2.15
6	100	37.43	50,685	49,784	25.10	18,574	18,786	2.73

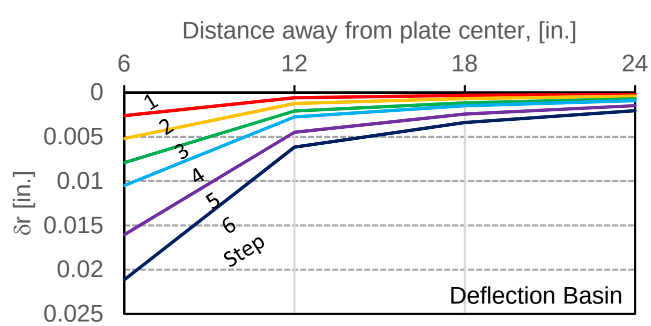




Model: AASHTO (2015)

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

Parameter	Value	P-Value
$k^*_{1\ (Base)}$	1521.2	1.34E-05
$k^*_{2\ (Base)}$	0.224	4.21E-01
$k^*_{3\ (Base)}$	1.189	5.49E-01
Adj. R^2	0.917	
Std. Error [psi]	3015	
$k^*_{1\ (Subgrade)}$	1305.4	3.65E-06
$k^*_{2\ (Subgrade)}$	-0.114	3.51E-01
$k^*_{3\ (Subgrade)}$	0.389	6.30E-01
Adj. R^2	0.624	
Std. Error [psi]	526	



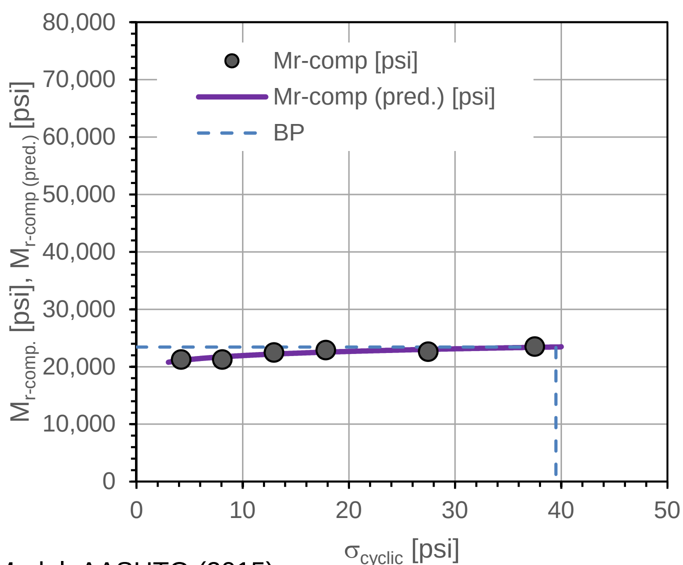
In-situ Resilient Modulus [Mr]: Cyclic Loading, Layered Analysis, Stress-Dependent

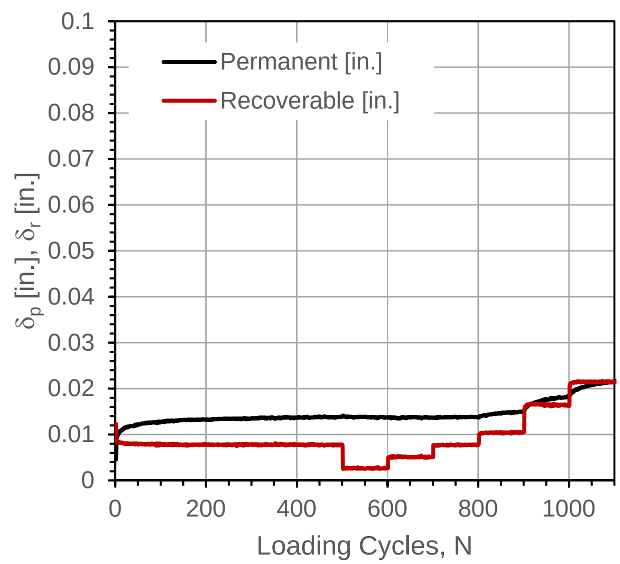
Project Name: Interstate 5: North County Coastal Test Sections
Project ID: TIC-00050
Location: Encinitas, California

Automated Plate Load Test [APLT]

Test:	In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent (5, 10, 15, 20, 30, 40)				
Date:	8/1/2019	Time:	6:39:49 AM	Test ID	**I5_NCC_TX5_pt3**
Tested By	PV, LC, HG	Location:	I-5_NCC Test Sections	Sta.	NA
Latitude,N:	33.045933	Longitude,W:	117.286460	Elev. (ft):	NA
Comments:	Nominal 0.35 ft thick recycled aggregate base course layer over subgrade, with TX5 multiaxial georid at the base and subgrade interface.				

Step	N	σ_{cyclic} [psi]	$M_{r\text{-}comp}$ [psi]	$M_{r\text{-}comp\ (pred.)}$ [psi]	δ_p [in.]	$\Delta\delta_p$ [in.]	d =$\Delta\log(\delta_p)/\Delta\log(N)$	Near-linear Elastic
Conditioning	500	12.95	---	---	0.0138	---	0.071	---
1	100	4.20	21,245	21,098	0.0137	-0.0001	-0.159	Y
2	100	8.09	21,259	21,731	0.0137	-0.0001	0.052	Y
3	100	12.95	22,473	22,210	0.0138	0.0000	0.188	Y
4	100	17.83	22,901	22,547	0.0149	0.0011	0.445	Y
5	100	27.47	22,614	23,023	0.0183	0.0045	0.462	Y
6	100	37.52	23,514	23,384	0.0216	0.0078	0.517	Y





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	1,459.4	7.47E-08
k^*_2	0.044	3.81E-01
k^*_3	0.024	9.44E-01
Adj. R^2	0.812	
Std. Error [psi]	364	

$M_{r\text{-}comp\ (pred.)\text{-}BP}$ [psi]		23,430
	$\sigma_{cyclic\text{-}BP}$ [psi]	39.5

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

Project Name: Interstate 5: North County Coastal Test Sections
Project ID: TIC-00050
Location: Encinitas, California

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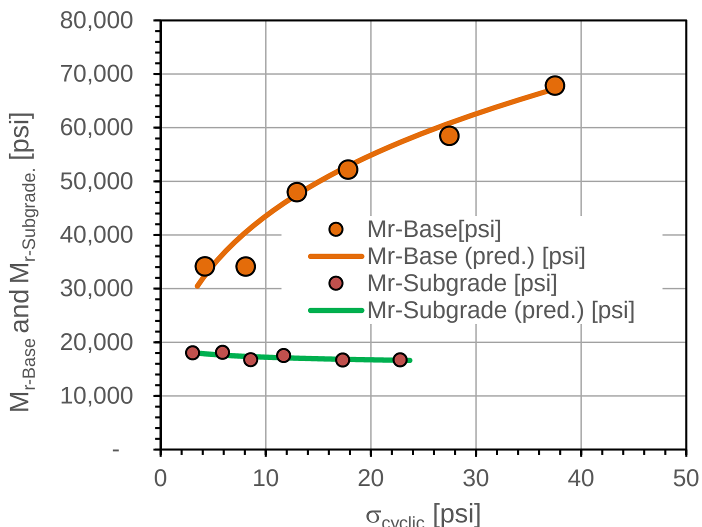
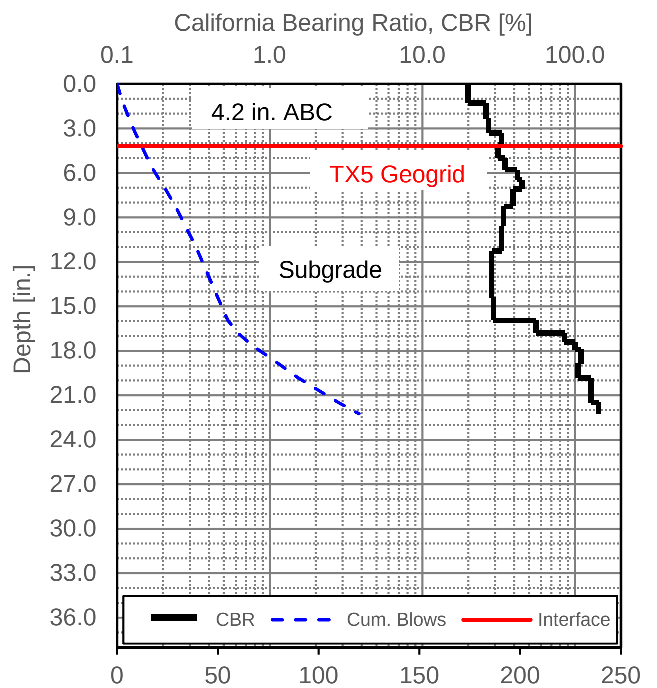
Automated Plate Load Test [APLT]

Test:	In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent (5, 10, 15, 20, 30, 40)				
Date:	8/1/2019	Time:	6:39:49 AM	Test ID	I5_NCC_TX5_pt3
Tested By	PV, LC, HG	Location:	I-5_NCC Test Sections	Sta.	NA
Latitude, N:	33.045933	Longitude, W:	117.286460	Elev. (ft):	NA
Comments:	Nominal 0.35 ft thick recycled aggregate base course layer over subgrade, with TX5 multiaxial georid at the base and subgrade interface.				

Step	N	$\sigma_{cyclic\_surface}$ [psi]	$M_{r\text{-Base}}$[psi]	$M_{r\text{-Base (pred.)}}$ [psi]	$\sigma_{cyclic\_Int.}$ [psi]	$M_{r\text{-Subgrade}}$ [psi]	$M_{r\text{-Subgrade (pred.)}}$ [psi]	Modulus Ratio
Conditioning	500	12.95	---	---	---	---	---	---
1	100	4.20	34,145	32,443	3.06	17,993	18,087	1.90
2	100	8.09	34,101	40,534	5.89	18,084	17,604	1.89
3	100	12.95	47,976	47,499	8.58	16,712	17,329	2.87
4	100	17.83	52,192	52,823	11.71	17,501	17,106	2.98
5	100	27.47	58,467	60,839	17.33	16,659	16,831	3.51
6	100	37.52	67,856	67,232	22.80	16,706	16,645	4.06

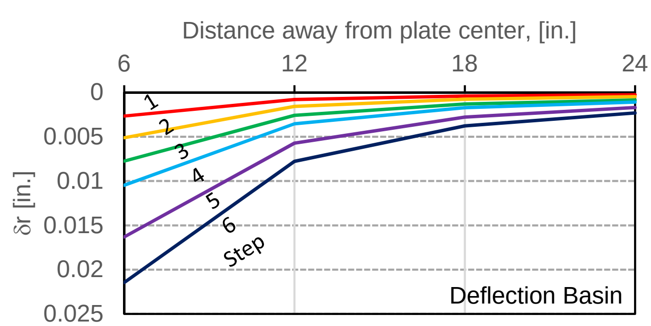




Model: AASHTO (2015)

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

Parameter	Value	P-Value
$k^*_{1\ (Base)}$	2550.3	2.01E-05
$k^*_{2\ (Base)}$	0.346	3.29E-01
$k^*_{3\ (Base)}$	-0.101	9.66E-01
Adj. R^2	0.836	
Std. Error [psi]	5198	
$k^*_{1\ (Subgrade)}$	1188.4	2.50E-06
$k^*_{2\ (Subgrade)}$	-0.046	6.12E-01
$k^*_{3\ (Subgrade)}$	0.021	9.75E-01
Adj. R^2	0.529	
Std. Error [psi]	362	



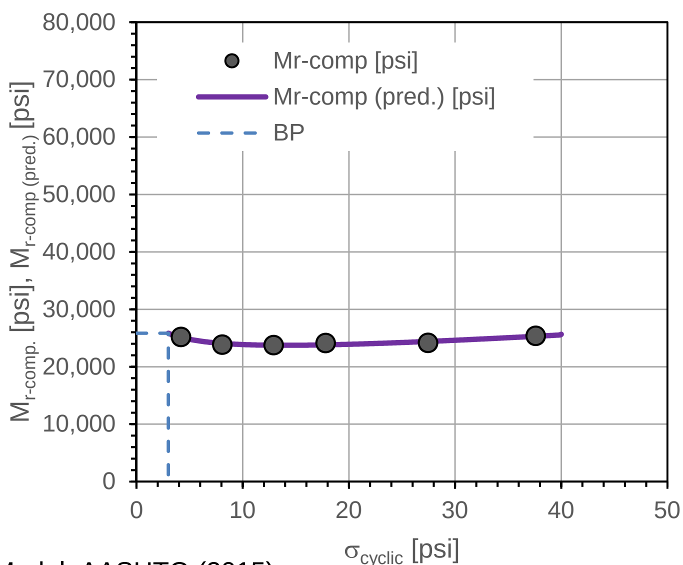
In-situ Resilient Modulus [Mr]: Cyclic Loading, Layered Analysis, Stress-Dependent

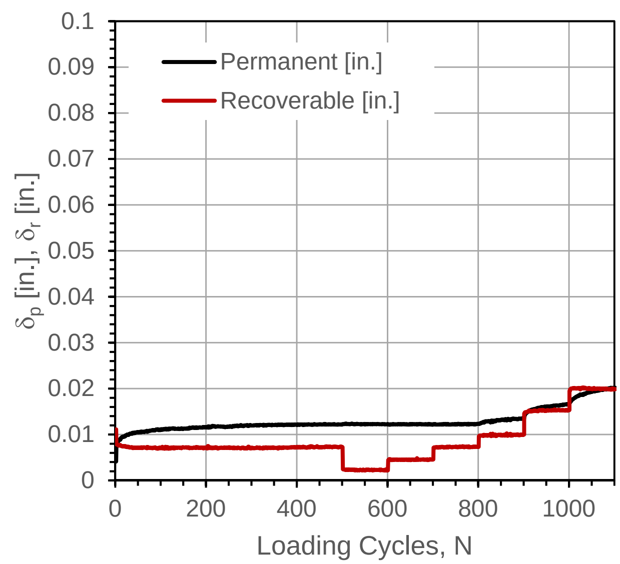
Project Name: Interstate 5: North County Coastal Test Sections
Project ID: TIC-00050
Location: Encinitas, California

Automated Plate Load Test [APLT]

Test:	In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent (5, 10, 15, 20, 30, 40)				
Date:	8/1/2019	Time:	7:10:55 AM	Test ID	**I5_NCC_TX5_pt4**
Tested By	PV, LC, HG	Location:	I-5_NCC Test Sections	Sta.	NA
Latitude,N:	33.045959	Longitude,W:	117.286480	Elev. (ft):	NA
Comments:	Nominal 0.35 ft thick recycled aggregate base course layer over subgrade, with TX5 multiaxial georid at the base and subgrade interface. Measured base layer thickness = 4.3 in.				

Step	N	σ_{cyclic} [psi]	$M_{r\text{-}comp}$ [psi]	$M_{r\text{-}comp\ (pred.)}$ [psi]	δ_p [in.]	$\Delta\delta_p$ [in.]	d =$\Delta\log(\delta_p)/\Delta\log(N)$	Near-linear Elastic
Conditioning	500	12.92	---	---	0.0122	---	0.084	---
1	100	4.20	25,180	25,105	0.0122	0.0001	-0.081	Y
2	100	8.08	23,859	24,064	0.0121	0.0000	0.030	Y
3	100	12.92	23,764	23,746	0.0123	0.0002	0.116	Y
4	100	17.81	24,113	23,815	0.0135	0.0013	0.520	Y
5	100	27.46	24,142	24,407	0.0166	0.0045	0.400	Y
6	100	37.60	25,392	25,308	0.0202	0.0080	0.512	Y





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	1,563.1	1.13E-08
k^*_2	-0.119	1.40E-02
k^*_3	0.916	1.21E-02
Adj. R^2	0.890	
Std. Error [psi]	220	

$M_{r\text{-}comp\ (pred.)\text{-}BP}$ [psi]	25,836
$\sigma_{cyclic\text{-}BP}$ [psi]	3.0

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

Project Name:	Interstate 5: North County Coastal Test Sections
Project ID:	TIC-00050
Location:	Encinitas, California

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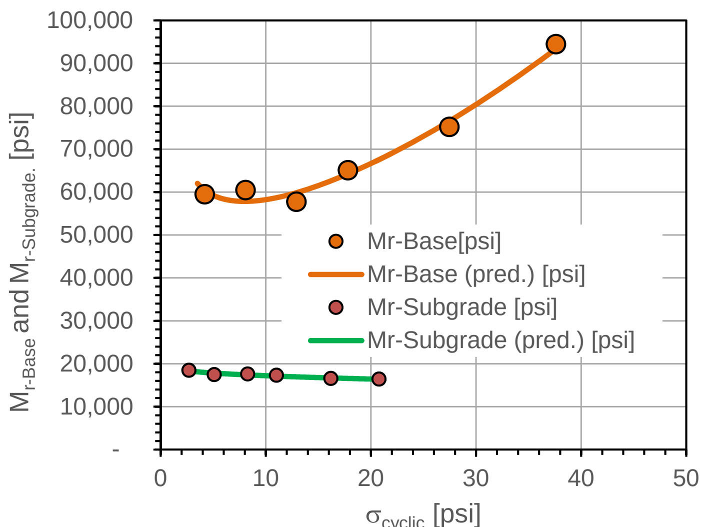
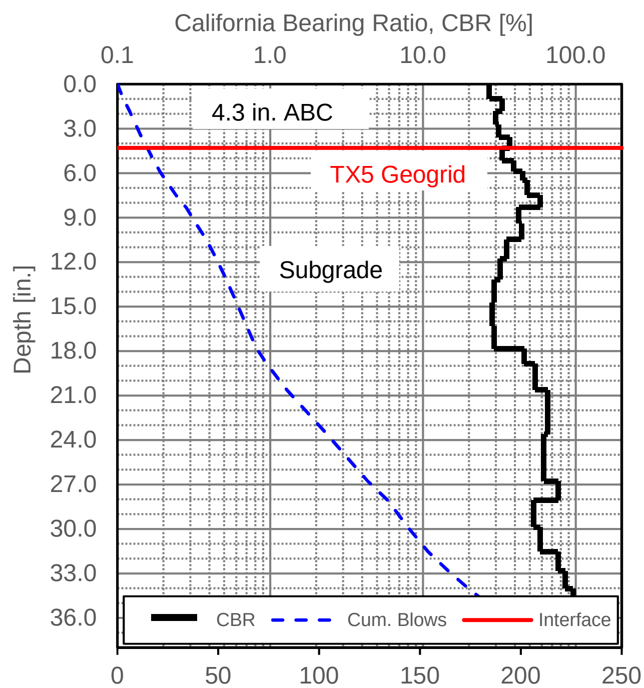
Automated Plate Load Test [APLT]

Test:	In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent (5, 10, 15, 20, 30, 40)				
Date:	8/1/2019	Time:	7:10:55 AM	Test ID	**I5_NCC_TX5_pt4**
Tested By	PV, LC, HG	Location:	I-5_NCC Test Sections	Sta.	NA
Latitude, N:	33.045959	Longitude, W:	117.286480	Elev. (ft):	NA
Comments:	Nominal 0.35 ft thick recycled aggregate base course layer over subgrade, with TX5 multiaxial georid at the base and subgrade interface. Measured base layer thickness = 4.3 in.				

Step	N	$\sigma_{cyclic\_surface}$ [psi]	$M_{r\text{-}Base}$[psi]	$M_{r\text{-}Base\ (pred.)}$ [psi]	$\sigma_{cyclic\_Int.}$ [psi]	$M_{r\text{-}Subgrade}$ [psi]	$M_{r\text{-}Subgrade\ (pred.)}$ [psi]	Modulus Ratio
Conditioning	500	12.92	---	---	---	---	---	---
1	100	4.20	59,493	60,446	2.70	18,442	18,305	3.23
2	100	8.08	60,477	57,819	5.11	17,448	17,818	3.47
3	100	12.92	57,726	59,854	8.29	17,594	17,393	3.28
4	100	17.81	65,085	64,217	11.03	17,276	17,111	3.77
5	100	27.46	75,179	76,531	16.20	16,541	16,690	4.54
6	100	37.60	94,478	93,391	20.78	16,411	16,387	5.76

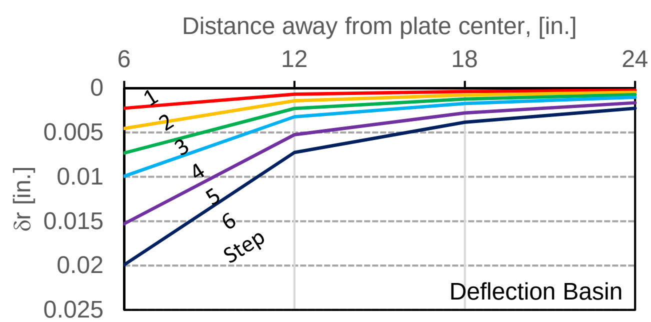




Model: AASHTO (2015)

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

Parameter	Value	P-Value
$k^*_{1\ (Base)}$	3137.8	3.33E-07
$k^*_{2\ (Base)}$	-0.280	3.68E-02
$k^*_{3\ (Base)}$	3.569	8.13E-03
Adj. R^2	0.980	
Std. Error [psi]	1972	
$k^*_{1\ (Subgrade)}$	1217.9	4.74E-07
$k^*_{2\ (Subgrade)}$	-0.036	4.59E-01
$k^*_{3\ (Subgrade)}$	-0.181	6.44E-01
Adj. R^2	0.889	
Std. Error [psi]	237	



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

Project Name: Interstate 5: North County Coastal Test Sections
Project ID: TIC-00050
Location: Encinitas, California

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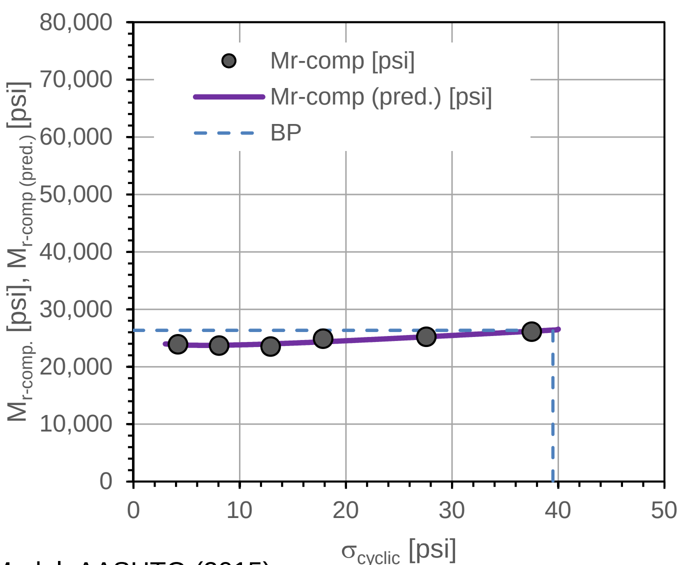
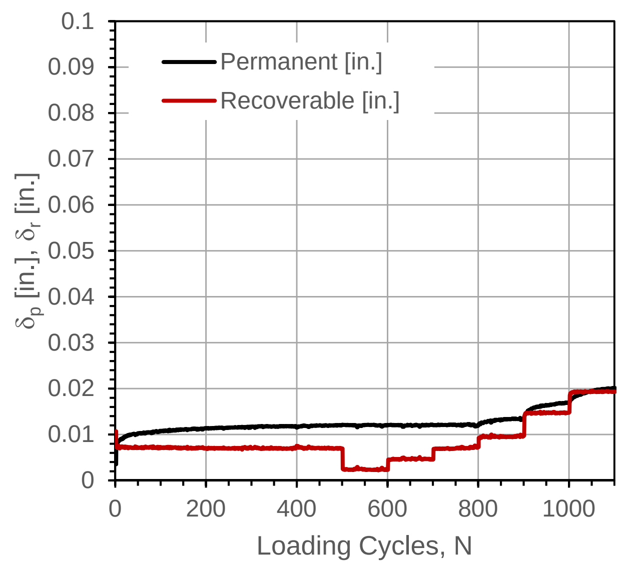
Automated Plate Load Test [APLT]

Test:	In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent (5, 10, 15, 20, 30, 40)				
Date:	8/1/2019	Time:	7:41:36 AM	Test ID	**I5_NCC_TX5_pt5**
Tested By	PV, LC, HG	Location:	I-5_NCC Test Sections	Sta.	NA
Latitude,N:	33.045979	Longitude,W:	117.286480	Elev. (ft):	NA
Comments:	Nominal 0.35 ft thick recycled aggregate base course layer over subgrade, with TX5 multiaxial georid at the base and subgrade interface.				

Step	N	σ_{cyclic} [psi]	$M_{r\text{-}comp}$ [psi]	$M_{r\text{-}comp\ (pred.)}$ [psi]	δ_p [in.]	$\Delta\delta_p$ [in.]	d =$\Delta\log(\delta_p)/\Delta\log(N)$	Near-linear Elastic
Conditioning	500	12.92	---	---	0.0120	---	0.085	---
1	100	4.20	23,913	23,826	0.0121	0.0000	-0.048	Y
2	100	8.06	23,688	23,746	0.0121	0.0001	-0.034	Y
3	100	12.92	23,526	23,978	0.0121	0.0000	-0.034	Y
4	100	17.85	24,885	24,346	0.0134	0.0014	0.411	Y
5	100	27.58	25,203	25,220	0.0169	0.0049	0.412	Y
6	100	37.52	26,100	26,189	0.0201	0.0081	0.507	Y





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	1,547.6	4.18E-08
k^*_2	-0.044	3.07E-01
k^*_3	0.648	8.77E-02
Adj. R^2	0.875	
Std. Error [psi]	342	

$M_{r\text{-}comp\ (pred.)\text{-}BP}$ [psi]	26,336
$\sigma_{cyclic\text{-}BP}$ [psi]	39.5

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

Project Name: Interstate 5: North County Coastal Test Sections
Project ID: TIC-00050
Location: Encinitas, California

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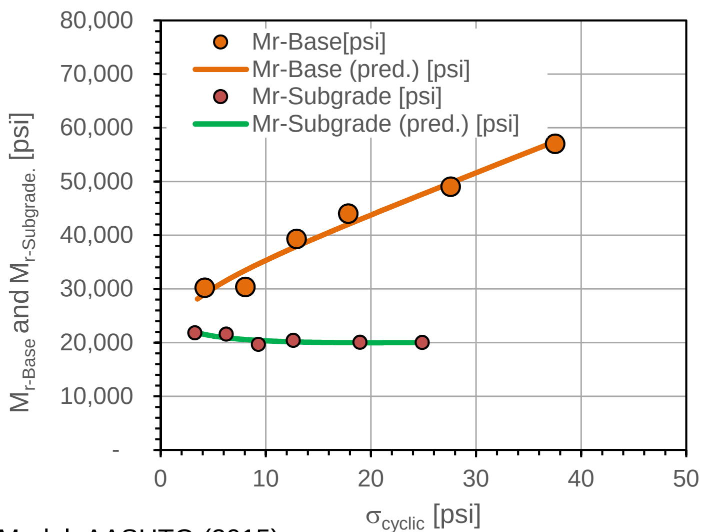
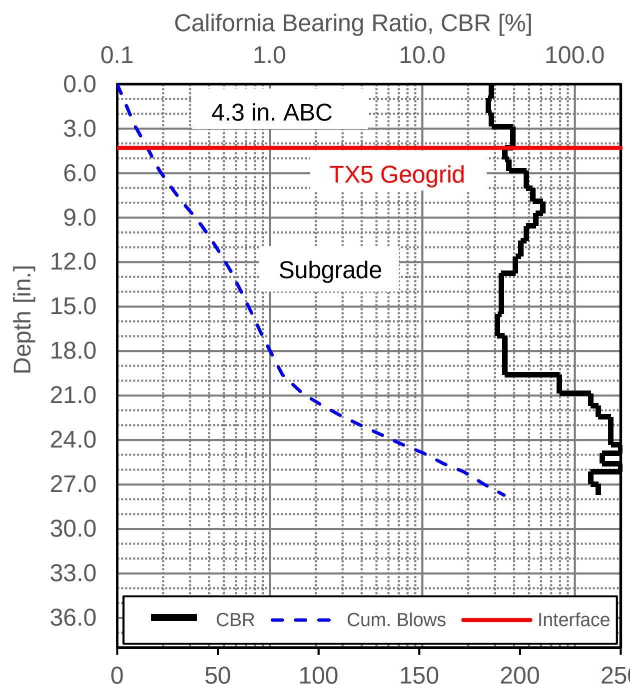
Automated Plate Load Test [APLT]

Test:	In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent (5, 10, 15, 20, 30, 40)				
Date:	8/1/2019	Time:	7:41:36 AM	Test ID	**I5_NCC_TX5_pt5**
Tested By	PV, LC, HG	Location:	I-5_NCC Test Sections	Sta.	NA
Latitude, N:	33.045979	Longitude, W:	117.286480	Elev. (ft):	NA
Comments:	Nominal 0.35 ft thick recycled aggregate base course layer over subgrade, with TX5 multiaxial georid at the base and subgrade interface.				

Step	N	$\sigma_{cyclic\_surface}$ [psi]	$M_{r\text{-}Base}$[psi]	$M_{r\text{-}Base\ (pred.)}$ [psi]	$\sigma_{cyclic\_Int.}$ [psi]	$M_{r\text{-}Subgrade}$ [psi]	$M_{r\text{-}Subgrade\ (pred.)}$ [psi]	Modulus Ratio
Conditioning	500	12.92	---	---	---	---	---	---
1	100	4.20	30,200	29,099	3.26	21,784	21,943	1.39
2	100	8.06	30,347	33,456	6.25	21,549	20,897	1.41
3	100	12.92	39,306	37,914	9.30	19,658	20,408	2.00
4	100	17.85	44,025	42,026	12.63	20,389	20,141	2.16
5	100	27.58	49,026	49,727	18.97	20,034	19,976	2.45
6	100	37.52	57,006	57,461	24.90	19,991	20,014	2.85

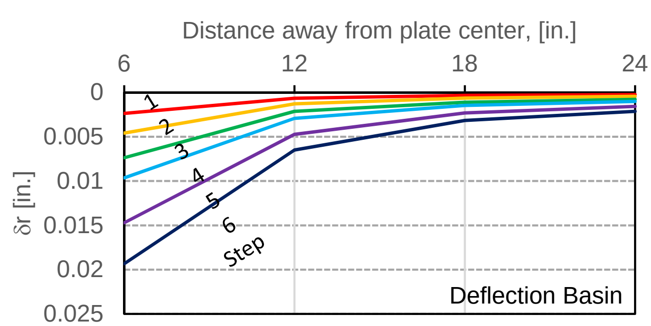




Model: AASHTO (2015)

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

Parameter	Value	P-Value
$k^*_{1\ (Base)}$	1976.1	2.60E-06
$k^*_{2\ (Base)}$	0.136	4.17E-01
$k^*_{3\ (Base)}$	1.302	3.07E-01
Adj. R^2	0.961	
Std. Error [psi]	2076	
$k^*_{1\ (Subgrade)}$	1346.8	1.57E-06
$k^*_{2\ (Subgrade)}$	-0.115	2.28E-01
$k^*_{3\ (Subgrade)}$	0.494	4.32E-01
Adj. R^2	0.656	
Std. Error [psi]	444	



In-situ Resilient Modulus [Mr]: Cyclic Loading, Layered Analysis, Stress-Dependent	
Project Name:	Interstate 5: North County Coastal Test Sections
Project ID:	TIC-00050
Location:	Encinitas, California

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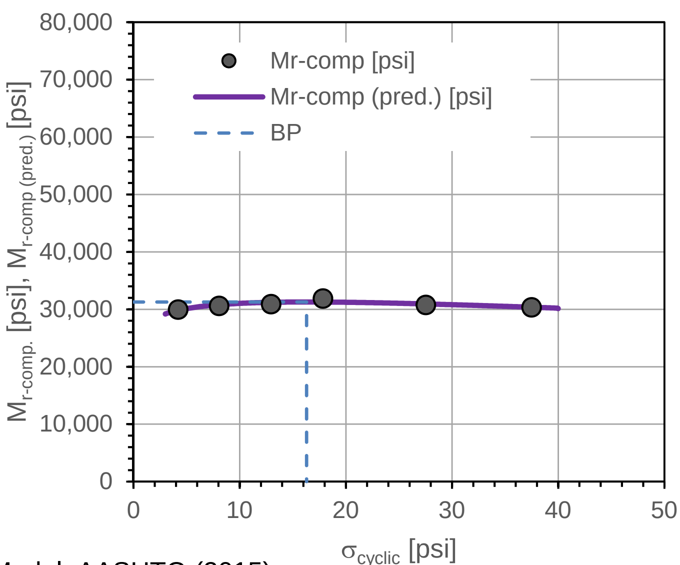
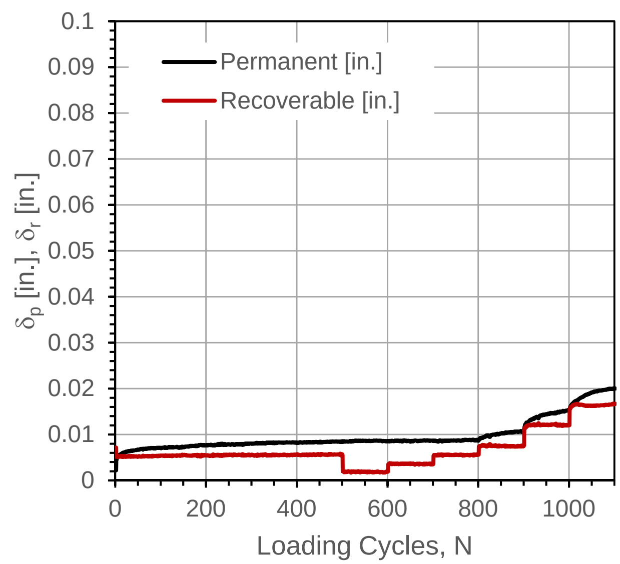
Automated Plate Load Test [APLT]

Test:	In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent (5, 10, 15, 20, 30, 40)				
Date:	8/1/2019	Time:	8:13:03 AM	Test ID	**I5_NCC_CTRL_pt6**
Tested By	PV, LC, HG	Location:	I-5_NCC Test Sections	Sta.	NA
Latitude,N:	33.046124	Longitude,W:	117.286520	Elev. (ft):	NA
Comments:	Nominal 0.70 ft thick recycled aggregate base course layer over subgrade (control).				

Measured base layer thickness = 9.0 in.

Step	N	σ_{cyclic} [psi]	$M_{r\text{-}comp}$ [psi]	$M_{r\text{-}comp\ (pred.)}$ [psi]	δ_p [in.]	$\Delta\delta_p$ [in.]	d =$\Delta\log(\delta_p)/\Delta\log(N)$	Near-linear Elastic
Conditioning	500	12.96	---	---	0.0084	---	0.113	---
1	100	4.21	29,949	29,824	0.0086	0.0002	0.177	Y
2	100	8.07	30,595	30,812	0.0087	0.0003	0.094	Y
3	100	12.96	30,899	31,220	0.0086	0.0003	0.194	Y
4	100	17.84	31,878	31,268	0.0107	0.0024	0.481	Y
5	100	27.54	30,771	30,937	0.0153	0.0069	0.419	Y
6	100	37.50	30,345	30,366	0.0201	0.0117	0.566	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	2,150.9	1.97E-08
k^*_2	0.083	6.33E-02
k^*_3	-0.562	7.65E-02
Adj. R^2	0.667	
Std. Error [psi]	319	

$M_{r\text{-}comp\ (pred.)\text{-}BP}$ [psi]	31,277
$\sigma_{cyclic\text{-}BP}$ [psi]	16.3

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

Project Name:	Interstate 5: North County Coastal Test Sections
Project ID:	TIC-00050
Location:	Encinitas, California

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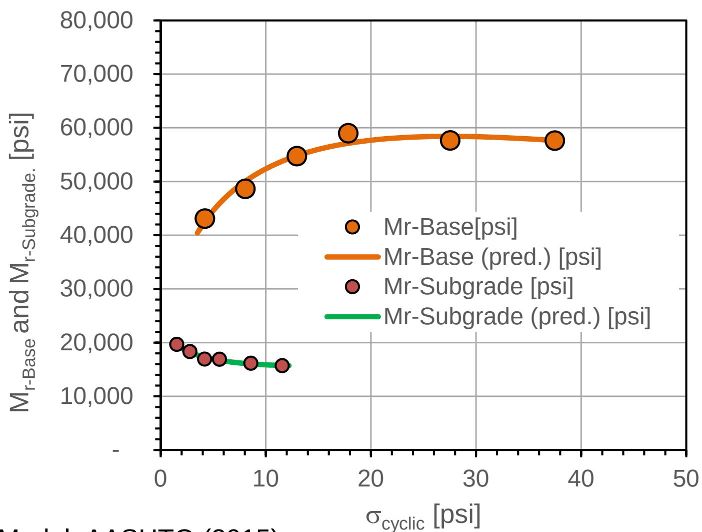
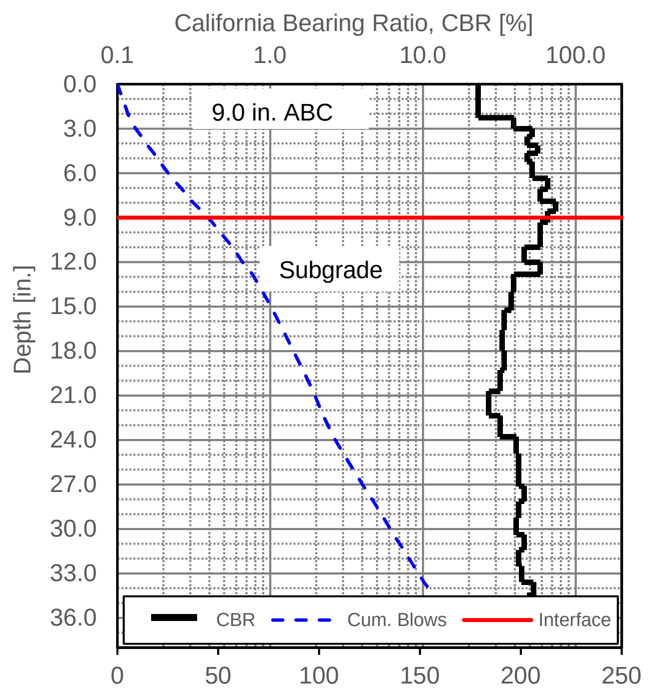
Automated Plate Load Test [APLT]

Test:	In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent (5, 10, 15, 20, 30, 40)				
Date:	8/1/2019	Time:	8:13:03 AM	Test ID	**I5_NCC_CTRL_pt6**
Tested By	PV, LC, HG	Location:	I-5_NCC Test Sections	Sta.	NA
Latitude, N:	33.046124	Longitude, W:	117.286520	Elev. (ft):	NA
Comments:	Nominal 0.70 ft thick recycled aggregate base course layer over subgrade (control).				

Measured base layer thickness = 9.0 in.

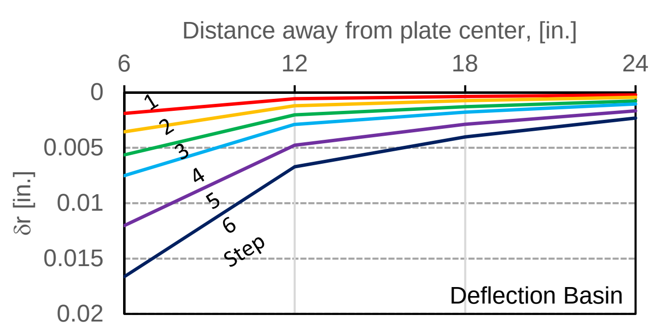
Step	N	$\sigma_{cyclic\_surface}$ [psi]	$M_{r\text{-Base}}$[psi]	$M_{r\text{-Base (pred.)}}$ [psi]	$\sigma_{cyclic\_Int.}$ [psi]	$M_{r\text{-Subgrade}}$ [psi]	$M_{r\text{-Subgrade}}$ (pred.) [psi]	Modulus Ratio
Conditioning	500	12.96	---	---	---	---	---	---
1	100	4.21	43,077	42,553	1.54	19,634	19,620	2.19
2	100	8.07	48,636	50,072	2.79	18,305	18,184	2.66
3	100	12.96	54,710	54,805	4.19	16,914	17,266	3.23
4	100	17.84	58,990	57,121	5.61	16,887	16,689	3.49
5	100	27.54	57,634	58,412	8.59	16,124	16,032	3.57
6	100	37.50	57,615	57,627	11.58	15,677	15,743	3.68





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)	3544.7	1.23E-07
k^*_2 (Base)	0.339	9.38E-03
k^*_3 (Base)	-1.495	3.65E-02
Adj. R^2	0.959	
Std. Error [psi]	1234	
k^*_1 (Subgrade)	1001.6	1.85E-06
k^*_2 (Subgrade)	-0.220	1.94E-02
k^*_3 (Subgrade)	1.127	1.53E-01
Adj. R^2	0.978	
Std. Error [psi]	216	

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

Project Name: Interstate 5: North County Coastal Test Sections
Project ID: TIC-00050
Location: Encinitas, California

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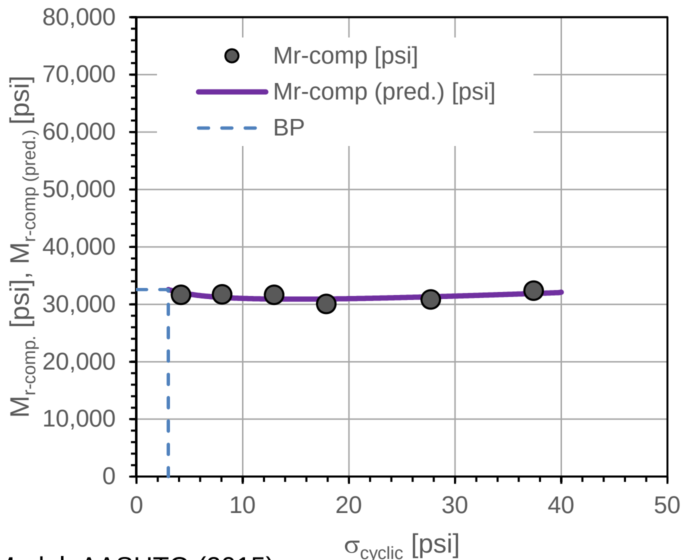
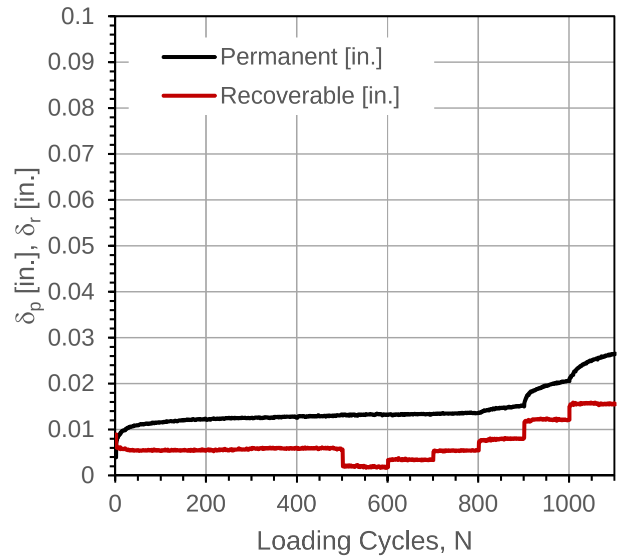
Automated Plate Load Test [APLT]

Test:	In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent (5, 10, 15, 20, 30, 40)				
Date:	8/1/2019	Time:	8:44:02 AM	Test ID	**I5_NCC_CTRL_pt7**
Tested By	PV, LC, HG	Location:	I-5_NCC Test Sections	Sta.	NA
Latitude,N:	33.046158	Longitude,W:	117.286520	Elev. (ft):	NA
Comments:	Nominal 0.70 ft thick recycled aggregate base course layer over subgrade (control).				

Step	N	σ_{cyclic} [psi]	$M_{r\text{-}comp}$ [psi]	$M_{r\text{-}comp\ (pred.)}$ [psi]	δ_p [in.]	$\Delta\delta_p$ [in.]	d $=\Delta\log(\delta_p)/\Delta\log(N)$	Near-linear Elastic
Conditioning	500	12.96	---	---	0.0131	---	0.094	---
1	100	4.20	31,644	32,016	0.0132	0.0001	0.140	Y
2	100	8.07	31,738	31,200	0.0134	0.0002	0.152	Y
3	100	12.96	31,659	30,917	0.0136	0.0004	0.272	Y
4	100	17.88	30,060	30,931	0.0153	0.0021	0.591	Y
5	100	27.71	30,828	31,315	0.0206	0.0074	0.477	Y
6	100	37.41	32,370	31,885	0.0264	0.0133	0.586	N





Model: AASHTO (2015)

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

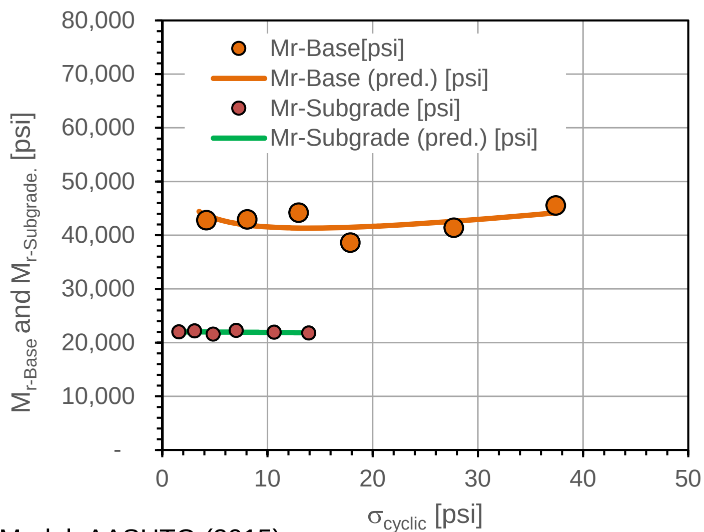
Parameter	Value	P-Value
k^*_1	2,070.8	1.59E-07
k^*_2	-0.070	3.14E-01
k^*_3	0.506	3.16E-01
Adj. R^2	0.164	
Std. Error [psi]	431	

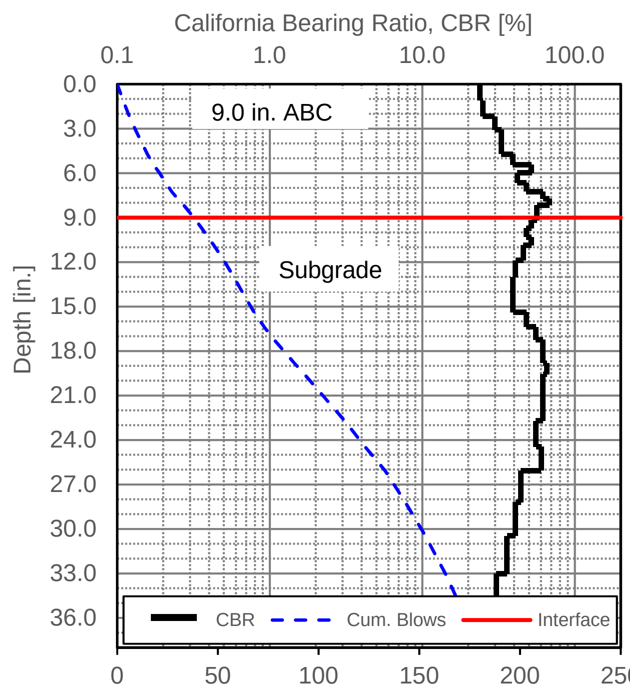
$M_{r\text{-}comp\ (pred.)\text{-}BP}$ [psi]		32,568
	$\sigma_{cyclic\text{-}BP}$ [psi]	3.0

Automated Plate Load Test [APLT]

Test:	In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent (5, 10, 15, 20, 30, 40)				
Date:	8/1/2019	Time:	8:44:02 AM	Test ID	**I5_NCC_CTRL_pt7**
Tested By	PV, LC, HG	Location:	I-5_NCC Test Sections	Sta.	NA
Latitude, N:	33.046158	Longitude, W:	117.286520	Elev. (ft):	NA
Comments:	Nominal 0.70 ft thick recycled aggregate base course layer over subgrade (control).				

Step	N	$\sigma_{cyclic\_surface}$ [psi]	$M_{r\text{-}Base}$[psi]	$M_{r\text{-}Base\ (pred.)}$ [psi]	$\sigma_{cyclic\_Int.}$ [psi]	$M_{r\text{-}Subgrade}$ [psi]	$M_{r\text{-}Subgrade\ (pred.)}$ [psi]	Modulus Ratio
Conditioning	500	12.96	---	---	---	---	---	---
1	100	4.20	42,791	43,728	1.60	21,975	21,983	1.95
2	100	8.07	42,933	41,886	3.08	22,164	21,989	1.94
3	100	12.96	44,184	41,333	4.86	21,551	21,976	2.05
4	100	17.88	38,627	41,476	7.04	22,249	21,948	1.74
5	100	27.71	41,380	42,593	10.64	21,905	21,889	1.89
6	100	37.41	45,521	44,162	13.94	21,778	21,829	2.09

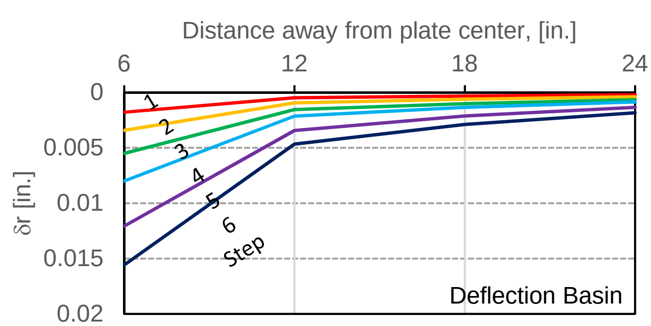




Model: AASHTO (2015)

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

Parameter	Value	P-Value
$k^*_{1\ (Base)}$	2715.6	1.80E-06
$k^*_{2\ (Base)}$	-0.122	4.29E-01
$k^*_{3\ (Base)}$	0.947	4.05E-01
Adj. R^2	0.054	
Std. Error [psi]	1156	
$k^*_{1\ (Subgrade)}$	1508.0	8.00E-07
$k^*_{2\ (Subgrade)}$	0.005	9.17E-01
$k^*_{3\ (Subgrade)}$	-0.095	8.46E-01
Adj. R^2	-0.170	
Std. Error [psi]	69	



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

Project Name: Interstate 5: North County Coastal Test Sections
Project ID: TIC-00050
Location: Encinitas, California

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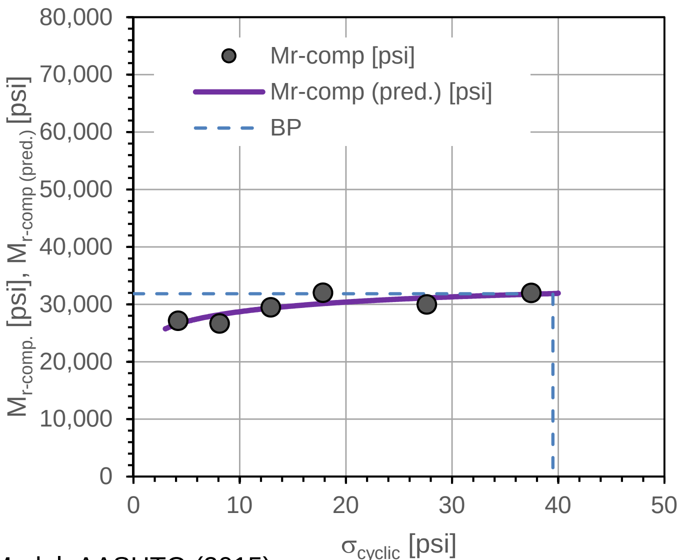
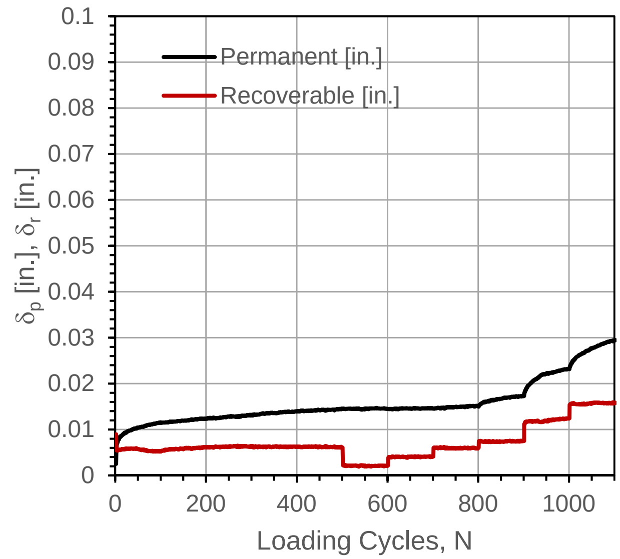
Automated Plate Load Test [APLT]

Test:	In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent (5, 10, 15, 20, 30, 40)				
Date:	8/1/2019	Time:	9:16:18 AM	Test ID	**I5_NCC_CTRL_pt8**
Tested By	PV, LC, HG	Location:	I-5_NCC Test Sections	Sta.	NA
Latitude,N:	33.046181	Longitude,W:	117.286530	Elev. (ft):	NA
Comments:	Nominal 0.70 ft thick recycled aggregate base course layer over subgrade (control).				

Measured base layer thickness = 8.75 in.

Step	N	σ_{cyclic} [psi]	$M_{r\text{-}comp}$ [psi]	$M_{r\text{-}comp\ (pred.)}$ [psi]	δ_p [in.]	$\Delta\delta_p$ [in.]	d = $\Delta\log(\delta_p)/\Delta\log(N)$	Near-linear Elastic
Conditioning	500	12.94	---	---	0.0146	---	0.151	---
1	100	4.21	27,148	26,570	0.0145	-0.0001	0.060	Y
2	100	8.11	26,664	28,198	0.0146	0.0001	0.232	Y
3	100	12.94	29,481	29,350	0.0151	0.0006	0.447	Y
4	100	17.84	32,016	30,124	0.0173	0.0027	0.492	Y
5	100	27.63	29,978	31,123	0.0232	0.0087	0.536	Y
6	100	37.46	31,970	31,763	0.0294	0.0149	0.601	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	1,890.2	1.23E-06
k^*_2	0.098	4.50E-01
k^*_3	-0.121	8.93E-01
Adj. R^2	0.636	
Std. Error [psi]	1,159	

$M_{r\text{-}comp\ (pred.)\text{-}BP}$ [psi]	31,843
$\sigma_{cyclic\text{-}BP}$ [psi]	39.5

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

Project Name: Interstate 5: North County Coastal Test Sections
Project ID: TIC-00050
Location: Encinitas, California

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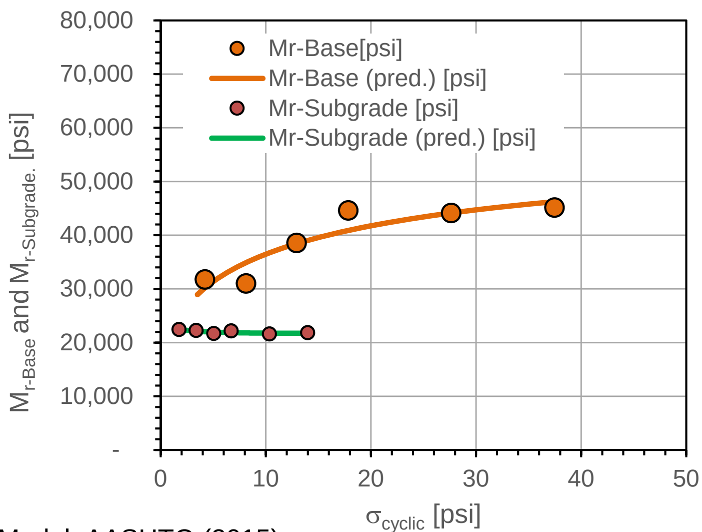
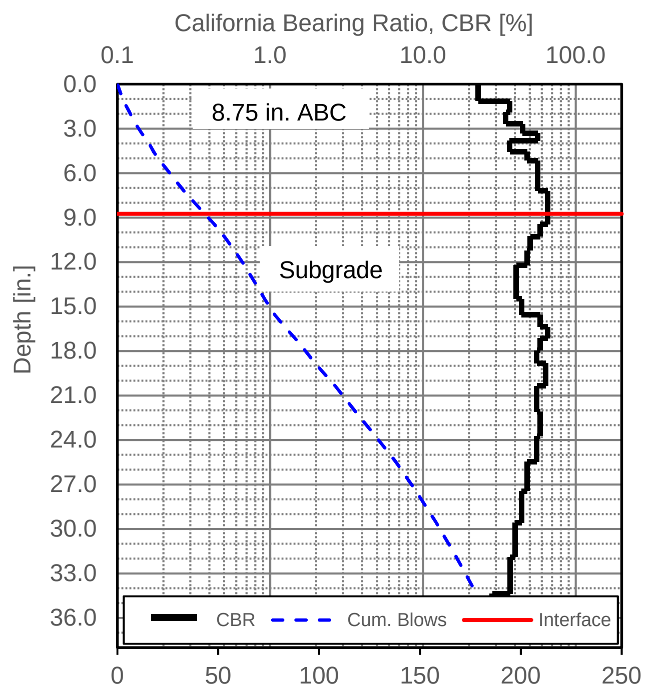
Automated Plate Load Test [APLT]

Test:	In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent (5, 10, 15, 20, 30, 40)				
Date:	8/1/2019	Time:	9:16:18 AM	Test ID	**I5_NCC_CTRL_pt8**
Tested By	PV, LC, HG	Location:	I-5_NCC Test Sections	Sta.	NA
Latitude, N:	33.046181	Longitude, W:	117.286530	Elev. (ft):	NA
Comments:	Nominal 0.70 ft thick recycled aggregate base course layer over subgrade (control).				

Measured base layer thickness = 8.75 in.

Step	N	$\sigma_{cyclic\_surface}$ [psi]	$M_{r\text{-}Base}$[psi]	$M_{r\text{-}Base\ (pred.)}$ [psi]	$\sigma_{cyclic\_Int.}$ [psi]	$M_{r\text{-}Subgrade}$ [psi]	$M_{r\text{-}Subgrade\ (pred.)}$ [psi]	Modulus Ratio
Conditioning	500	12.94	---	---	---	---	---	---
1	100	4.21	31,756	30,185	1.75	22,436	22,456	1.42
2	100	8.11	31,023	34,885	3.39	22,237	22,130	1.40
3	100	12.94	38,569	38,423	5.06	21,686	21,956	1.78
4	100	17.84	44,603	40,882	6.72	22,153	21,855	2.01
5	100	27.63	44,127	44,136	10.37	21,592	21,761	2.04
6	100	37.46	45,141	46,242	14.00	21,812	21,754	2.07

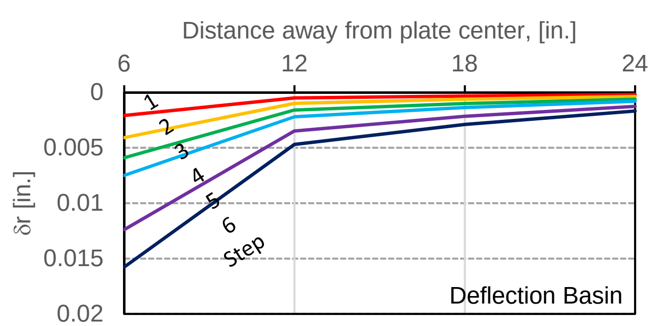




Model: AASHTO (2015)

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

Parameter	Value	P-Value
$k^*_{1\ (Base)}$	2297.4	5.33E-06
$k^*_{2\ (Base)}$	0.241	2.92E-01
$k^*_{3\ (Base)}$	-0.343	8.19E-01
Adj. R^2	0.808	
Std. Error [psi]	2607	
$k^*_{1\ (Subgrade)}$	1452.4	4.61E-07
$k^*_{2\ (Subgrade)}$	-0.040	3.37E-01
$k^*_{3\ (Subgrade)}$	0.242	5.67E-01
Adj. R^2	0.548	
Std. Error [psi]	181	



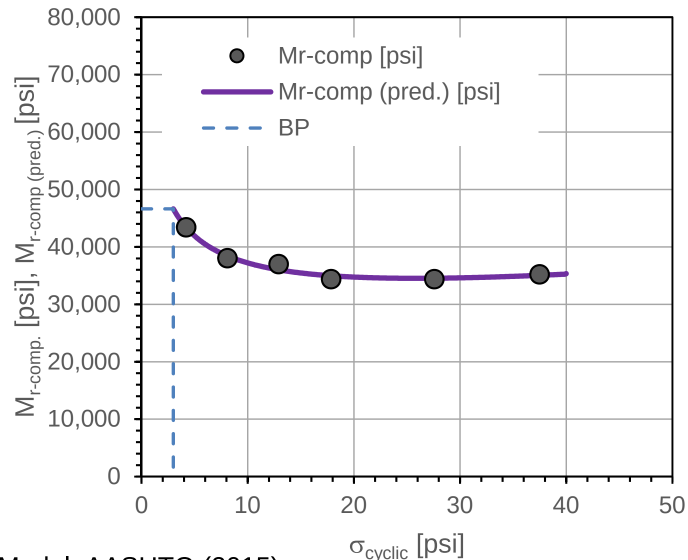
In-situ Resilient Modulus [Mr]: Cyclic Loading, Layered Analysis, Stress-Dependent

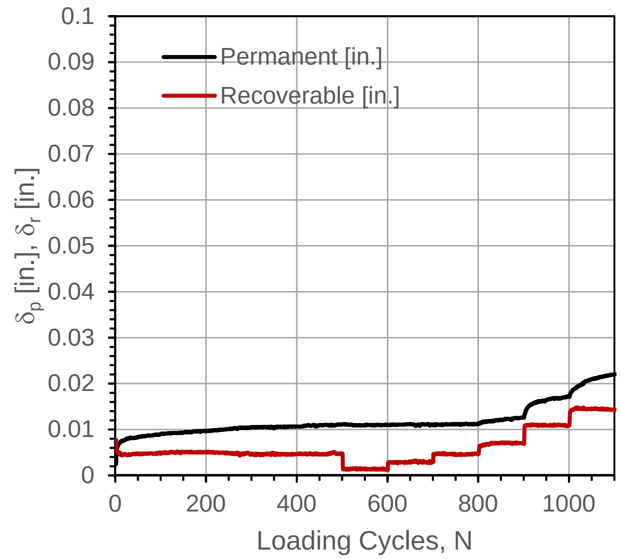
Project Name:	Interstate 5: North County Coastal Test Sections
Project ID:	TIC-00050
Location:	Encinitas, California

Automated Plate Load Test [APLT]

Test:	In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent (5, 10, 15, 20, 30, 40)				
Date:	8/1/2019	Time:	9:47:02 AM	Test ID	**I5_NCC_CTRL_pt9**
Tested By	PV, LC, HG	Location:	I-5_NCC Test Sections	Sta.	NA
Latitude,N:	33.046204	Longitude,W:	117.286540	Elev. (ft):	NA
Comments:	Nominal 0.70 ft thick recycled aggregate base course layer over subgrade (control).				

Step	N	σ_{cyclic} [psi]	$M_{r\text{-}comp}$ [psi]	$M_{r\text{-}comp\ (pred.)}$ [psi]	δ_p [in.]	$\Delta\delta_p$ [in.]	d = $\Delta\log(\delta_p)/\Delta\log(N)$	Near-linear Elastic
Conditioning	500	12.92	---	---	0.0111	---	0.127	---
1	100	4.20	43,414	43,389	0.0111	-0.0001	-0.160	Y
2	100	8.09	38,024	38,424	0.0110	-0.0001	0.031	Y
3	100	12.92	37,002	36,009	0.0112	0.0001	0.173	Y
4	100	17.86	34,374	34,972	0.0127	0.0016	0.479	Y
5	100	27.58	34,390	34,547	0.0172	0.0060	0.447	Y
6	100	37.49	35,211	35,053	0.0219	0.0108	0.574	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	2,526.0	5.48E-08
k^*_2	-0.256	8.58E-03
k^*_3	1.185	2.98E-02
Adj. R^2	0.967	
Std. Error [psi]	616	

$M_{r\text{-}comp\ (pred.)\text{-}BP}$ [psi]	46,616
$\sigma_{cyclic\text{-}BP}$ [psi]	3.0

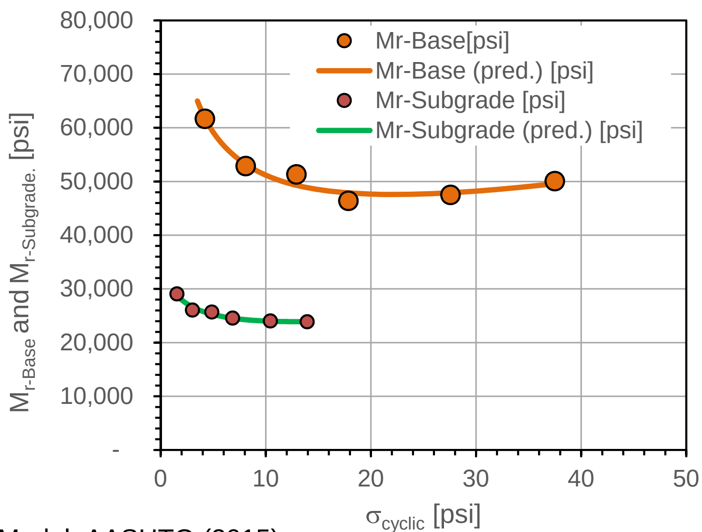
In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent

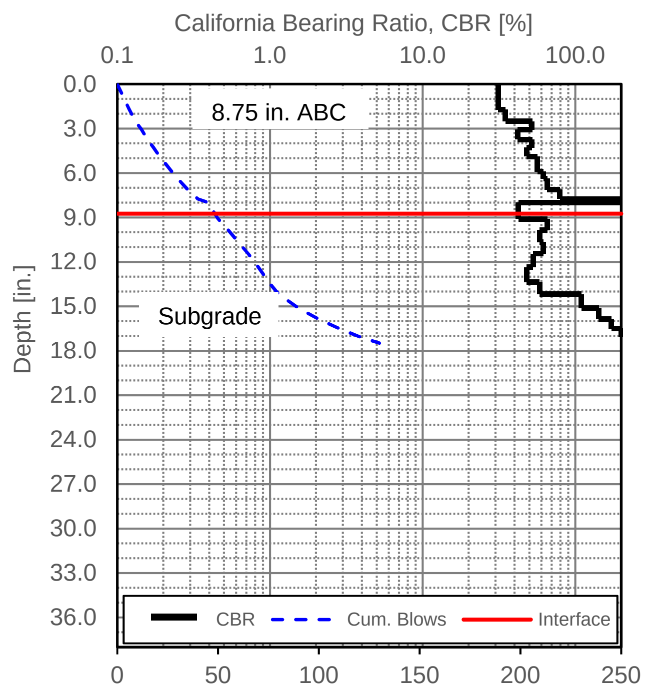
Project Name: Interstate 5: North County Coastal Test Sections
Project ID: TIC-00050
Location: Encinitas, California

Automated Plate Load Test [APLT]

Test:	In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent (5, 10, 15, 20, 30, 40)				
Date:	8/1/2019	Time:	9:47:02 AM	Test ID	**I5_NCC_CTRL_pt9**
Tested By	PV, LC, HG	Location:	I-5_NCC Test Sections	Sta.	NA
Latitude, N:	33.046204	Longitude, W:	117.286540	Elev. (ft):	NA
Comments:	Nominal 0.70 ft thick recycled aggregate base course layer over subgrade (control).				

Step	N	$\sigma_{cyclic\_surface}$ [psi]	$M_{r\text{-Base}}$[psi]	$M_{r\text{-Base (pred.)}}$ [psi]	$\sigma_{cyclic\_Int.}$ [psi]	$M_{r\text{-Subgrade}}$ [psi]	$M_{r\text{-Subgrade (pred.)}}$ [psi]	Modulus Ratio
Conditioning	500	12.92	---	---	---	---	---	---
1	100	4.20	61,681	61,889	1.56	29,030	28,793	2.12
2	100	8.09	52,871	53,191	3.04	26,037	26,616	2.03
3	100	12.92	51,319	49,306	4.88	25,661	25,283	2.00
4	100	17.86	46,395	47,882	6.86	24,536	24,537	1.89
5	100	27.58	47,501	47,906	10.45	24,013	23,983	1.98
6	100	37.49	50,060	49,590	13.95	23,862	23,917	2.10

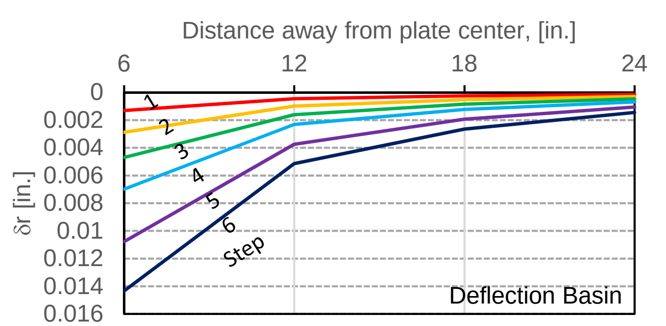




Model: AASHTO (2015)

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

Parameter	Value	P-Value
$k^*_{1\ (Base)}$	3403.9	1.78E-07
$k^*_{2\ (Base)}$	-0.335	1.34E-02
$k^*_{3\ (Base)}$	1.749	3.30E-02
Adj. R^2	0.943	
Std. Error [psi]	1283	
$k^*_{1\ (Subgrade)}$	1483.4	1.01E-06
$k^*_{2\ (Subgrade)}$	-0.208	1.73E-02
$k^*_{3\ (Subgrade)}$	1.242	8.43E-02
Adj. R^2	0.964	
Std. Error [psi]	359	



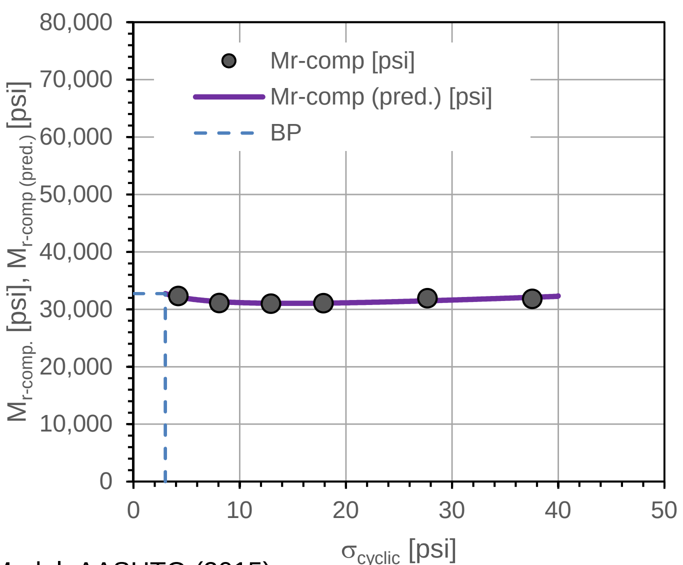
In-situ Resilient Modulus [Mr]: Cyclic Loading, Layered Analysis, Stress-Dependent

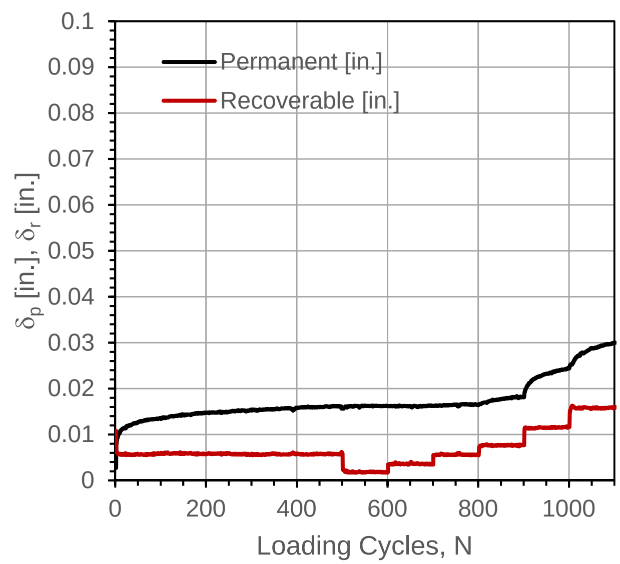
Project Name: Interstate 5: North County Coastal Test Sections
Project ID: TIC-00050
Location: Encinitas, California

Automated Plate Load Test [APLT]

Test:	In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent (5, 10, 15, 20, 30, 40)				
Date:	8/1/2019	Time:	10:17:08 AM	Test ID	**I5_NCC_CTRL_pt10**
Tested By	PV, LC, HG	Location:	I-5_NCC Test Sections	Sta.	NA
Latitude,N:	33.046219	Longitude,W:	117.286540	Elev. (ft):	NA
Comments:	Nominal 0.70 ft thick recycled aggregate base course layer over subgrade (control).				

Step	N	σ_{cyclic} [psi]	$M_{r\text{-comp}}$ [psi]	$M_{r\text{-comp (pred.)}}$ [psi]	δ_p [in.]	$\Delta\delta_p$ [in.]	d =$\Delta\log(\delta_p)/\Delta\log(N)$	Near-linear Elastic
Conditioning	500	12.95	---	---	0.0158	---	0.123	---
1	100	4.22	32,306	32,161	0.0162	0.0004	0.244	Y
2	100	8.08	31,103	31,338	0.0162	0.0004	-0.014	Y
3	100	12.95	30,984	31,056	0.0164	0.0005	0.223	Y
4	100	17.89	31,076	31,079	0.0182	0.0023	0.563	Y
5	100	27.69	31,928	31,487	0.0244	0.0085	0.490	Y
6	100	37.56	31,827	32,099	0.0300	0.0141	0.627	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	2,077.9	9.32E-09
k^*_2	-0.071	5.10E-02
k^*_3	0.523	4.98E-02
Adj. R^2	0.715	
Std. Error [psi]	260	

$M_{r\text{-comp (pred.)-BP}}$ [psi]	32,733
$\sigma_{cyclic\text{-BP}}$ [psi]	3.0

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

Project Name:	Interstate 5: North County Coastal Test Sections
Project ID:	TIC-00050
Location:	Encinitas, California

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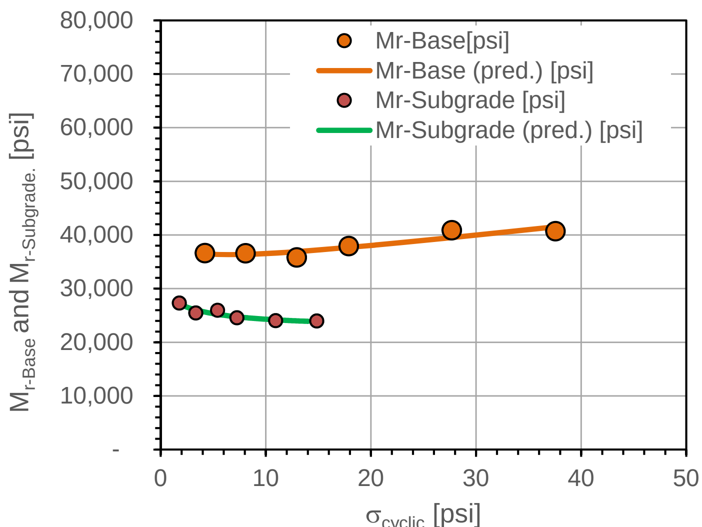
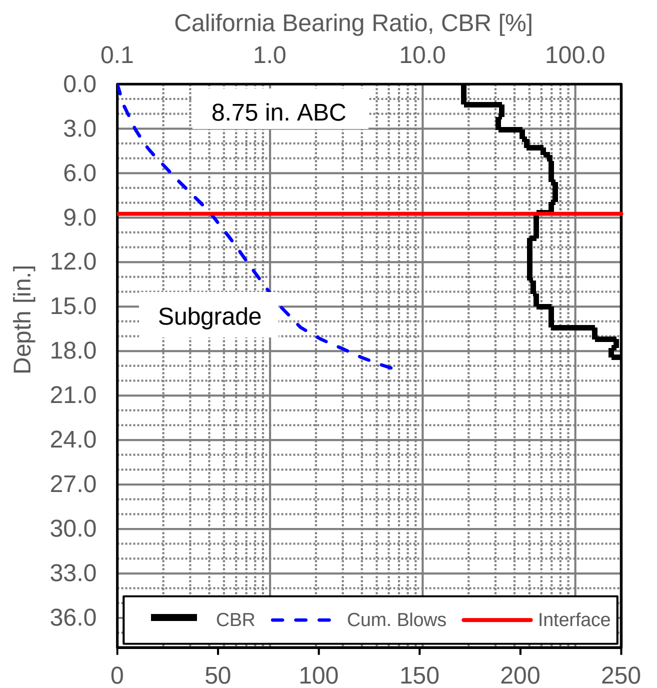
Automated Plate Load Test [APLT]

Test:	In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent (5, 10, 15, 20, 30, 40)				
Date:	8/1/2019	Time:	10:17:08 AM	Test ID	**I5_NCC_CTRL_pt10**
Tested By	PV, LC, HG	Location:	I-5_NCC Test Sections	Sta.	NA
Latitude, N:	33.046219	Longitude, W:	117.286540	Elev. (ft):	NA
Comments:	Nominal 0.70 ft thick recycled aggregate base course layer over subgrade (control).				

Step	N	$\sigma_{cyclic\_surface}$ [psi]	$M_{r\text{-}Base}$[psi]	$M_{r\text{-}Base\ (pred.)}$ [psi]	$\sigma_{cyclic\_Int.}$ [psi]	$M_{r\text{-}Subgrade}$ [psi]	$M_{r\text{-}Subgrade\ (pred.)}$ [psi]	Modulus Ratio
Conditioning	500	12.95	---	---	---	---	---	---
1	100	4.22	36,609	36,469	1.78	27,296	27,127	1.34
2	100	8.08	36,585	36,383	3.35	25,442	26,028	1.44
3	100	12.95	35,798	36,900	5.43	25,955	25,207	1.38
4	100	17.89	37,935	37,678	7.27	24,532	24,748	1.55
5	100	27.69	40,890	39,520	10.96	24,012	24,185	1.70
6	100	37.56	40,715	41,534	14.87	23,930	23,851	1.70

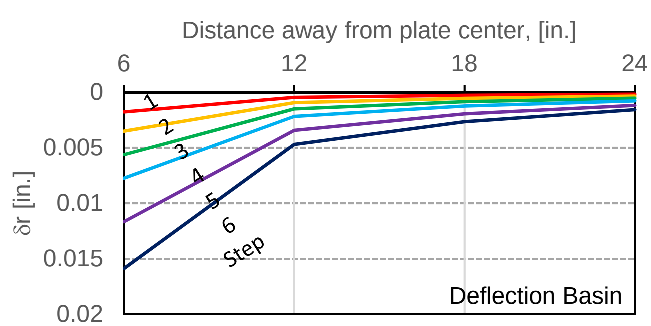




Model: AASHTO (2015)

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

Parameter	Value	P-Value
$k^*_{1\ (Base)}$	2338.8	1.79E-07
$k^*_{2\ (Base)}$	-0.054	4.42E-01
$k^*_{3\ (Base)}$	0.846	1.54E-01
Adj. R^2	0.801	
Std. Error [psi]	914	
$k^*_{1\ (Subgrade)}$	1647.4	2.53E-06
$k^*_{2\ (Subgrade)}$	-0.098	2.19E-01
$k^*_{3\ (Subgrade)}$	0.300	6.84E-01
Adj. R^2	0.851	
Std. Error [psi]	472	



In-situ Resilient Modulus [Mr]: Cyclic Loading, Layered Analysis, Stress-Dependent	
Project Name:	Interstate 5: North County Coastal Test Sections
Project ID:	TIC-00050
Location:	Encinitas, California

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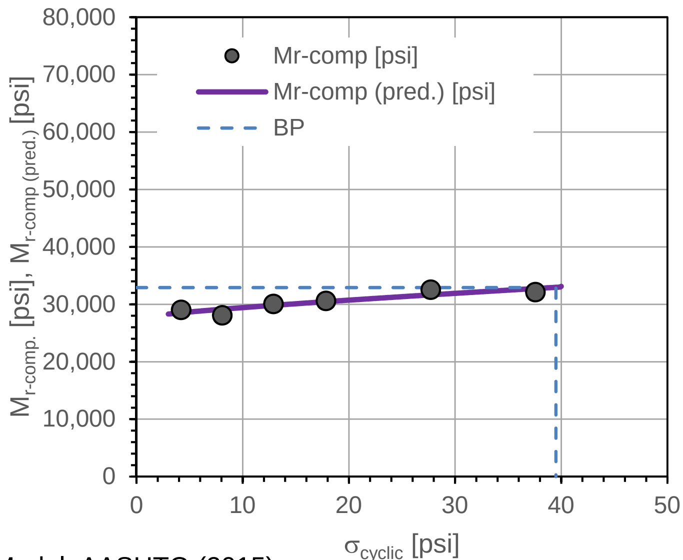
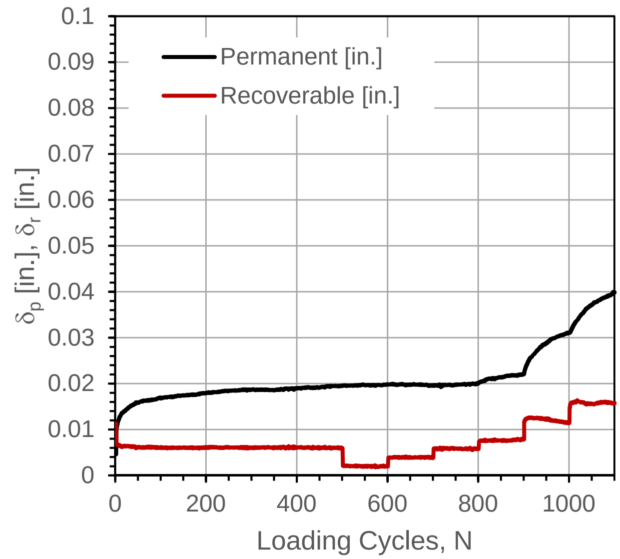
Automated Plate Load Test [APLT]

Test:	In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent (5, 10, 15, 20, 30, 40)				
Date:	8/1/2019	Time:	11:06:11 AM	Test ID	**I5_NCC_TX5_0.85_pt11**
Tested By	PV, LC, HG	Location:	I-5_NCC Test Sections	Sta.	NA
Latitude,N:	33.046959	Longitude,W:	117.286770	Elev. (ft):	NA
Comments:	Nominal 0.85 ft thick recycled aggregate base course layer over subgrade, with TX5 multiaxial georid at the base and subgrade interface. Measured base layer thickness = 9.75 in.				

Step	N	σ_{cyclic} [psi]	$M_{r\text{-}comp}$ [psi]	$M_{r\text{-}comp\ (pred.)}$ [psi]	δ_p [in.]	$\Delta\delta_p$ [in.]	d =$\Delta\log(\delta_p)/\Delta\log(N)$	Near-linear Elastic
Conditioning	500	12.90	---	---	0.0195	---	0.111	---
1	100	4.20	29,021	28,535	0.0198	0.0004	0.221	Y
2	100	8.08	28,095	29,152	0.0197	0.0002	-0.145	Y
3	100	12.90	30,052	29,823	0.0201	0.0006	0.192	Y
4	100	17.85	30,598	30,463	0.0221	0.0026	0.558	Y
5	100	27.72	32,530	31,650	0.0311	0.0117	0.657	N
6	100	37.57	32,124	32,754	0.0400	0.0205	0.835	N





Model: AASHTO (2015)

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

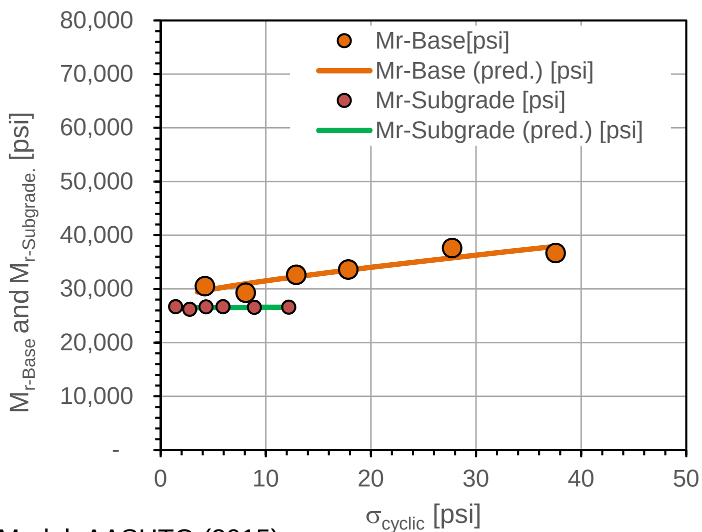
Parameter	Value	P-Value
k^*_1	1,913.5	2.26E-07
k^*_2	0.009	9.03E-01
k^*_3	0.406	4.50E-01
Adj. R^2	0.782	
Std. Error [psi]	737	

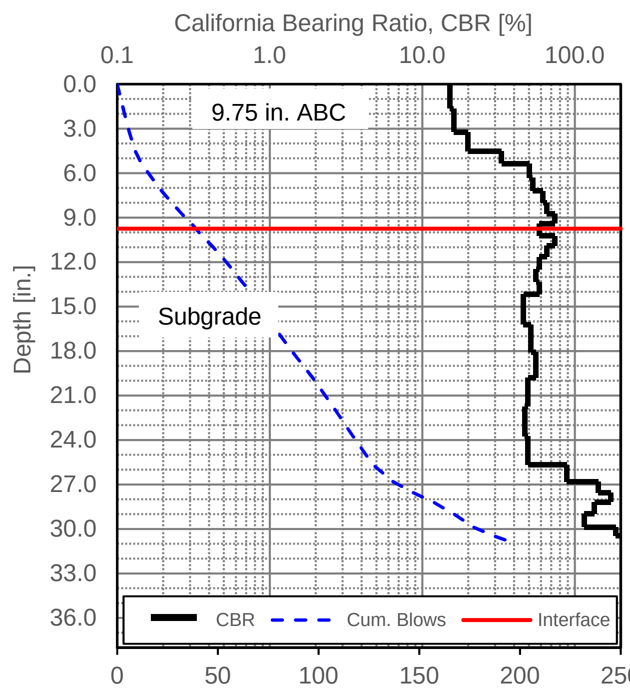
$M_{r\text{-}comp\ (pred.)\text{-}BP}$ [psi]	32,909
$\sigma_{cyclic\text{-}BP}$ [psi]	39.5

Automated Plate Load Test [APLT]

Test:	In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent (5, 10, 15, 20, 30, 40)				
Date:	8/1/2019	Time:	11:06:11 AM	Test ID	I5_NCC_TX5_0.85_pt11
Tested By	PV, LC, HG	Location:	I-5_NCC Test Sections	Sta.	NA
Latitude, N:	33.046959	Longitude, W:	117.286770	Elev. (ft):	NA
Comments:	Nominal 0.85 ft thick recycled aggregate base course layer over subgrade, with TX5 multiaxial georid at the base and subgrade interface. Measured base layer thickness = 9.75 in.				

Step	N	$\sigma_{cyclic\_surface}$ [psi]	$M_{r\text{-Base}}$[psi]	$M_{r\text{-Base (pred.)}}$ [psi]	$\sigma_{cyclic\_Int.}$ [psi]	$M_{r\text{-Subgrade}}$ [psi]	$M_{r\text{-Subgrade (pred.)}}$ [psi]	Modulus Ratio
Conditioning	500	12.90	---	---	---	---	---	---
1	100	4.20	30,496	29,708	1.44	26,643	26,511	1.14
2	100	8.08	29,272	30,957	2.78	26,185	26,502	1.12
3	100	12.90	32,612	32,267	4.32	26,614	26,508	1.23
4	100	17.85	33,603	33,500	5.94	26,655	26,522	1.26
5	100	27.72	37,595	35,785	8.93	26,540	26,557	1.42
6	100	37.57	36,690	37,931	12.19	26,570	26,603	1.38

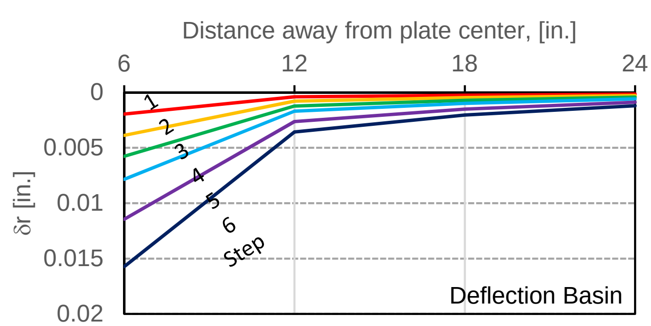




Model: AASHTO (2015)

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

Parameter	Value	P-Value
$k^*_{1\ (Base)}$	1983.2	9.44E-07
$k^*_{2\ (Base)}$	0.024	8.31E-01
$k^*_{3\ (Base)}$	0.651	4.54E-01
Adj. R^2	0.808	
Std. Error [psi]	1346	
$k^*_{1\ (Subgrade)}$	1793.0	2.03E-07
$k^*_{2\ (Subgrade)}$	-0.003	9.05E-01
$k^*_{3\ (Subgrade)}$	0.064	8.46E-01
Adj. R^2	-0.190	
Std. Error [psi]	43	



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

Project Name:	Interstate 5: North County Coastal Test Sections
Project ID:	TIC-00050
Location:	Encinitas, California

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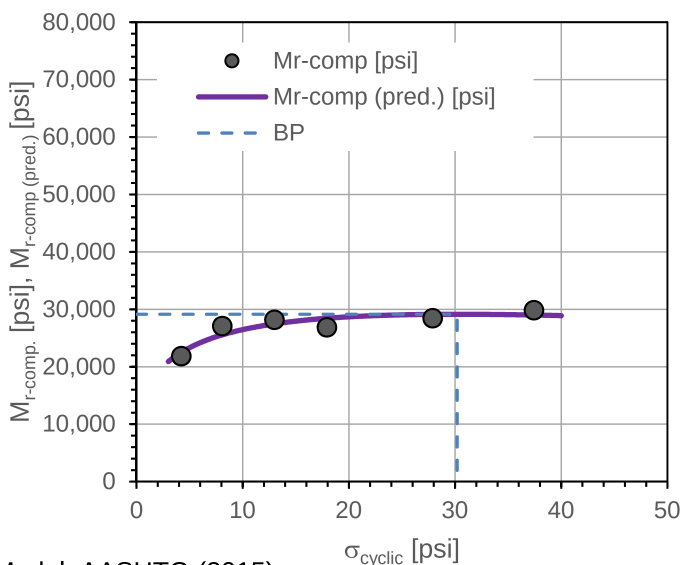
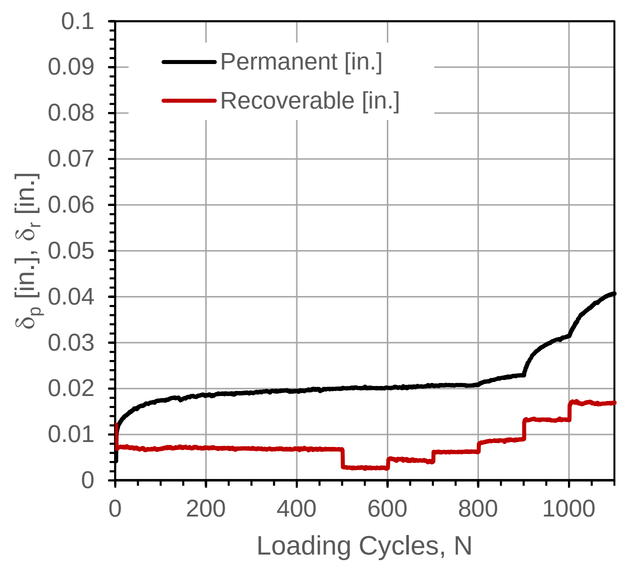
Automated Plate Load Test [APLT]

Test:	In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent (5, 10, 15, 20, 30, 40)				
Date:	8/1/2019	Time:	11:37:08 AM	Test ID	I5_NCC_TX5_0.85_pt12
Tested By	PV, LC, HG	Location:	I-5_NCC Test Sections	Sta.	NA
Latitude,N:	33.046978	Longitude,W:	117.286780	Elev. (ft):	NA
Comments:	Nominal 0.85 ft thick recycled aggregate base course layer over subgrade, with TX5 multiaxial georid at the base and subgrade interface.				

Step	N	σ_{cyclic} [psi]	$M_{r\text{-}comp}$ [psi]	$M_{r\text{-}comp\ (pred.)}$ [psi]	δ_p [in.]	$\Delta\delta_p$ [in.]	d =$\Delta\log(\delta_p)/\Delta\log(N)$	Near-linear Elastic
Conditioning	500	12.99	---	---	0.0200	---	0.122	---
1	100	4.22	21,843	22,515	0.0201	0.0002	0.016	Y
2	100	8.09	27,067	25,550	0.0208	0.0008	0.389	Y
3	100	12.99	28,170	27,464	0.0209	0.0009	0.131	Y
4	100	17.94	26,861	28,445	0.0229	0.0030	0.556	Y
5	100	27.90	28,446	29,121	0.0315	0.0115	0.602	N
6	100	37.43	29,829	29,006	0.0407	0.0207	0.753	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	1,778.6	1.44E-06
k^*_2	0.257	1.18E-01
k^*_3	-1.051	3.09E-01
Adj. R^2	0.775	
Std. Error [psi]	1,220	

$M_{r\text{-}comp\ (pred.)\text{-}BP}$ [psi]	29,139
$\sigma_{cyclic\text{-}BP}$ [psi]	30.2

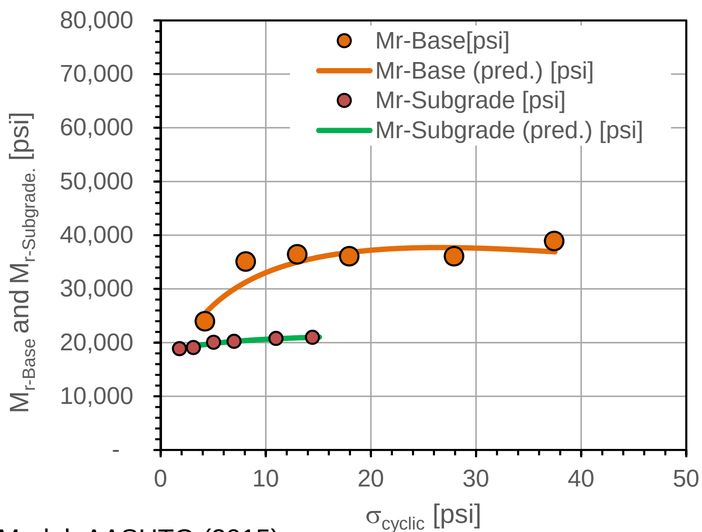
In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent

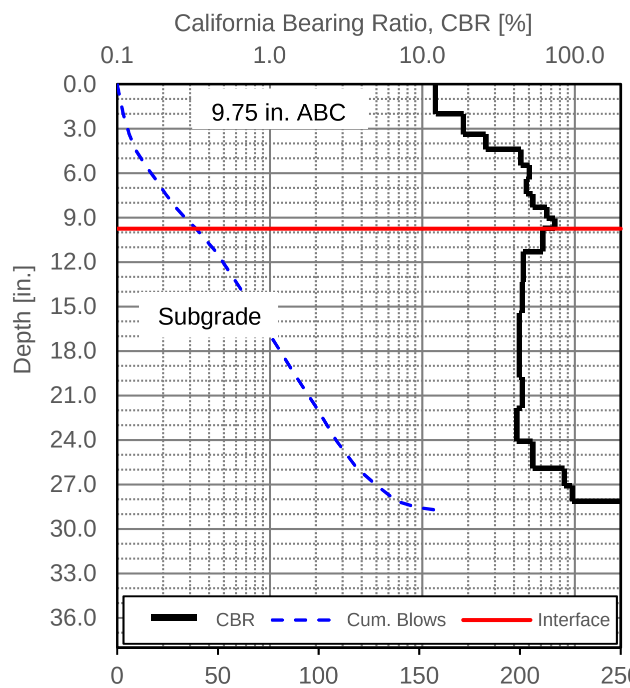
Project Name: Interstate 5: North County Coastal Test Sections
Project ID: TIC-00050
Location: Encinitas, California

Automated Plate Load Test [APLT]

Test:	In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent (5, 10, 15, 20, 30, 40)				
Date:	8/1/2019	Time:	11:37:08 AM	Test ID	I5_NCC_TX5_0.85_pt12
Tested By	PV, LC, HG	Location:	I-5_NCC Test Sections	Sta.	NA
Latitude, N:	33.046978	Longitude, W:	117.286780	Elev. (ft):	NA
Comments:	Nominal 0.85 ft thick recycled aggregate base course layer over subgrade, with TX5 multiaxial georid at the base and subgrade interface.				

Step	N	$\sigma_{cyclic\_surface}$ [psi]	$M_{r\text{-Base}}$[psi]	$M_{r\text{-Base (pred.)}}$ [psi]	$\sigma_{cyclic\_Int.}$ [psi]	$M_{r\text{-Subgrade}}$ [psi]	$M_{r\text{-Subgrade (pred.)}}$ [psi]	Modulus Ratio
Conditioning	500	12.99	---	---	---	---	---	---
1	100	4.22	23,964	25,429	1.81	18,855	18,747	1.27
2	100	8.09	35,088	31,244	3.13	19,060	19,316	1.84
3	100	12.99	36,437	34,981	5.05	20,023	19,853	1.82
4	100	17.94	36,072	36,802	7.00	20,206	20,226	1.79
5	100	27.90	36,085	37,682	10.98	20,752	20,715	1.74
6	100	37.43	38,905	36,908	14.45	20,951	20,987	1.86

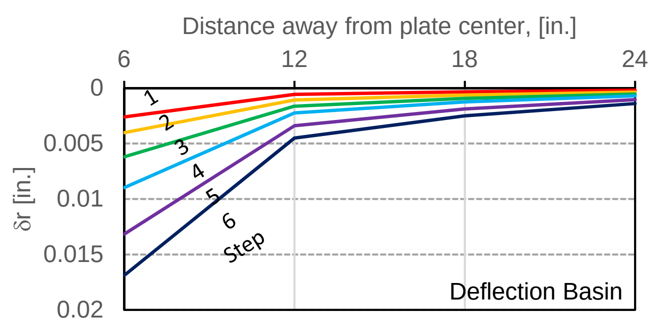




Model: AASHTO (2015)

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

Parameter	Value	P-Value
$k^*_{1\ (Base)}$	2244.0	9.14E-06
$k^*_{2\ (Base)}$	0.433	1.51E-01
$k^*_{3\ (Base)}$	-1.958	3.20E-01
Adj. R^2	0.644	
Std. Error [psi]	2819	
$k^*_{1\ (Subgrade)}$	1393.1	2.79E-07
$k^*_{2\ (Subgrade)}$	0.081	7.31E-02
$k^*_{3\ (Subgrade)}$	-0.185	5.97E-01
Adj. R^2	0.963	
Std. Error [psi]	163	



In-situ Resilient Modulus [Mr]: Cyclic Loading, Layered Analysis, Stress-Dependent	
Project Name:	Interstate 5: North County Coastal Test Sections
Project ID:	TIC-00050
Location:	Encinitas, California

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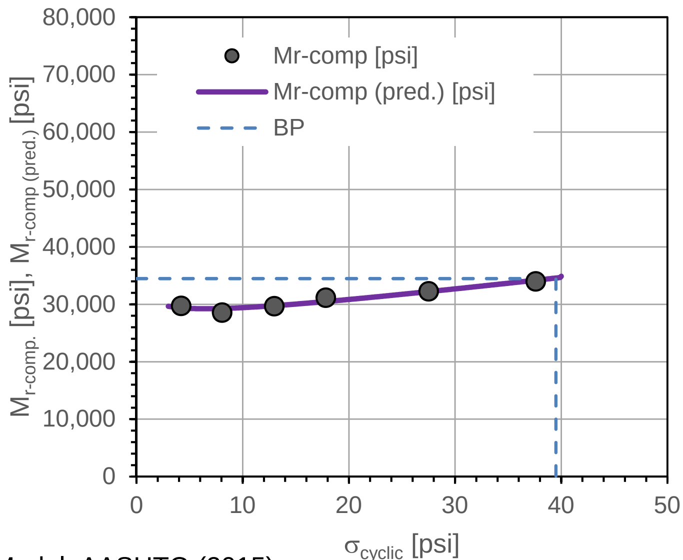
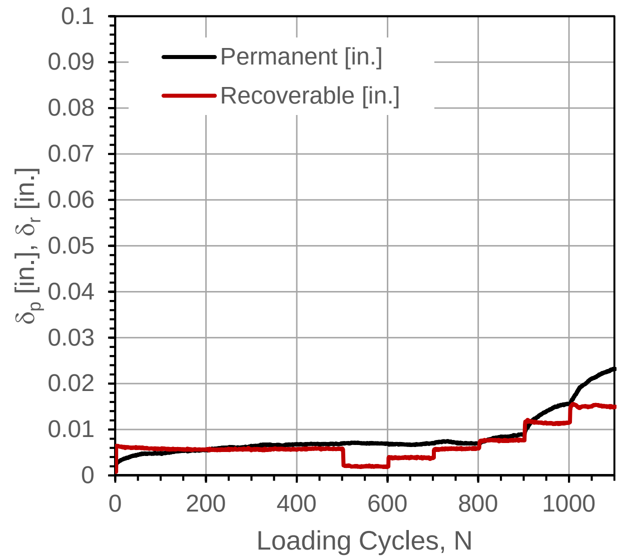
Automated Plate Load Test [APLT]

Test:	In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent (5, 10, 15, 20, 30, 40)				
Date:	8/1/2019	Time:	12:09:32 PM	Test ID	I5_NCC_TX5_0.85_pt13
Tested By	PV, LC, HG	Location:	I-5_NCC Test Sections	Sta.	NA
Latitude,N:	33.046993	Longitude,W:	117.286770	Elev. (ft):	NA
Comments:	Nominal 0.85 ft thick recycled aggregate base course layer over subgrade, with TX5 multiaxial georid at the base and subgrade interface. Measured base layer thickness = 9.75 in.				

Step	N	σ_{cyclic} [psi]	$M_{r\text{-}comp}$ [psi]	$M_{r\text{-}comp\ (pred.)}$ [psi]	δ_p [in.]	$\Delta\delta_p$ [in.]	d =$\Delta\log(\delta_p)$/ $\Delta\log(N)$	Near-linear Elastic
Conditioning	500	12.97	---	---	0.0069	---	0.204	---
1	100	4.20	29,714	29,378	0.0069	0.0000	-0.051	Y
2	100	8.06	28,566	29,279	0.0071	0.0001	-0.018	Y
3	100	12.97	29,668	29,763	0.0070	0.0000	-0.212	Y
4	100	17.84	31,143	30,486	0.0090	0.0020	0.601	Y
5	100	27.52	32,265	32,217	0.0155	0.0086	0.726	N
6	100	37.60	33,979	34,196	0.0232	0.0163	0.836	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	1,863.5	6.55E-08
k^*_2	-0.064	2.25E-01
k^*_3	0.998	4.83E-02
Adj. R^2	0.930	
Std. Error [psi]	516	

$M_{r\text{-}comp\ (pred.)\text{-}BP}$ [psi]	34,479
$\sigma_{cyclic\text{-}BP}$ [psi]	39.5

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

Project Name: Interstate 5: North County Coastal Test Sections
Project ID: TIC-00050
Location: Encinitas, California

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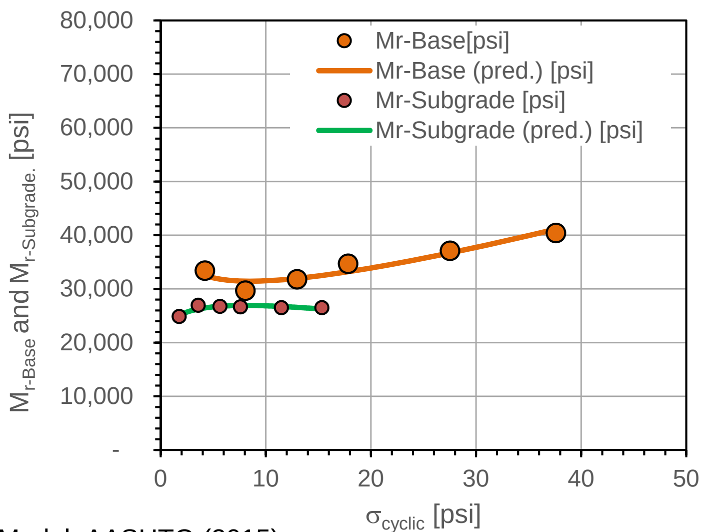
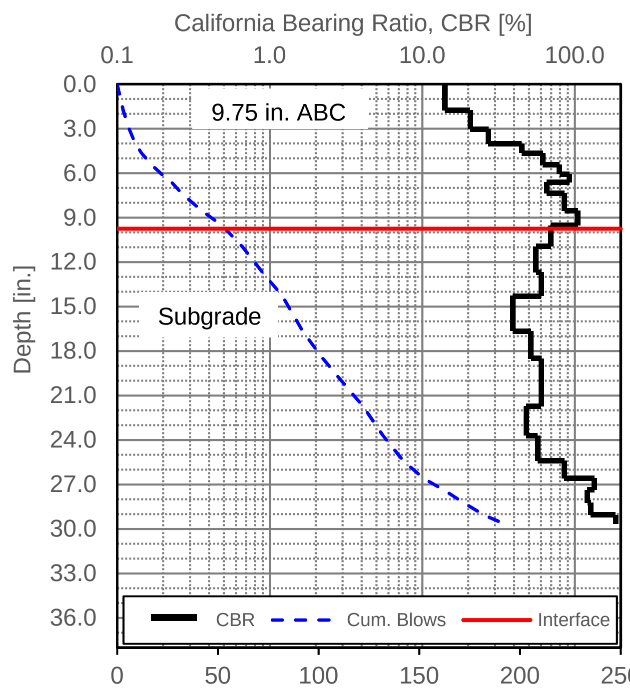
Automated Plate Load Test [APLT]

Test:	In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent (5, 10, 15, 20, 30, 40)				
Date:	8/1/2019	Time:	12:09:32 PM	Test ID	I5_NCC_TX5_0.85_pt13
Tested By	PV, LC, HG	Location:	I-5_NCC Test Sections	Sta.	NA
Latitude, N:	33.046993	Longitude, W:	117.286770	Elev. (ft):	NA
Comments:	Nominal 0.85 ft thick recycled aggregate base course layer over subgrade, with TX5 multiaxial georid at the base and subgrade interface. Measured base layer thickness = 9.75 in.				

Step	N	$\sigma_{cyclic\_surface}$ [psi]	$M_{r\text{-}Base}$[psi]	$M_{r\text{-}Base\ (pred.)}$ [psi]	$\sigma_{cyclic\_Int.}$ [psi]	$M_{r\text{-}Subgrade}$ [psi]	$M_{r\text{-}Subgrade\ (pred.)}$ [psi]	Modulus Ratio
Conditioning	500	12.97	---	---	---	---	---	---
1	100	4.20	33,385	32,492	1.78	24,839	25,124	1.34
2	100	8.06	29,657	31,443	3.59	26,916	26,245	1.10
3	100	12.97	31,797	31,954	5.66	26,704	26,769	1.19
4	100	17.84	34,689	33,205	7.60	26,620	26,917	1.30
5	100	27.52	37,087	36,701	11.50	26,487	26,730	1.40
6	100	37.60	40,413	41,143	15.34	26,471	26,239	1.53

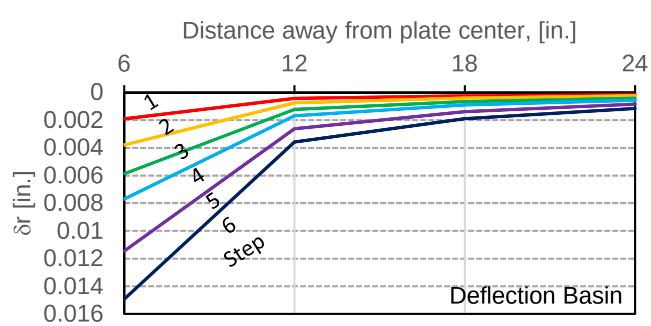




Model: AASHTO (2015)

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

Parameter	Value	P-Value
$k^*_{1\ (Base)}$	1875.4	7.85E-07
$k^*_{2\ (Base)}$	-0.176	1.67E-01
$k^*_{3\ (Base)}$	2.117	5.81E-02
Adj. R^2	0.884	
Std. Error [psi]	1280	
$k^*_{1\ (Subgrade)}$	2057.6	1.18E-06
$k^*_{2\ (Subgrade)}$	0.139	7.59E-02
$k^*_{3\ (Subgrade)}$	-1.198	1.10E-01
Adj. R^2	0.675	
Std. Error [psi]	375	



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

Project Name:	Interstate 5: North County Coastal Test Sections
Project ID:	TIC-00050
Location:	Encinitas, California

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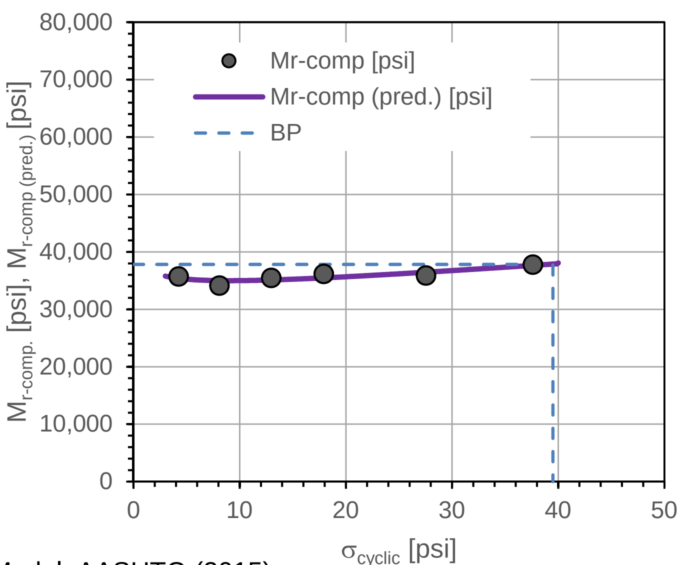
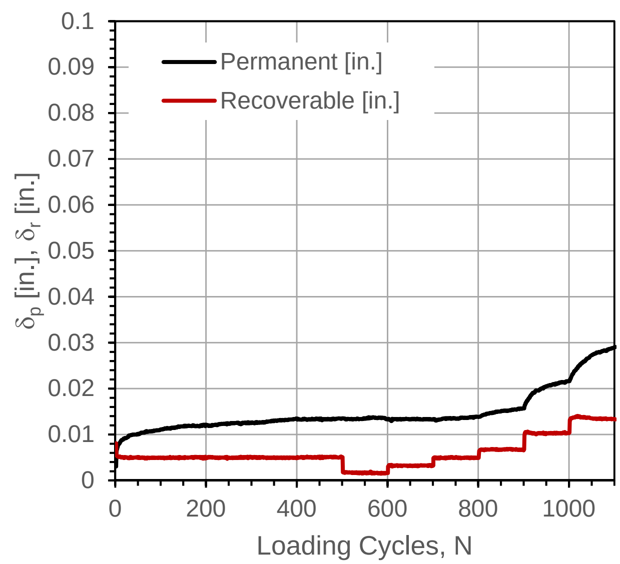
Automated Plate Load Test [APLT]

Test:	In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent (5, 10, 15, 20, 30, 40)				
Date:	8/1/2019	Time:	12:38:00 PM	Test ID	**I5_NCC_TX5_0.85_pt14**
Tested By	PV, LC, HG	Location:	I-5_NCC Test Sections	Sta.	NA
Latitude,N:	33.047016	Longitude,W:	117.286790	Elev. (ft):	NA
Comments:	Nominal 0.85 ft thick recycled aggregate base course layer over subgrade, with TX5 multiaxial georid at the base and subgrade interface.				

Step	N	σ_{cyclic} [psi]	$M_{r\text{-}comp}$ [psi]	$M_{r\text{-}comp\ (pred.)}$ [psi]	δ_p [in.]	$\Delta\delta_p$ [in.]	d $=\Delta\log(\delta_p)/\Delta\log(N)$	Near-linear Elastic
Conditioning	500	12.97	---	---	0.0135	---	0.134	---
1	100	4.25	35,712	35,393	0.0133	-0.0002	0.230	Y
2	100	8.09	34,122	35,002	0.0133	-0.0002	0.058	Y
3	100	12.97	35,458	35,115	0.0139	0.0003	0.328	Y
4	100	17.93	36,163	35,480	0.0157	0.0022	0.631	Y
5	100	27.55	35,891	36,466	0.0217	0.0081	0.594	N
6	100	37.61	37,785	37,650	0.0290	0.0155	0.719	N





Model: AASHTO (2015)

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

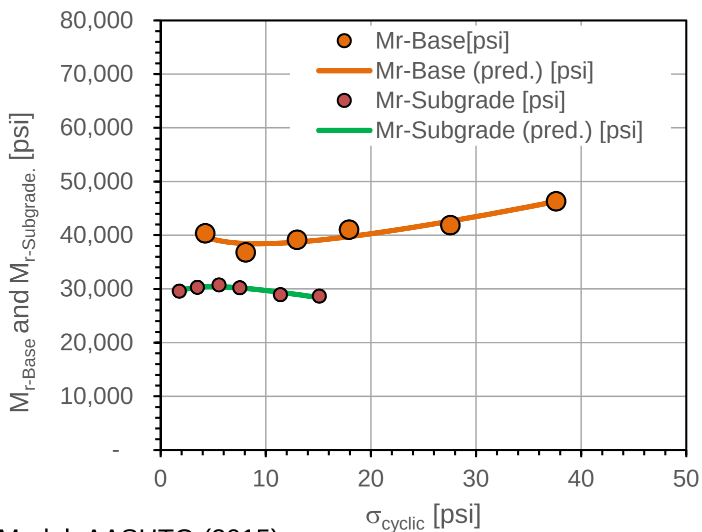
Parameter	Value	P-Value
k^*_1	2,294.3	7.62E-08
k^*_2	-0.054	3.29E-01
k^*_3	0.610	1.67E-01
Adj. R^2	0.677	
Std. Error [psi]	581	

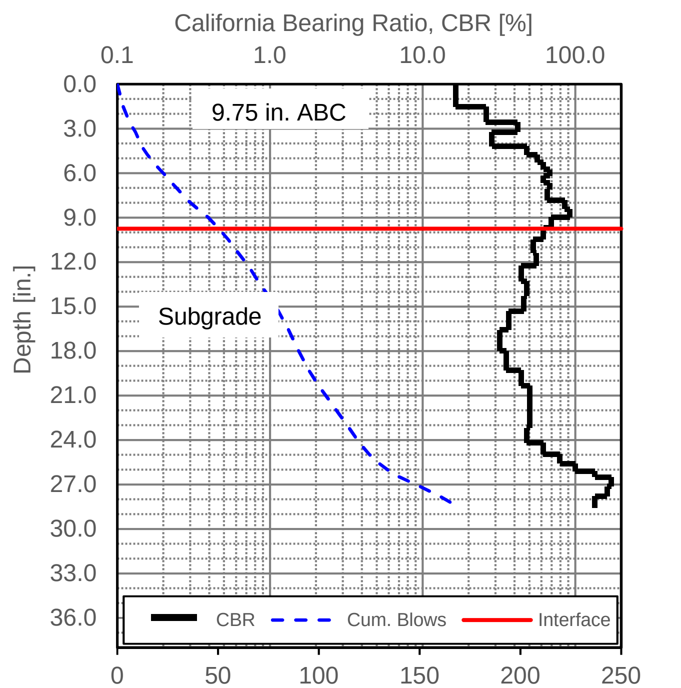
$M_{r\text{-}comp\ (pred.)\text{-}BP}$ [psi]	37,818
$\sigma_{cyclic\text{-}BP}$ [psi]	39.5

Automated Plate Load Test [APLT]

Test:	In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent (5, 10, 15, 20, 30, 40)				
Date:	8/1/2019	Time:	12:38:00 PM	Test ID	**I5_NCC_TX5_0.85_pt14**
Tested By	PV, LC, HG	Location:	I-5_NCC Test Sections	Sta.	NA
Latitude, N:	33.047016	Longitude, W:	117.286790	Elev. (ft):	NA
Comments:	Nominal 0.85 ft thick recycled aggregate base course layer over subgrade, with TX5 multiaxial georid at the base and subgrade interface.				

Step	N	$\sigma_{cyclic\_surface}$ [psi]	$M_{r\text{-Base}}$[psi]	$M_{r\text{-Base (pred.)}}$ [psi]	$\sigma_{cyclic\_Int.}$ [psi]	$M_{r\text{-Subgrade}}$ [psi]	$M_{r\text{-Subgrade (pred.)}}$ [psi]	Modulus Ratio
Conditioning	500	12.97	---	---	---	---	---	---
1	100	4.25	40,340	39,671	1.79	29,541	29,604	1.37
2	100	8.09	36,810	38,450	3.51	30,254	30,286	1.22
3	100	12.97	39,154	38,715	5.56	30,727	30,400	1.27
4	100	17.93	41,042	39,732	7.55	30,171	30,185	1.36
5	100	27.55	41,871	42,619	11.41	28,899	29,366	1.45
6	100	37.61	46,321	46,282	15.10	28,631	28,375	1.62

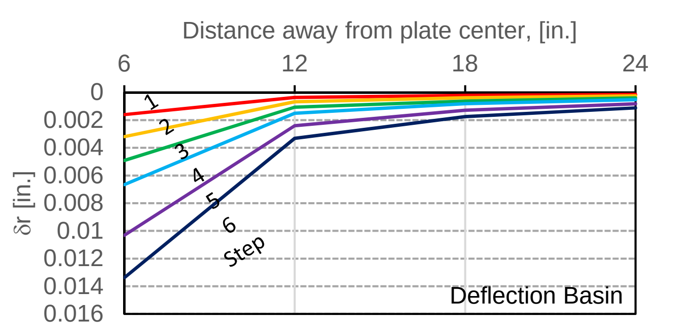




Model: AASHTO (2015)

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

Parameter	Value	P-Value
$k^*_{1\ (Base)}$	2375.7	3.02E-07
$k^*_{2\ (Base)}$	-0.144	1.45E-01
$k^*_{3\ (Base)}$	1.593	5.85E-02
Adj. R^2	0.861	
Std. Error [psi]	1125	
$k^*_{1\ (Subgrade)}$	2375.1	3.46E-07
$k^*_{2\ (Subgrade)}$	0.111	5.06E-02
$k^*_{3\ (Subgrade)}$	-1.407	2.99E-02
Adj. R^2	0.854	
Std. Error [psi]	293	



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

Project Name:	Interstate 5: North County Coastal Test Sections
Project ID:	TIC-00050
Location:	Encinitas, California

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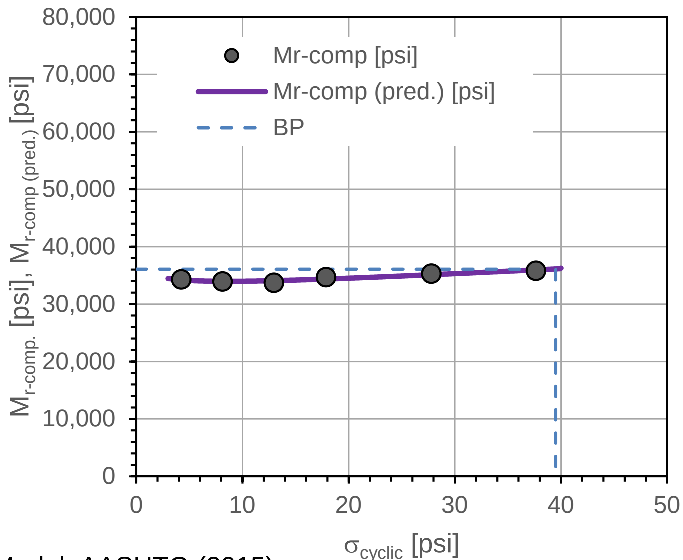
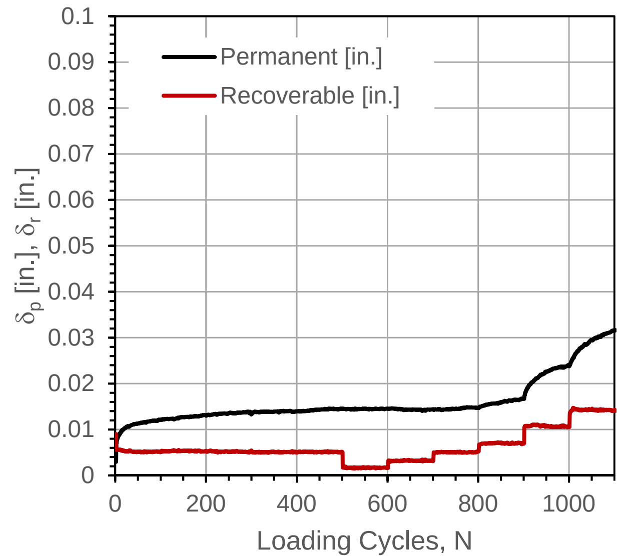
Automated Plate Load Test [APLT]

Test:	In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent (5, 10, 15, 20, 30, 40)				
Date:	8/1/2019	Time:	1:07:23 PM	Test ID	I5_NCC_TX5_0.85_pt15
Tested By	PV, LC, HG	Location:	I-5_NCC Test Sections	Sta.	NA
Latitude,N:	33.047031	Longitude,W:	117.286790	Elev. (ft):	NA
Comments:	Nominal 0.85 ft thick recycled aggregate base course layer over subgrade, with TX5 multiaxial georid at the base and subgrade interface.				

Step	N	σ_{cyclic} [psi]	$M_{r\text{-}comp}$ [psi]	$M_{r\text{-}comp\ (pred.)}$ [psi]	δ_p [in.]	$\Delta\delta_p$ [in.]	d =$\Delta\log(\delta_p)/\Delta\log(N)$	Near-linear Elastic
Conditioning	500	12.96	---	---	0.0145	---	0.124	---
1	100	4.24	34,292	34,209	0.0146	0.0000	0.017	Y
2	100	8.12	33,923	33,970	0.0144	-0.0001	-0.207	Y
3	100	12.96	33,713	34,082	0.0147	0.0002	0.372	Y
4	100	17.87	34,678	34,361	0.0167	0.0022	0.573	Y
5	100	27.79	35,300	35,116	0.0238	0.0092	0.583	N
6	100	37.64	35,795	35,958	0.0316	0.0171	0.722	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	2,247.3	5.72E-09
k^*_2	-0.038	1.48E-01
k^*_3	0.450	4.98E-02
Adj. R^2	0.883	
Std. Error [psi]	265	

$M_{r\text{-}comp\ (pred.)\text{-}BP}$ [psi]	36,077
$\sigma_{cyclic\text{-}BP}$ [psi]	39.5

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

Project Name:	Interstate 5: North County Coastal Test Sections
Project ID:	TIC-00050
Location:	Encinitas, California

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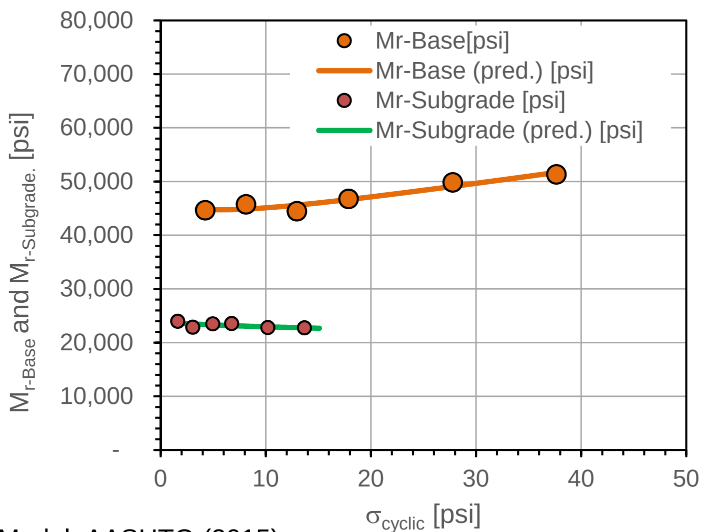
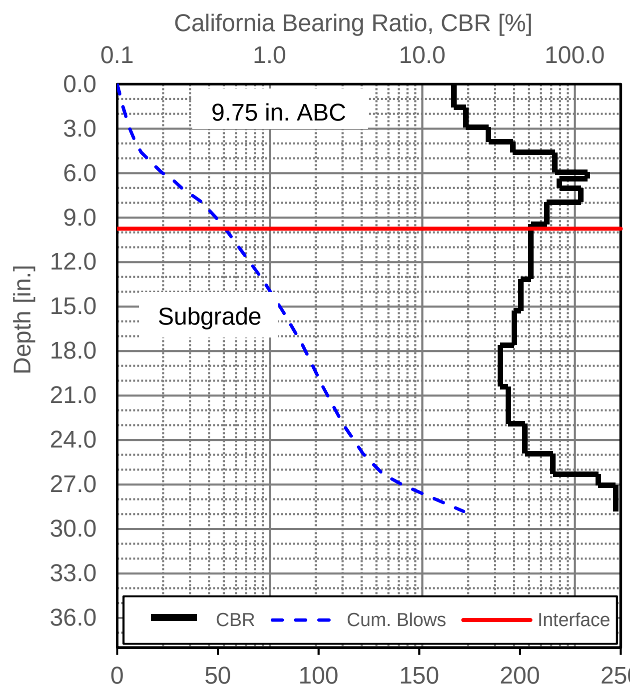
Automated Plate Load Test [APLT]

Test:	In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent (5, 10, 15, 20, 30, 40)				
Date:	8/1/2019	Time:	1:07:23 PM	Test ID	I5_NCC_TX5_0.85_pt15
Tested By	PV, LC, HG	Location:	I-5_NCC Test Sections	Sta.	NA
Latitude, N:	33.047031	Longitude, W:	117.286790	Elev. (ft):	NA
Comments:	Nominal 0.85 ft thick recycled aggregate base course layer over subgrade, with TX5 multiaxial georid at the base and subgrade interface.				

Step	N	$\sigma_{cyclic\_surface}$ [psi]	$M_{r\text{-}Base}$[psi]	$M_{r\text{-}Base\ (pred.)}$ [psi]	$\sigma_{cyclic\_Int.}$ [psi]	$M_{r\text{-}Subgrade}$ [psi]	$M_{r\text{-}Subgrade\ (pred.)}$ [psi]	Modulus Ratio
Conditioning	500	12.96	---	---	---	---	---	---
1	100	4.24	44,651	44,835	1.63	23,940	23,658	1.87
2	100	8.12	45,745	44,863	3.07	22,837	23,476	2.00
3	100	12.96	44,450	45,602	4.97	23,472	23,295	1.89
4	100	17.87	46,755	46,642	6.76	23,523	23,157	1.99
5	100	27.79	49,831	49,083	10.21	22,783	22,935	2.19
6	100	37.64	51,316	51,693	13.70	22,725	22,745	2.26

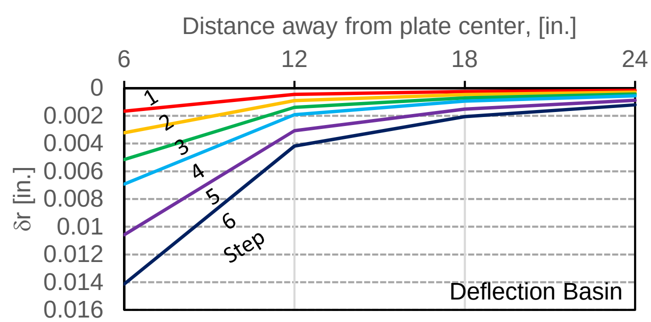




Model: AASHTO (2015)

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

Parameter	Value	P-Value
$k^*_{1\ (Base)}$	2877.7	6.15E-08
$k^*_{2\ (Base)}$	-0.051	3.37E-01
$k^*_{3\ (Base)}$	0.860	7.55E-02
Adj. R^2	0.911	
Std. Error [psi]	817	
$k^*_{1\ (Subgrade)}$	1596.5	2.37E-06
$k^*_{2\ (Subgrade)}$	-0.011	8.60E-01
$k^*_{3\ (Subgrade)}$	-0.119	8.69E-01
Adj. R^2	0.327	
Std. Error [psi]	278	



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

Project Name: Interstate 5: North County Coastal Test Sections
Project ID: TIC-00050
Location: Encinitas, California

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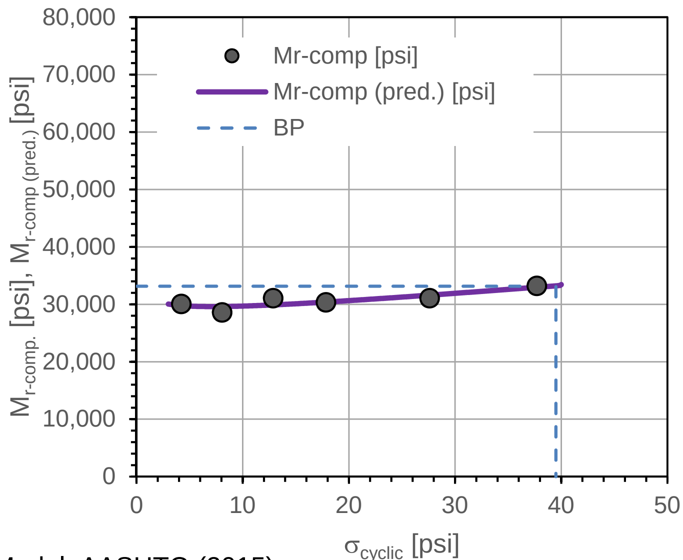
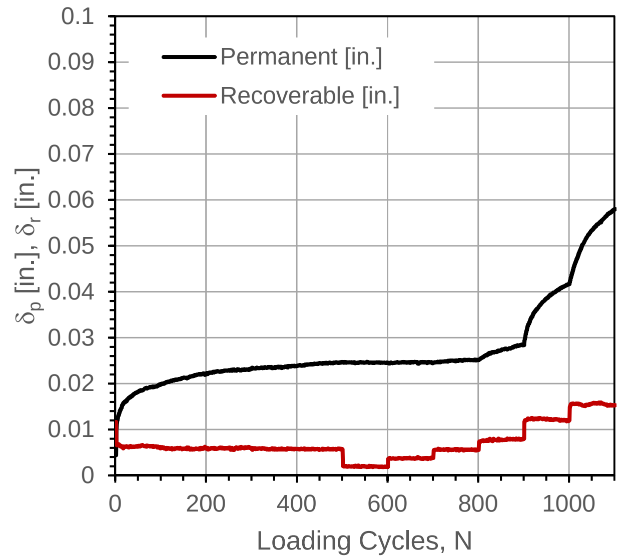
Automated Plate Load Test [APLT]

Test:	In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent (5, 10, 15, 20, 30, 40)				
Date:	8/1/2019	Time:	1:38:12 PM	Test ID	I5_NCC_CTRL_2.25_pt16
Tested By	PV, LC, HG	Location:	I-5_NCC Test Sections	Sta.	NA
Latitude,N:	33.047310	Longitude,W:	117.286880	Elev. (ft):	NA
Comments:	Nominal 2.25 ft thick recycled aggregate base course layer over subgrade (Control).				

Step	N	σ_{cyclic} [psi]	$M_{r\text{-}comp}$ [psi]	$M_{r\text{-}comp\ (pred.)}$ [psi]	δ_p [in.]	$\Delta\delta_p$ [in.]	d = $\Delta\log(\delta_p)/\Delta\log(N)$	Near-linear Elastic
Conditioning	500	12.87	---	---	0.0246	---	0.152	---
1	100	4.22	30,063	29,782	0.0246	-0.0001	-0.089	Y
2	100	8.06	28,580	29,617	0.0244	-0.0002	0.107	Y
3	100	12.87	31,071	29,900	0.0251	0.0004	0.432	Y
4	100	17.85	30,334	30,396	0.0284	0.0038	0.719	N
5	100	27.61	31,069	31,602	0.0416	0.0170	0.653	N
6	100	37.71	33,202	32,975	0.0579	0.0332	0.807	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	1,920.7	2.61E-07
k^*_2	-0.052	4.97E-01
k^*_3	0.735	2.33E-01
Adj. R^2	0.690	
Std. Error [psi]	735	

$M_{r\text{-}comp\ (pred.)\text{-}BP}$ [psi]	33,154
$\sigma_{cyclic\text{-}BP}$ [psi]	39.5

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

Project Name: Interstate 5: North County Coastal Test Sections
Project ID: TIC-00050
Location: Encinitas, California

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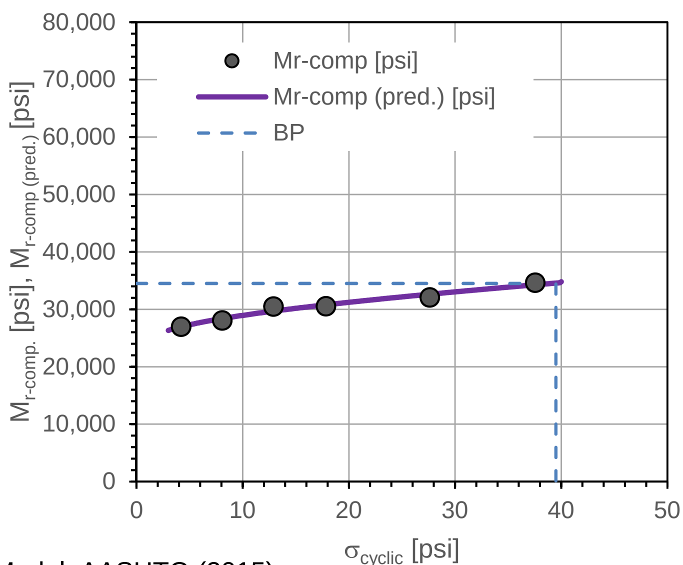
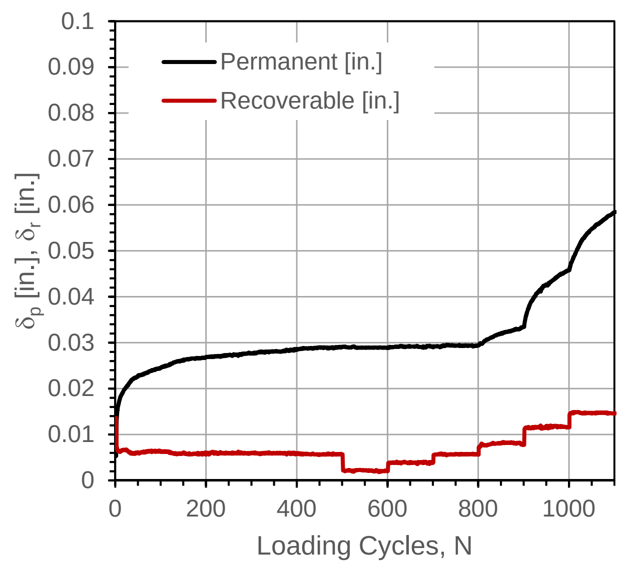
Automated Plate Load Test [APLT]

Test:	In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent (5, 10, 15, 20, 30, 40)				
Date:	8/1/2019	Time:	2:07:30 PM	Test ID	I5_NCC_CTRL_2.25_pt17
Tested By	PV, LC, HG	Location:	I-5_NCC Test Sections	Sta.	NA
Latitude,N:	33.047333	Longitude,W:	117.286880	Elev. (ft):	NA
Comments:	Nominal 2.25 ft thick recycled aggregate base course layer over subgrade (Control).				

Step	N	σ_{cyclic} [psi]	$M_{r\text{-}comp}$ [psi]	$M_{r\text{-}comp\ (pred.)}$ [psi]	δ_p [in.]	$\Delta\delta_p$ [in.]	d =$\Delta\log(\delta_p)/\Delta\log(N)$	Near-linear Elastic
Conditioning	500	12.90	---	---	0.0291	---	0.138	---
1	100	4.21	26,972	26,958	0.0289	-0.0002	-0.249	Y
2	100	8.08	28,054	28,392	0.0292	0.0001	0.170	Y
3	100	12.90	30,491	29,687	0.0294	0.0003	0.196	Y
4	100	17.84	30,541	30,784	0.0334	0.0043	0.680	N
5	100	27.63	32,069	32,634	0.0457	0.0166	0.653	N
6	100	37.55	34,618	34,269	0.0584	0.0293	0.724	N





Model: AASHTO (2015)

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

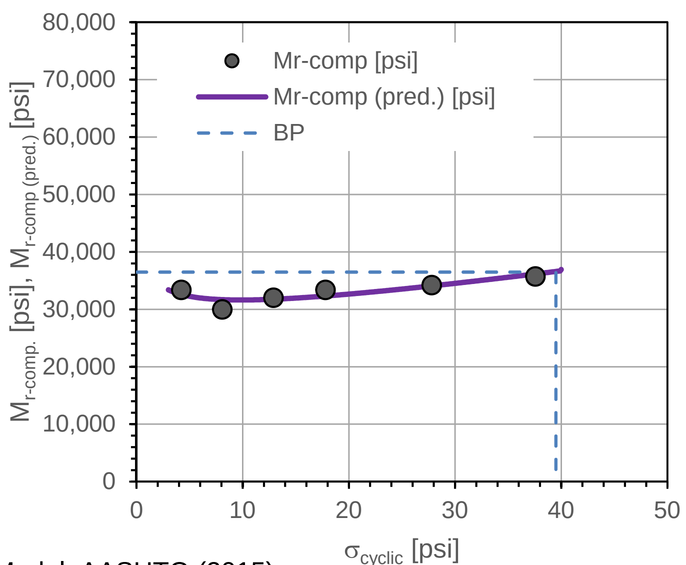
Parameter	Value	P-Value
k^*_1	1,842.0	7.29E-08
k^*_2	0.055	2.98E-01
k^*_3	0.406	2.94E-01
Adj. R^2	0.958	
Std. Error [psi]	551	

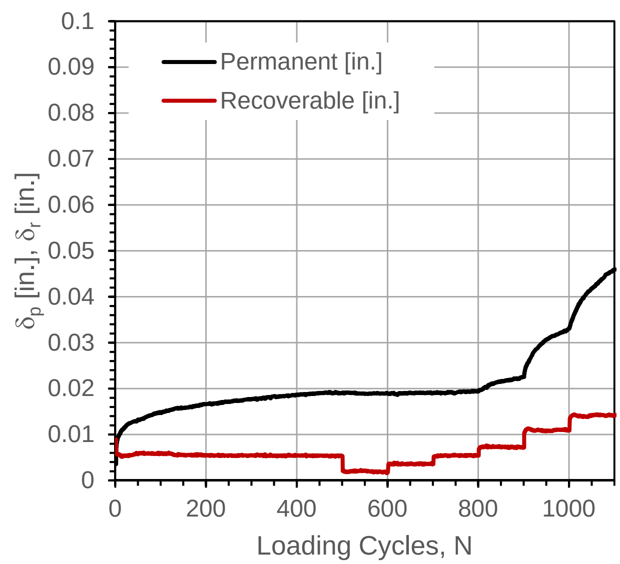
$M_{r\text{-}comp\ (pred.)\text{-}BP}$ [psi]	34,494
$\sigma_{cyclic\text{-}BP}$ [psi]	39.5

Automated Plate Load Test [APLT]

Test:	In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent (5, 10, 15, 20, 30, 40)				
Date:	8/1/2019	Time:	2:38:59 PM	Test ID	I5_NCC_CTRL_2.25_pt18
Tested By	PV, LC, HG	Location:	I-5_NCC Test Sections	Sta.	NA
Latitude,N:	33.047352	Longitude,W:	117.286880	Elev. (ft):	NA
Comments:	Nominal 2.25 ft thick recycled aggregate base course layer over subgrade (Control).				

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	12.90	---	---	0.0190	---	0.172	---
1	100	4.22	33,364	32,587	0.0190	0.0000	-0.241	Y
2	100	8.08	29,981	31,686	0.0191	0.0001	0.162	Y
3	100	12.90	32,009	31,757	0.0195	0.0005	0.282	Y
4	100	17.80	33,365	32,318	0.0225	0.0035	0.668	N
5	100	27.81	34,222	34,078	0.0331	0.0141	0.614	N
6	100	37.57	35,718	36,158	0.0460	0.0270	0.781	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	2,005.9	4.91E-07
k^*_2	-0.116	2.63E-01
k^*_3	1.216	1.42E-01
Adj. R^2	0.682	
Std. Error [psi]	976	

$M_{r-comp\ (pred.)-BP}$ [psi]	36,481
$\sigma_{cyclic-BP}$ [psi]	39.5

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

Project Name:	Interstate 5: North County Coastal Test Sections
Project ID:	TIC-00050
Location:	Encinitas, California

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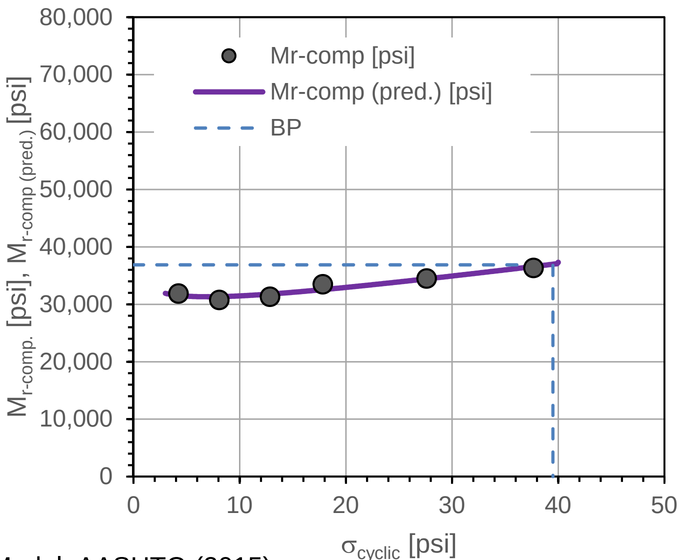
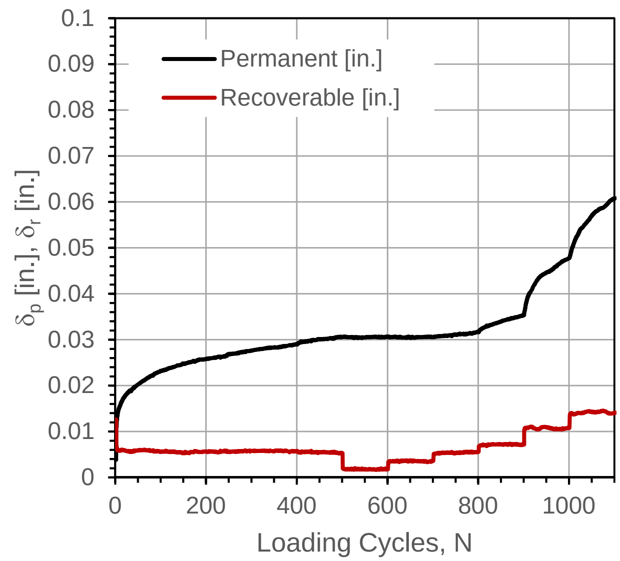
Automated Plate Load Test [APLT]

Test:	In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent (5, 10, 15, 20, 30, 40)				
Date:	8/1/2019	Time:	3:13:26 PM	Test ID	I5_NCC_CTRL_2.25_pt19
Tested By	PV, LC, HG	Location:	I-5_NCC Test Sections	Sta.	NA
Latitude,N:	33.047379	Longitude,W:	117.286890	Elev. (ft):	NA
Comments:	Nominal 2.25 ft thick recycled aggregate base course layer over subgrade (Control).				

Step	N	σ_{cyclic} [psi]	$M_{r\text{-}comp}$ [psi]	$M_{r\text{-}comp\ (pred.)}$ [psi]	δ_p [in.]	$\Delta\delta_p$ [in.]	d =$\Delta\log(\delta_p)$/ $\Delta\log(N)$	Near-linear Elastic
Conditioning	500	12.86	---	---	0.0306	---	0.185	---
1	100	4.24	31,871	31,543	0.0306	0.0000	-0.017	Y
2	100	8.09	30,770	31,340	0.0306	0.0000	-0.016	Y
3	100	12.86	31,319	31,790	0.0317	0.0011	0.514	Y
4	100	17.84	33,495	32,561	0.0353	0.0048	0.611	N
5	100	27.61	34,497	34,434	0.0478	0.0172	0.641	N
6	100	37.67	36,321	36,581	0.0607	0.0302	0.776	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	1,991.5	8.55E-08
k^*_2	-0.072	2.24E-01
k^*_3	1.039	5.63E-02
Adj. R^2	0.912	
Std. Error [psi]	615	

$M_{r\text{-}comp\ (pred.)\text{-}BP}$ [psi]		36,875
	$\sigma_{cyclic\text{-}BP}$ [psi]	39.5

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

Project Name:	Interstate 5: North County Coastal Test Sections
Project ID:	TIC-00050
Location:	Encinitas, California

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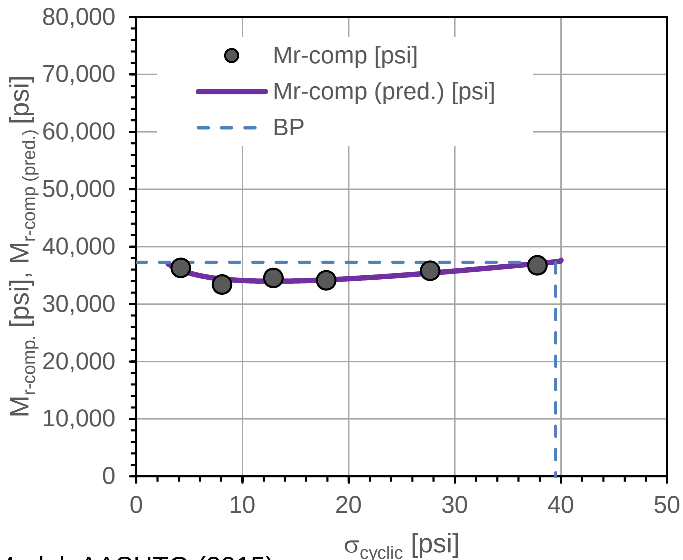
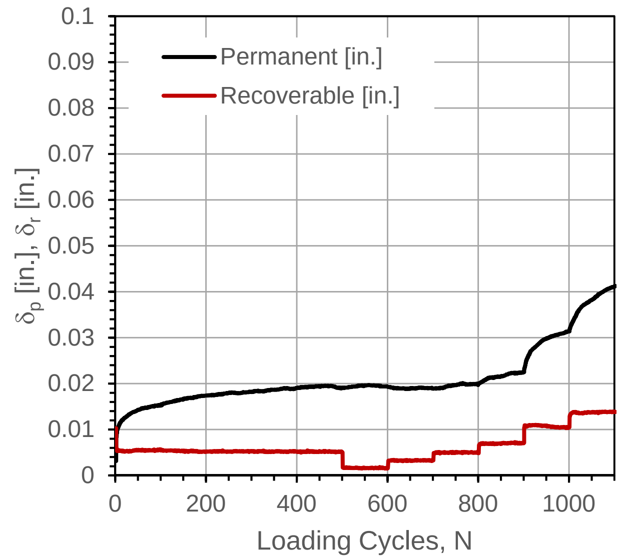
Automated Plate Load Test [APLT]

Test:	In-situ Resilient Modulus [Mr]: Cyclic Loading, Composite, Stress-Dependent (5, 10, 15, 20, 30, 40)				
Date:	8/1/2019	Time:	3:44:23 PM	Test ID	I5_NCC_CTRL_2.25_pt20
Tested By	PV, LC, HG	Location:	I-5_NCC Test Sections	Sta.	NA
Latitude,N:	33.047455	Longitude,W:	117.286910	Elev. (ft):	NA
Comments:	Nominal 2.25 ft thick recycled aggregate base course layer over subgrade (Control).				

Step	N	σ_{cyclic} [psi]	$M_{r\text{-}comp}$ [psi]	$M_{r\text{-}comp\ (pred.)}$ [psi]	δ_p [in.]	$\Delta\delta_p$ [in.]	d =$\Delta\log(\delta_p)/\Delta\log(N)$	Near-linear Elastic
Conditioning	500	12.91	---	---	0.0190	---	0.154	---
1	100	4.20	36,293	35,904	0.0193	0.0003	0.376	Y
2	100	8.08	33,414	34,366	0.0189	-0.0001	-0.139	Y
3	100	12.91	34,550	33,982	0.0197	0.0007	0.714	Y
4	100	17.88	34,130	34,211	0.0225	0.0035	0.626	Y
5	100	27.68	35,804	35,394	0.0314	0.0124	0.569	N
6	100	37.78	36,747	37,058	0.0411	0.0221	0.685	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	2,207.9	7.11E-08
k^*_2	-0.131	6.02E-02
k^*_3	1.085	4.42E-02
Adj. R^2	0.763	
Std. Error [psi]	582	

No Picture

$M_{r\text{-}comp\ (pred.)\text{-}BP}$ [psi]	37,275
$\sigma_{cyclic\text{-}BP}$ [psi]	39.5

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

Project Name: Interstate 5: North County Coastal Test Sections
Project ID: TIC-00050
Location: Encinitas, California

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Date of Test	8/1/2019	Test ID	I5_NCC_TX5_pt1	Operator	HG, LC	ASTM	D6951
Latitude, N	33.04591		Longitude, W	117.286450		Elevation (ft)	NA
Location	I-5_NCC Test Sections		Station	NA			
Comments	Nominal 0.35 ft (measured = 4.0 in.) thick recycled aggregate base course layer over subgrade, with TX5 multiaxial georid at the base and subgrade interface.						

Parameter	DPI (mm/blow)	CBR (%)	E_{CBR}, Elastic Modulus (ksi) (non stress-dependent)	$S_{u\text{-}CBR}$, Bearing Capacity (psf)
Avg. Top Layer [0-4.0 in.]	5.6	42.8	28.2	6,617
Avg. Bottom Layer [4.0-24 in.]	Refusal	Refusal	Refusal	Refusal
Ratio of Avg.0-4.0 in./4.3-24 in.	NA	NA	NA	NA
Stdev Top Layer [0-4.0 in.]	0.9	9.0	10.4	2,355
Stdev. Bottom Layer [4.0-24 in.]	Refusal	Refusal	Refusal	Refusal

NOTES:

Subgrade is assumed as silty sand.

[1]CBR = $292/DPI^{1.12}$

[1]CBR = 1/(0.002871*DPI)

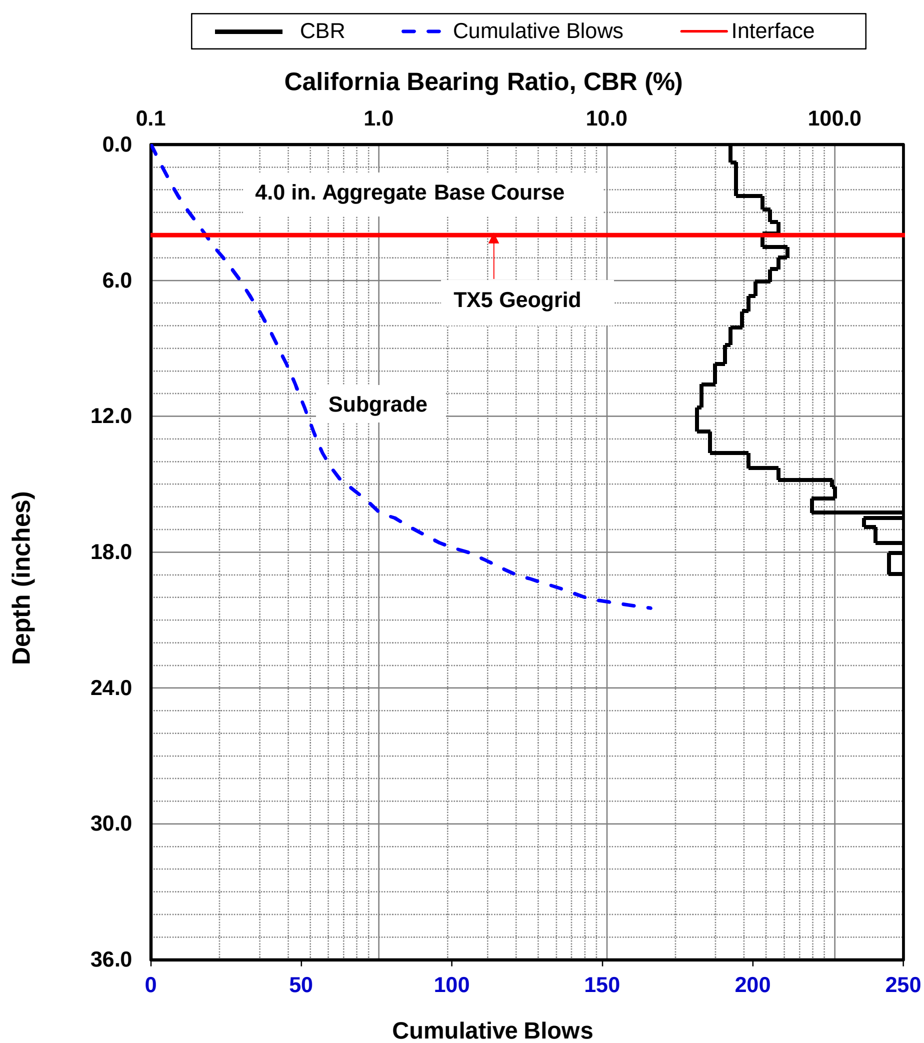
[2]E (ksi) = $(17.6\ CBR^{0.64}) \times 0.1450377$

[3]S_u (psf) =$(3.794 \times CBR^{0.664}) \times 144$

[1]ASTM D6951-03

[2]Powell et al. (1986)

[3]Portland Cement Assoc. (1955)



Dynamic Cone Penetrometer (DCP) Test Results

Project Name:	Interstate 5: North County Coastal Test Sections
Project ID:	TIC-00050
Location:	Encinitas, California

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Date of Test	8/1/2019	Test ID	I5_NCC_TX5_pt2	Operator	HG, LC	ASTM	D6951
Latitude, N	33.04592		Longitude, W	117.286450		Elevation (ft)	NA
Location	I-5_NCC Test Sections		Station	NA			
Comments	Nominal 0.35 ft (measured = 4.2 in.) thick recycled aggregate base course layer over subgrade, with TX5 multiaxial georid at the base and subgrade interface.						

Parameter	DPI (mm/blow)	CBR (%)	E_{CBR}, Elastic Modulus (ksi) (non stress-dependent)	$S_{u\text{-}CBR}$, Bearing Capacity (psf)
Avg. Top Layer [0-4.2 in.]	7.4	31.0	23.0	5,346
Avg. Bottom Layer [4.2-24 in.]	Refusal	Refusal	Refusal	Refusal
Ratio of Avg.0-4.2 in./4.2-24 in.	NA	NA	NA	NA
Stdev Top Layer [0-4.2 in.]	2.1	13.4	13.5	3,064
Stdev. Bottom Layer [4.2-24 in.]	Refusal	Refusal	Refusal	Refusal

NOTES:

Subgrade is assumed as silty sand.

[1]$CBR = 292/DPI^{1.12}$

[1]$CBR = 1/(0.002871 \cdot DPI)$

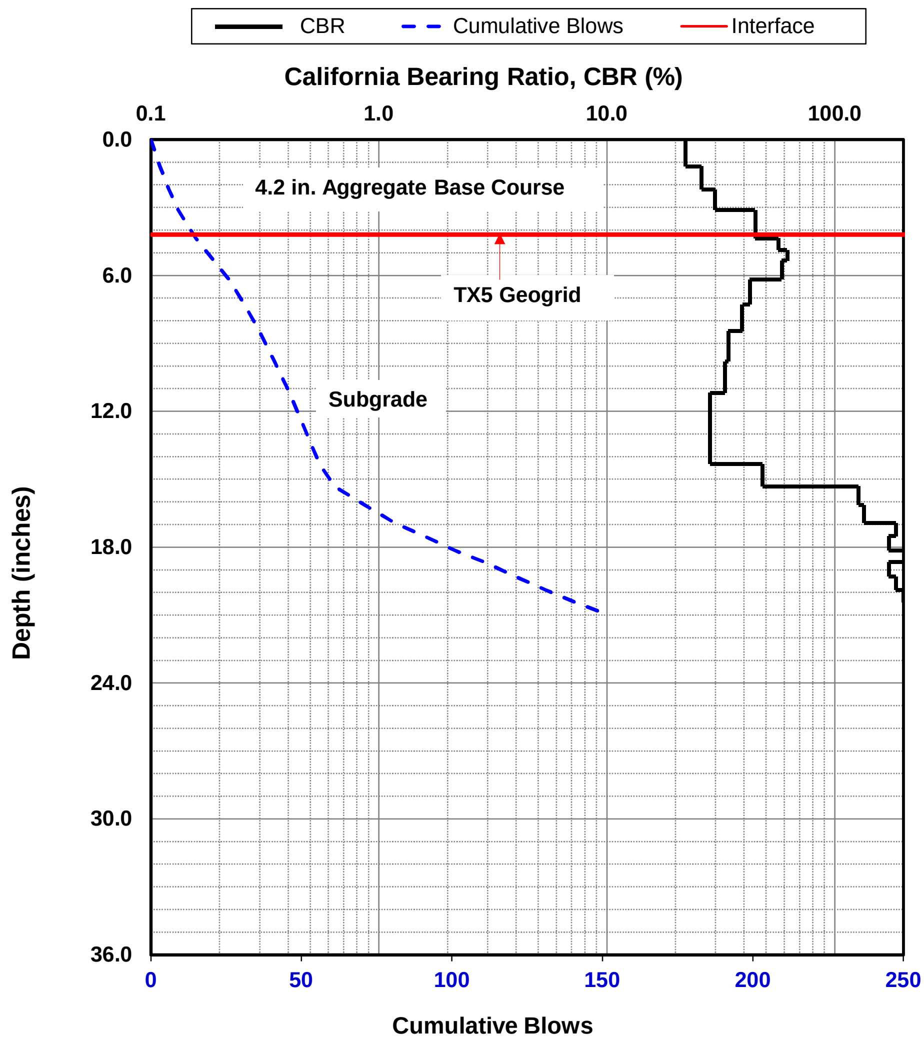
[2]$E\ (ksi) = (17.6\ CBR^{0.64}) \times 0.1450377$

[3]$S_u\ (psf) = (3.794 \times CBR^{0.664}) \times 144$

[1]ASTM D6951-03

[2]Powell et al. (1986)

[3]Portland Cement Assoc. (1955)



Dynamic Cone Penetrometer (DCP) Test Results

Project Name: Interstate 5: North County Coastal Test Sections

Project ID: TIC-00050

Location: Encinitas, California

Date of Test	8/1/2019	Test ID	I5_NCC_TX5_pt3	Operator	HG, LC	ASTM	D6951
Latitude, N	33.04593	Longitude, W		117.286460		Elevation (ft)	NA
Location	I-5_NCC Test Sections	Station		NA			
Comments	Nominal 0.35 ft thick recycled aggregate base course layer over subgrade, with TX5 multiaxial georid at the base and subgrade interface.						

Parameter	DPI (mm/blow)	CBR (%)	E_{CBR}, Elastic Modulus (ksi) (non stress-dependent)	$S_{u\text{-}CBR}$, Bearing Capacity (psf)
Avg. Top Layer [0-4.2 in.]	8.8	25.7	20.4	4,720
Avg. Bottom Layer [4.2-24 in.]	Refusal	Refusal	Refusal	Refusal
Ratio of Avg.0-4.2 in./4.2-24 in.	NA	NA	NA	NA
Stdev Top Layer [0-4.2 in.]	1.8	7.5	9.3	2,088
Stdev. Bottom Layer [4.2-24 in.]	Refusal	Refusal	Refusal	Refusal

NOTES:

Subgrade is assumed as silty sand.

[1]$CBR = 292/DPI^{1.12}$

[1]$CBR = 1/(0.002871*DPI)$

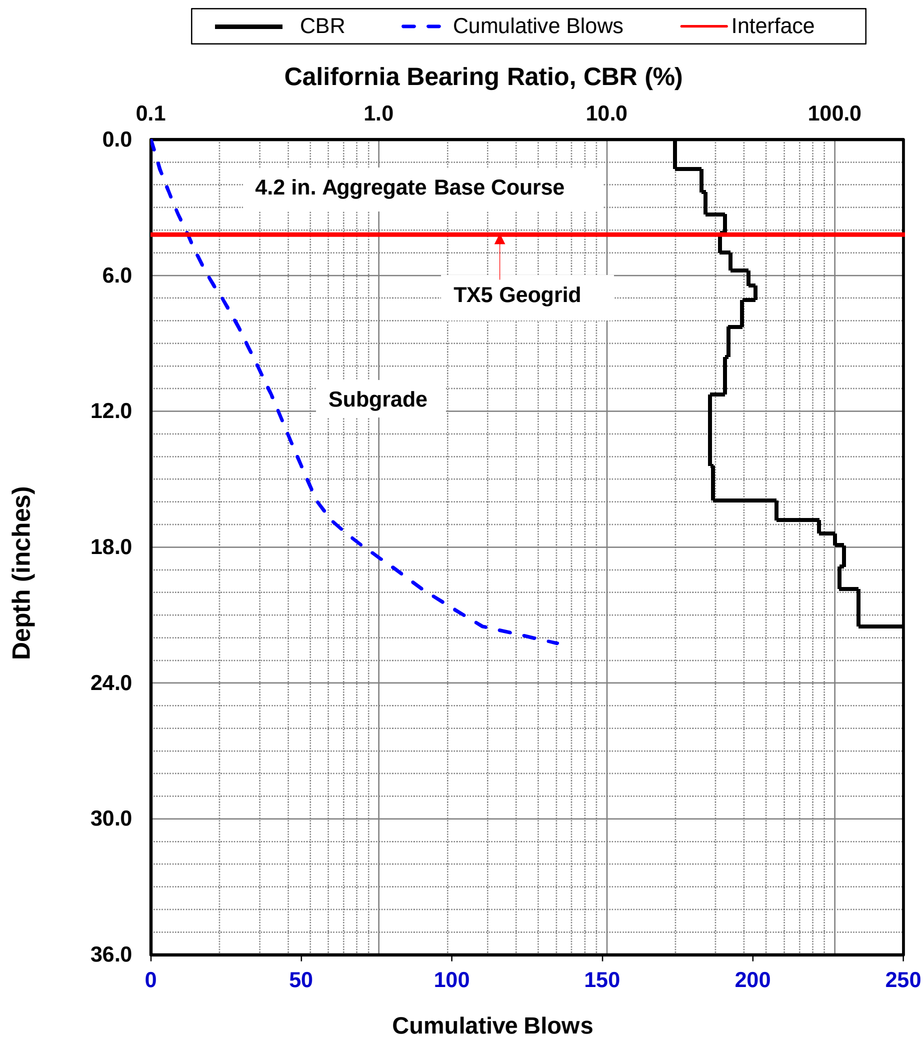
[2]$E\ (ksi) = (17.6\ CBR^{0.64}) \times 0.1450377$

[3]$S_u\ (psf) = (3.794 \times CBR^{0.664}) \times 144$

[1]ASTM D6951-03

[2]Powell et al. (1986)

[3]Portland Cement Assoc. (1955)



Dynamic Cone Penetrometer (DCP) Test Results

Project Name:	Interstate 5: North County Coastal Test Sections
Project ID:	TIC-00050
Location:	Encinitas, California

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Date of Test	8/1/2019	Test ID	I5_NCC_TX5_pt4	Operator	HG, LC	ASTM	D6951
Latitude, N	33.04596		Longitude, W	117.286480		Elevation (ft)	NA
Location	I-5_NCC Test Sections		Station	NA			
Comments	Nominal 0.35 ft (measured = 4.3 in.) thick recycled aggregate base course layer over subgrade, with TX5 multiaxial georid at the base and subgrade interface.						

Parameter	DPI (mm/blow)	CBR (%)	E_{CBR}, Elastic Modulus (ksi) (non stress-dependent)	$S_{u\text{-}CBR}$, Bearing Capacity (psf)
Avg. Top Layer [0-4.3 in.]	7.3	31.4	23.2	5,382
Avg. Bottom Layer [4.3-24 in.]	5.5	43.2	28.4	6,661
Ratio of Avg.0-4.3 in./4.3-24 in.	1.3	0.7	0.8	0.8
Stdev Top Layer [0-4.3 in.]	0.8	3.7	5.9	1,314
Stdev. Bottom Layer [4.3-24 in.]	1.4	12.4	12.8	2,903

NOTES:

Subgrade is assumed as silty sand.

[1]$CBR = 292/DPI^{1.12}$

[1]$CBR = 1/(0.002871*DPI)$

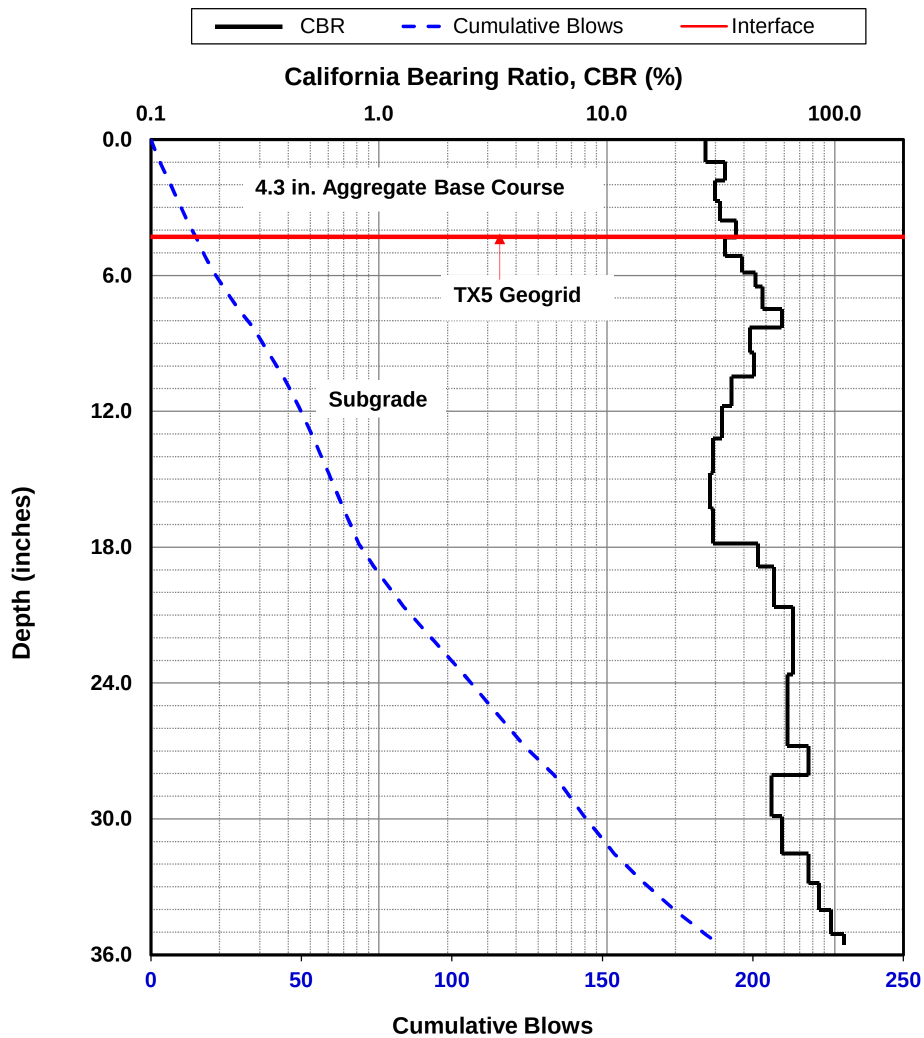
[2]$E\ (ksi) = (17.6\ CBR^{0.64}) \times 0.1450377$

[3]$S_u\ (psf) = (3.794 \times CBR^{0.664}) \times 144$

[1]ASTM D6951-03

[2]Powell et al. (1986)

[3]Portland Cement Assoc. (1955)



Dynamic Cone Penetrometer (DCP) Test Results	
Project Name:	Interstate 5: North County Coastal Test Sections
Project ID:	TIC-00050
Location:	Encinitas, California

Date of Test	8/1/2019	Test ID	I5_NCC_TX5_pt5	Operator	HG, LC	ASTM	D6951
Latitude, N	33.04598	Longitude, W	117.286480			Elevation (ft)	NA
Location	I-5_NCC Test Sections	Station	NA				
Comments	Nominal 0.35 ft thick recycled aggregate base course layer over subgrade, with TX5 multiaxial georid at the base and subgrade interface.						

Parameter	DPI (mm/blow)	CBR (%)	E_{CBR}, Elastic Modulus (ksi) (non stress-dependent)	$S_{u\text{-}CBR}$, Bearing Capacity (psf)
Avg. Top Layer [0-4.2 in.]	7.3	31.7	23.3	5,419
Avg. Bottom Layer [4.2-24 in.]	4.0	61.7	35.7	8,435
Ratio of Avg.0-4.2 in./4.2-24 in.	1.8	0.5	0.7	0.6
Stdev Top Layer [0-4.2 in.]	1.1	5.8	7.8	1,749
Stdev. Bottom Layer [4.2-24 in.]	2.0	52.4	32.2	7,573

NOTES:

Subgrade is assumed as silty sand.

[1]$CBR = 292/DPI^{1.12}$

[1]$CBR = 1/(0.002871*DPI)$

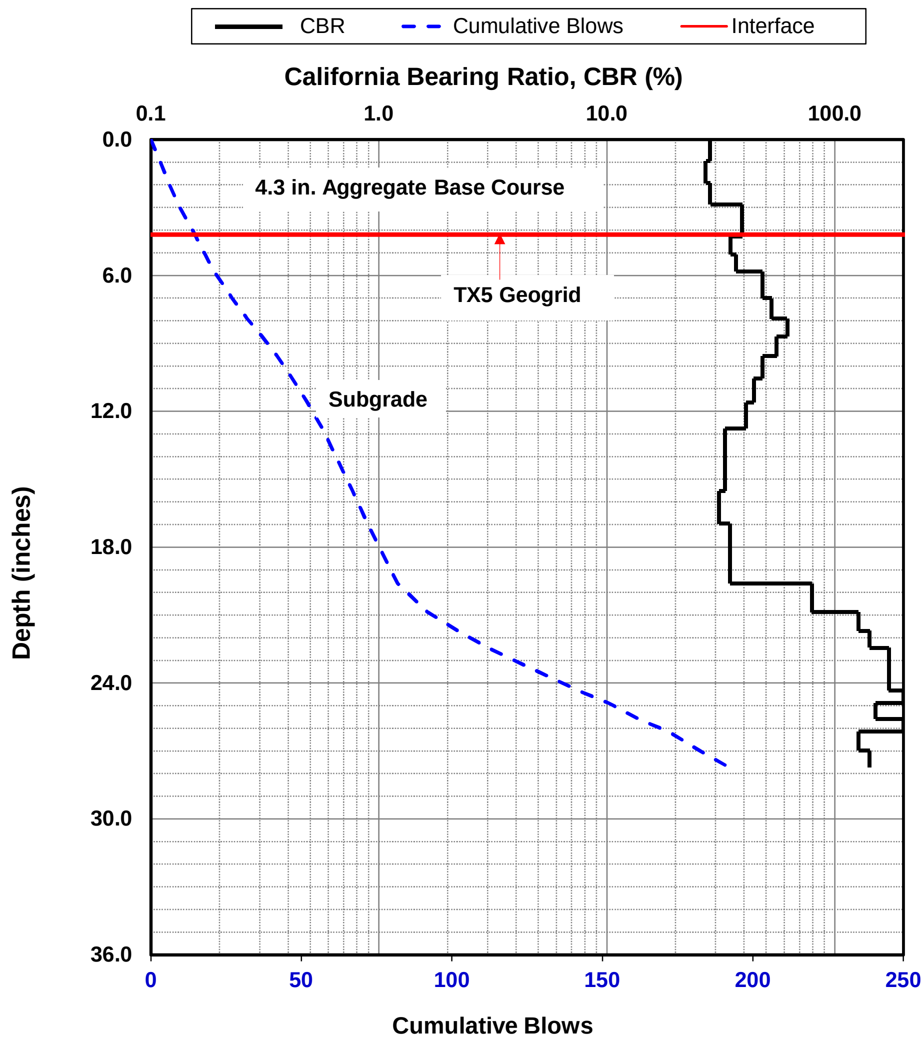
[2]$E\ (ksi) = (17.6\ CBR^{0.64}) \times 0.1450377$

[3]$S_u\ (psf) = (3.794 \times CBR^{0.664}) \times 144$

[1]ASTM D6951-03

[2]Powell et al. (1986)

[3]Portland Cement Assoc. (1955)



Dynamic Cone Penetrometer (DCP) Test Results	
Project Name:	Interstate 5: North County Coastal Test Sections
Project ID:	TIC-00050
Location:	Encinitas, California

Date of Test	8/1/2019	Test ID	I5_NCC_CTRL_pt6	Operator	HG, LC	ASTM	D6951
Latitude, N	33.0461240		Longitude, W	117.286520		Elevation (ft)	NA
Location	I-5_NCC Test Sections		Station	NA			
Comments	Nominal 0.70 ft (measured = 9.0 in.) thick recycled aggregate base course layer over subgrade (control).						

Parameter	DPI (mm/blow)	CBR (%)	E_{CBR}, Elastic Modulus (ksi) (non stress-dependent)	$S_{u\text{-}CBR}$, Bearing Capacity (psf)
Avg. Top Layer [0-9.0 in.]	5.0	47.7	30.3	7,111
Avg. Bottom Layer [9.0-24 in.]	6.1	38.4	26.4	6,160
Ratio of Avg.0-9.0 in./9.0-24 in.	0.8	1.2	1.1	1.2
Stdev Top Layer [0-9.0 in.]	2.3	16.3	15.3	3,492
Stdev. Bottom Layer [9.0-24 in.]	1.4	11.6	12.2	2,780

NOTES:

Subgrade is assumed as silty sand.

[1]CBR = $292/DPI^{1.12}$

[1]CBR = 1/(0.002871*DPI)

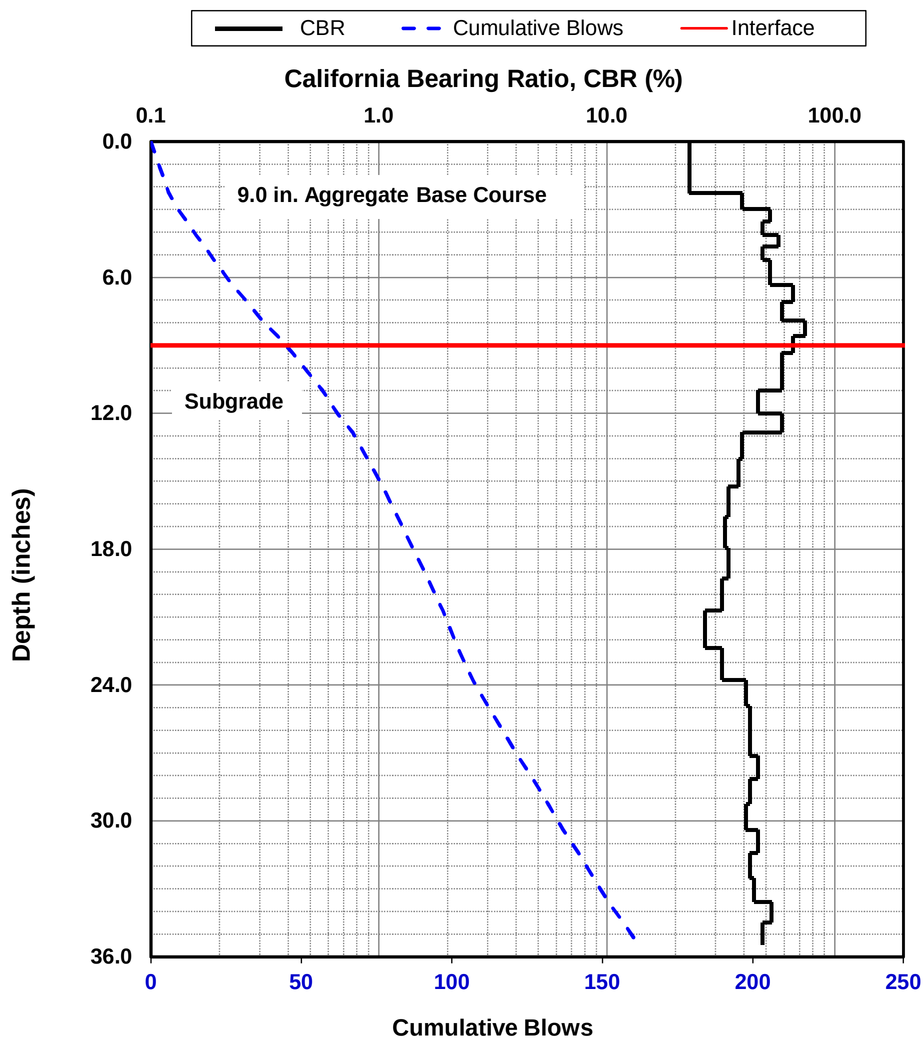
[2]E (ksi) = $(17.6\ CBR^{0.64}) \times 0.1450377$

[3]S_u (psf) = $(3.794 \times CBR^{0.664}) \times 144$

[1]ASTM D6951-03

[2]Powell et al. (1986)

[3]Portland Cement Assoc. (1955)



Dynamic Cone Penetrometer (DCP) Test Results	
Project Name:	Interstate 5: North County Coastal Test Sections
Project ID:	TIC-00050
Location:	Encinitas, California

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Date of Test	8/1/2019	Test ID	I5_NCC_CTRL_pt7	Operator	HG, LC	ASTM	D6951
Latitude, N	33.0461580	Longitude, W		117.286520		Elevation (ft)	NA
Location	I-5_NCC Test Sections	Station		NA			
Comments	Nominal 0.70 ft thick recycled aggregate base course layer over subgrade (control).						

Parameter	DPI (mm/blow)	CBR (%)	E_{CBR}, Elastic Modulus (ksi) (non stress-dependent)	$S_{u\text{-}CBR}$, Bearing Capacity (psf)
Avg. Top Layer [0-9.0 in.]	6.0	39.4	26.8	6,268
Avg. Bottom Layer [9.0-24 in.]	4.6	52.6	32.2	7,590
Ratio of Avg.0-9.0 in./9.0-24 in.	1.3	0.7	0.8	0.8
Stdev Top Layer [0-9.0 in.]	2.0	14.9	14.4	3,288
Stdev. Bottom Layer [9.0-24 in.]	0.8	8.9	10.3	2,328

NOTES:

Subgrade is assumed as silty sand.

[1]CBR = $292/DPI^{1.12}$

[1]CBR = 1/(0.002871*DPI)

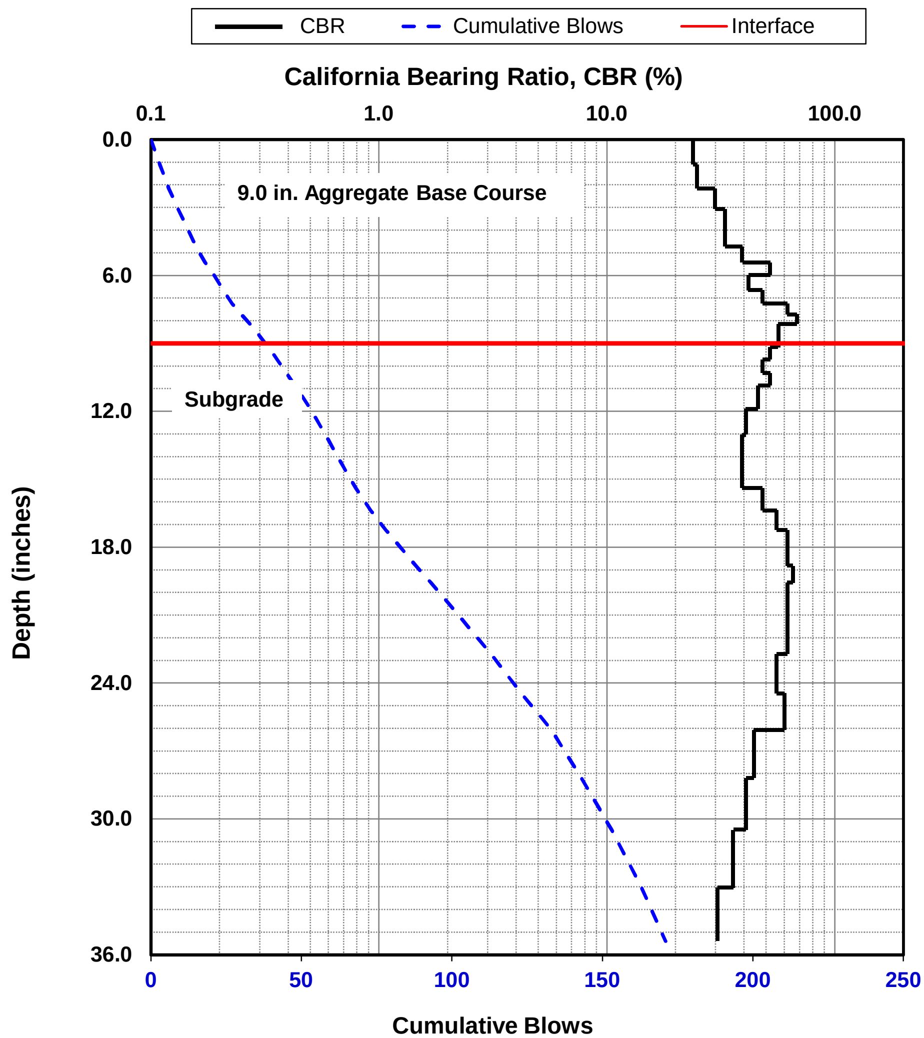
[2]E (ksi) = $(17.6\ CBR^{0.64}) \times 0.1450377$

[3]S_u (psf) = $(3.794 \times CBR^{0.664}) \times 144$

[1]ASTM D6951-03

[2]Powell et al. (1986)

[3]Portland Cement Assoc. (1955)



Dynamic Cone Penetrometer (DCP) Test Results	
Project Name:	Interstate 5: North County Coastal Test Sections
Project ID:	TIC-00050
Location:	Encinitas, California

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Date of Test	8/1/2019	Test ID	I5_NCC_CTRL_pt8	Operator	HG, LC	ASTM	D6951
Latitude, N	33.0461810	Longitude, W		117.286530		Elevation (ft)	NA
Location	I-5_NCC Test Sections	Station		NA			
Comments	Nominal 0.70 ft (measured = 8.75 in.) thick recycled aggregate base course layer over subgrade (control).						

Parameter	DPI (mm/blow)	CBR (%)	E_{CBR}, Elastic Modulus (ksi) (non stress-dependent)	$S_{u\text{-}CBR}$, Bearing Capacity (psf)
Avg. Top Layer [0-8.75 in.]	5.1	46.7	29.9	7,011
Avg. Bottom Layer [8.75-24 in.]	4.5	54.3	32.9	7,747
Ratio of Avg.0-8.75 in./8.75-24 in.	1.1	0.9	0.9	0.9
Stdev Top Layer [0-8.75 in.]	2.0	14.3	14.0	3,189
Stdev. Bottom Layer [8.75-24 in.]	0.7	8.0	9.7	2,182

NOTES:

Subgrade is assumed as silty sand.

[1]$CBR = 292/DPI^{1.12}$

[1]$CBR = 1/(0.002871*DPI)$

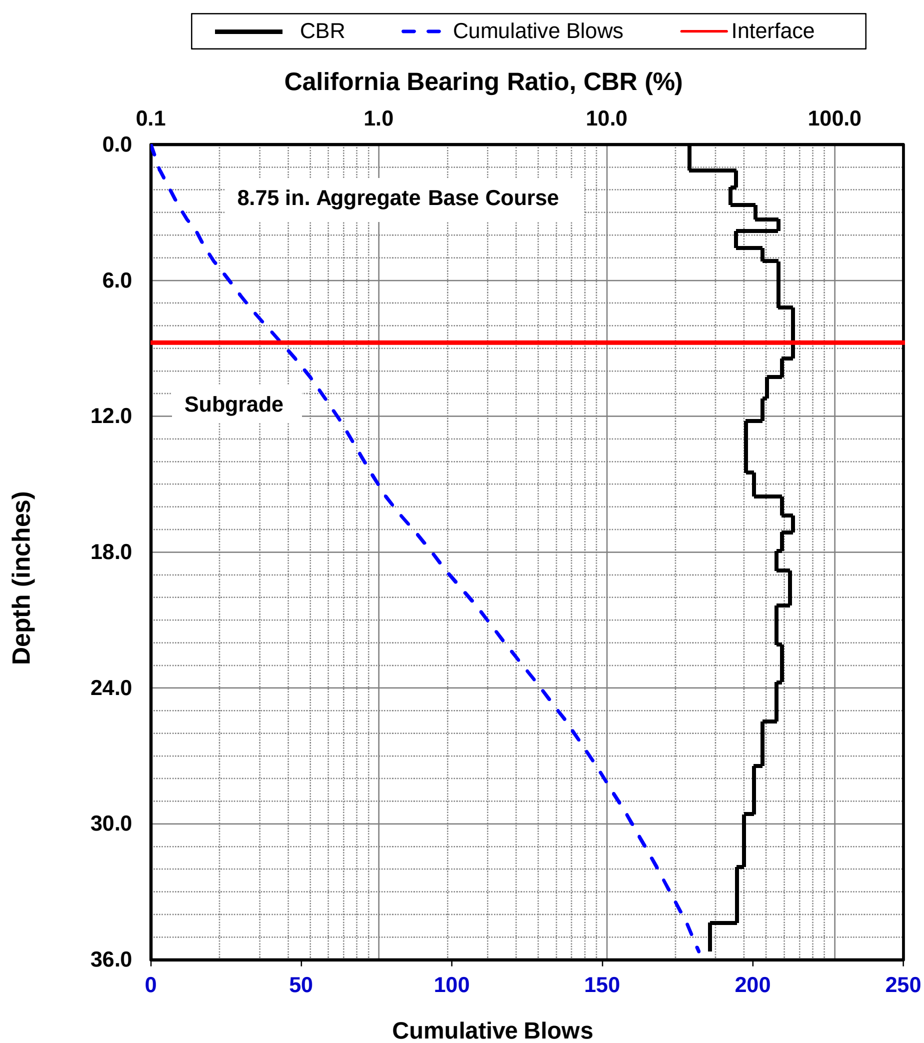
[2]$E\ (ksi) = (17.6\ CBR^{0.64}) \times 0.1450377$

[3]$S_u\ (psf) = (3.794 \times CBR^{0.664}) \times 144$

[1]ASTM D6951-03

[2]Powell et al. (1986)

[3]Portland Cement Assoc. (1955)



Dynamic Cone Penetrometer (DCP) Test Results	
Project Name:	Interstate 5: North County Coastal Test Sections
Project ID:	TIC-00050
Location:	Encinitas, California

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Date of Test	8/1/2019	Test ID	I5_NCC_CTRL_pt9	Operator	HG, LC	ASTM	D6951
Latitude, N	33.0462040	Longitude, W		117.286540		Elevation (ft)	NA
Location	I-5_NCC Test Sections	Station		NA			
Comments	Nominal 0.70 ft thick recycled aggregate base course layer over subgrade (control).						

Parameter	DPI (mm/blow)	CBR (%)	E_{CBR}, Elastic Modulus (ksi) (non stress-dependent)	S_{u-CBR}, Bearing Capacity (psf)
Avg. Top Layer [0-9.0 in.]	4.6	52.6	32.2	7,589
Avg. Bottom Layer [9.0-24 in.]	Refusal	Refusal	Refusal	Refusal
Ratio of Avg.0-9.0 in./9.0-24 in.	NA	NA	NA	NA
Stdev Top Layer [0-9.0 in.]	1.7	28.3	21.7	5,034
Stdev. Bottom Layer [9.0-24 in.]	Refusal	Refusal	Refusal	Refusal

NOTES:

Subgrade is assumed as silty sand.

[1]CBR = $292/DPI^{1.12}$

[1]CBR = 1/(0.002871*DPI)

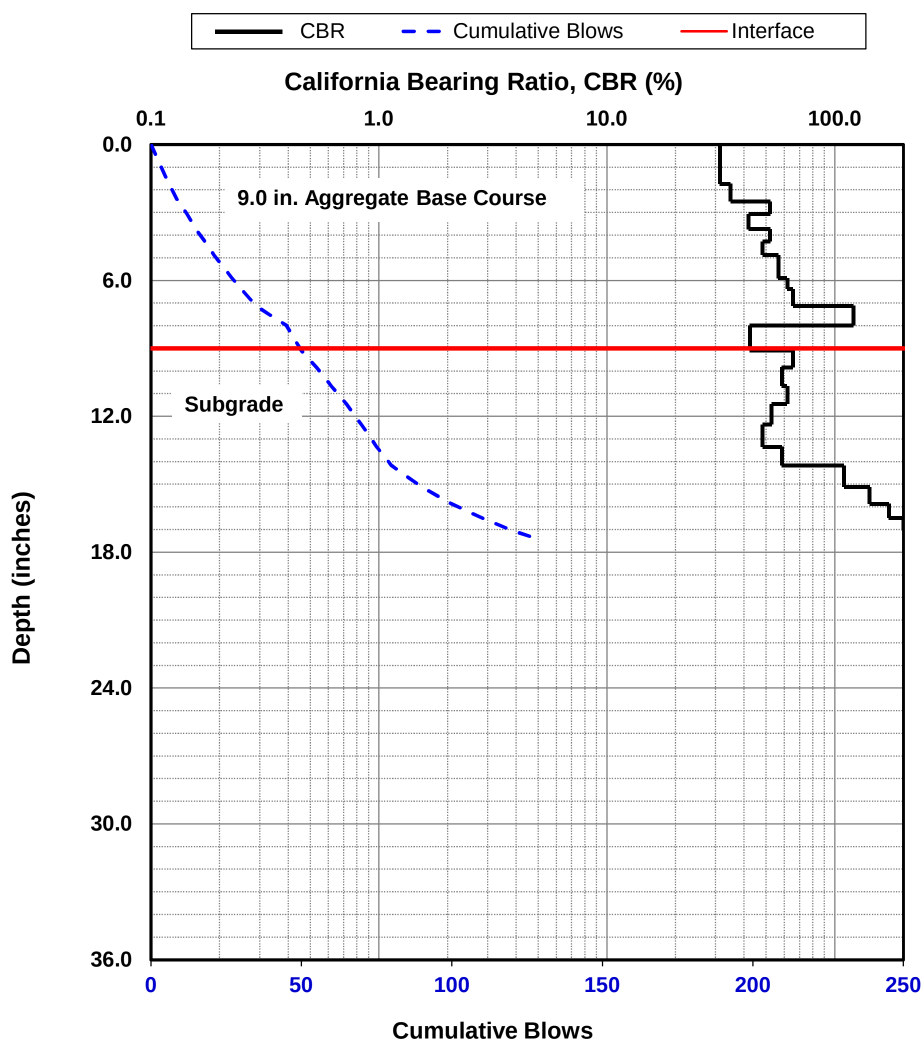
[2]E (ksi) = $(17.6\ CBR^{0.64}) \times 0.1450377$

[3]S_u (psf) = $(3.794 \times CBR^{0.664}) \times 144$

[1]ASTM D6951-03

[2]Powell et al. (1986)

[3]Portland Cement Assoc. (1955)



Dynamic Cone Penetrometer (DCP) Test Results	
Project Name:	Interstate 5: North County Coastal Test Sections
Project ID:	TIC-00050
Location:	Encinitas, California

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Date of Test	8/1/2019	Test ID	I5_NCC_CTRL_pt10	Operator	HG, LC	ASTM	D6951
Latitude, N	33.0462190	Longitude, W		117.286540		Elevation (ft)	NA
Location	I-5_NCC Test Sections	Station		NA			
Comments	Nominal 0.70 ft thick recycled aggregate base course layer over subgrade (control).						

Parameter	DPI (mm/blow)	CBR (%)	E_{CBR}, Elastic Modulus (ksi) (non stress-dependent)	$S_{u\text{-}CBR}$, Bearing Capacity (psf)
Avg. Top Layer [0-9.0 in.]	4.8	50.6	31.5	7,396
Avg. Bottom Layer [9.0-24 in.]	Refusal	Refusal	Refusal	Refusal
Ratio of Avg.0-9.0 in./9.0-24 in.	NA	NA	NA	NA
Stdev Top Layer [0-9.0 in.]	3.0	21.1	18.0	4,137
Stdev. Bottom Layer [9.0-24 in.]	Refusal	Refusal	Refusal	Refusal

NOTES:

Subgrade is assumed as silty sand.

[1]$CBR = 292/DPI^{1.12}$

[1]$CBR = 1/(0.002871*DPI)$

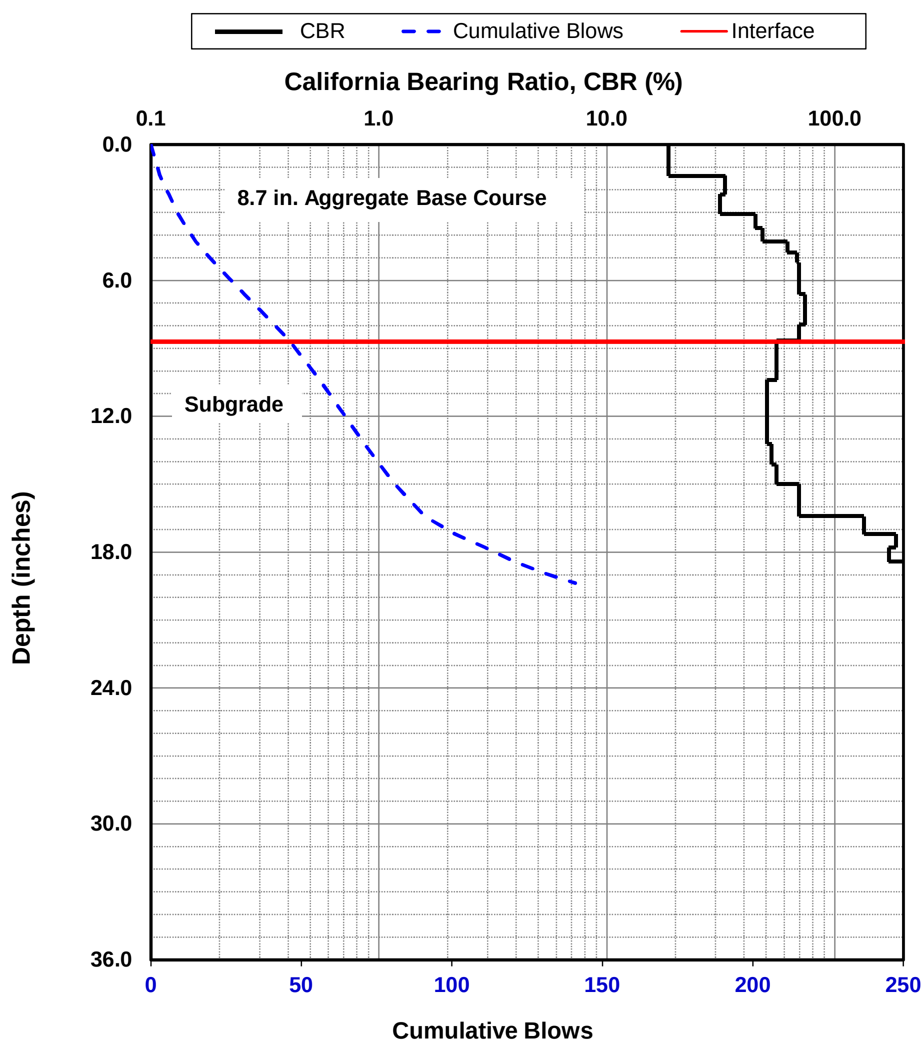
[2]$E\ (ksi) = (17.6\ CBR^{0.64}) \times 0.1450377$

[3]$S_u\ (psf) = (3.794 \times CBR^{0.664}) \times 144$

[1]ASTM D6951-03

[2]Powell et al. (1986)

[3]Portland Cement Assoc. (1955)



Dynamic Cone Penetrometer (DCP) Test Results	
Project Name:	Interstate 5: North County Coastal Test Sections
Project ID:	TIC-00050
Location:	Encinitas, California

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Date of Test	8/1/2019	Test ID	I5_NCC_TX5_0.85_pt11	Operator	HG, LC	ASTM	D6951
Latitude, N	33.0469590		Longitude, W	117.286770		Elevation (ft)	NA
Location	I-5_NCC Test Sections		Station	NA			
Comments	Nominal 0.85 ft (measured = 9.75 in.) thick recycled aggregate base course layer over subgrade, with TX5 multiaxial georid at the base and subgrade interface.						

Parameter	DPI (mm/blow)	CBR (%)	E_{CBR}, Elastic Modulus (ksi) (non stress-dependent)	$S_{u\text{-}CBR}$, Bearing Capacity (psf)
Avg. Top Layer [0-9.75 in.]	6.2	37.9	26.1	6,105
Avg. Bottom Layer [9.75-24 in.]	4.6	53.2	32.5	7,647
Ratio of Avg.0-9.75 in./9.75-24 in.	1.4	0.7	0.8	0.8
Stdev Top Layer [0-9.75 in.]	4.5	22.6	18.8	4,334
Stdev. Bottom Layer [9.75-24 in.]	0.6	8.7	10.2	2,291

NOTES:

Subgrade is assumed as silty sand.

[1]CBR = 292/DPI$^{1.12}$

[1]CBR = 1/(0.002871*DPI)

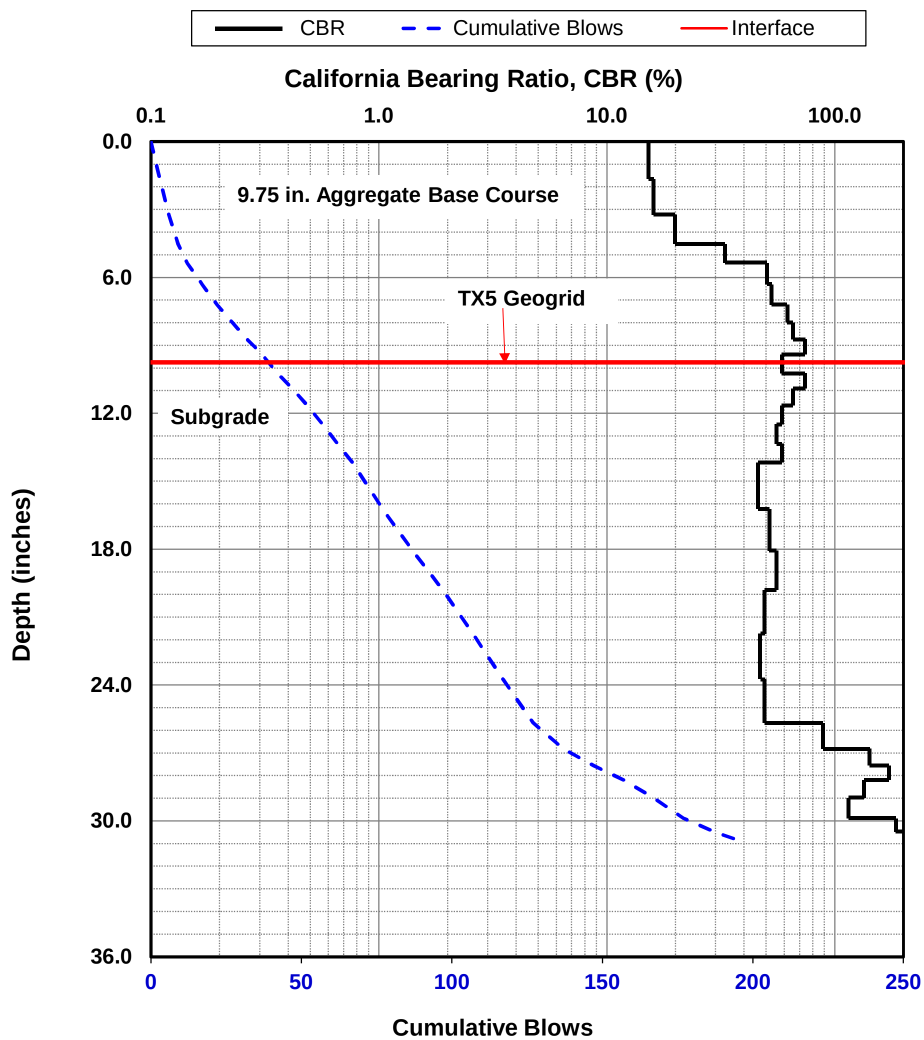
[2]E (ksi) = (17.6 CBR$^{0.64}$) x 0.1450377

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

[1]ASTM D6951-03

[2]Powell et al. (1986)

[3]Portland Cement Assoc. (1955)



Dynamic Cone Penetrometer (DCP) Test Results

Project Name:	Interstate 5: North County Coastal Test Sections
Project ID:	TIC-00050
Location:	Encinitas, California

Date of Test	8/1/2019	Test ID	I5_NCC_TX5_0.85_pt12	Operator	HG, LC	ASTM	D6951
Latitude, N	33.0469780	Longitude, W	117.286780			Elevation (ft)	NA
Location	I-5_NCC Test Sections	Station	NA				
Comments	Nominal 0.85 ft thick recycled aggregate base course layer over subgrade, with TX5 multiaxial georid at the base and subgrade interface.						

Parameter	DPI (mm/blow)	CBR (%)	E_{CBR}, Elastic Modulus (ksi) (non stress-dependent)	$S_{u\text{-}CBR}$, Bearing Capacity (psf)
Avg. Top Layer [0-9.75 in.]	6.3	36.9	25.7	6,002
Avg. Bottom Layer [9.75-24 in.]	4.3	56.3	33.7	7,943
Ratio of Avg.0-9.75 in./9.75-24 in.	1.5	0.7	0.8	0.8
Stdev Top Layer [0-9.75 in.]	5.3	22.0	18.5	4,257
Stdev. Bottom Layer [9.75-24 in.]	0.6	6.9	8.8	1,965

NOTES:

Subgrade is assumed as silty sand.

[1]CBR = $292/DPI^{1.12}$

[1]CBR = 1/(0.002871*DPI)

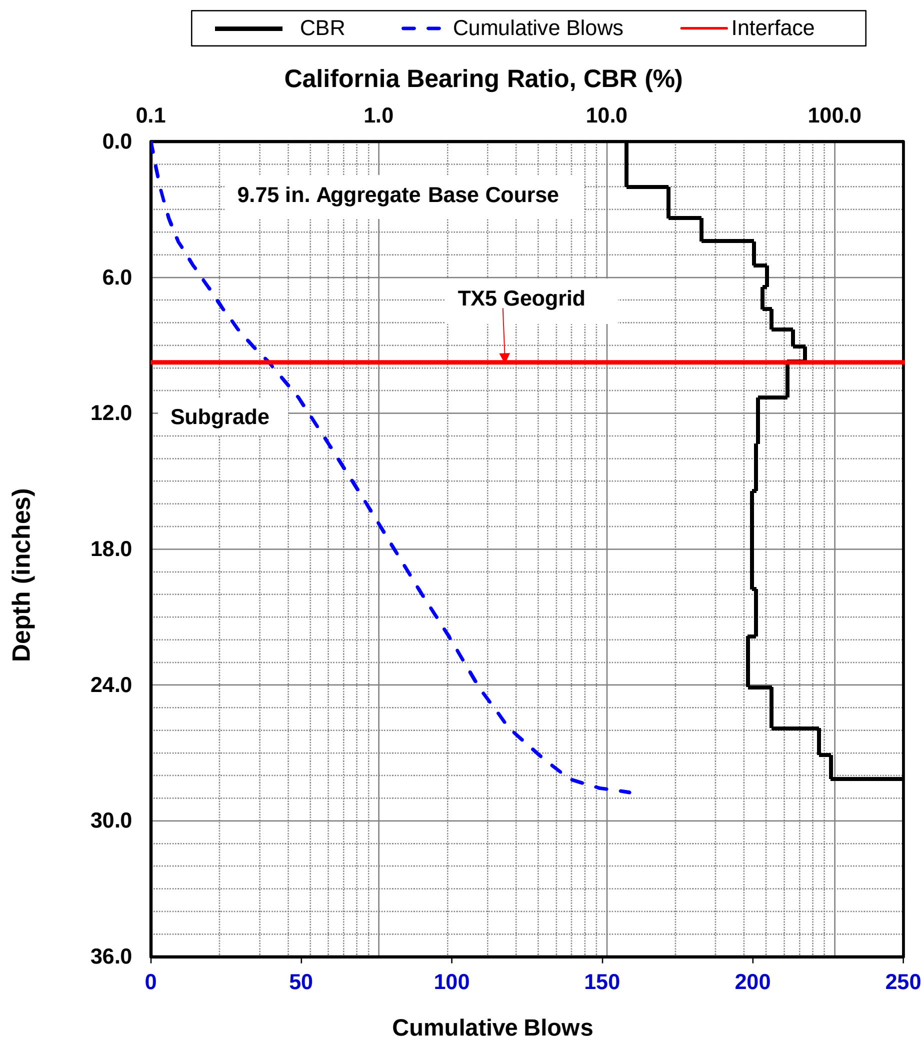
[2]E (ksi) = $(17.6\ CBR^{0.64}) \times 0.1450377$

[3]S_u (psf) = $(3.794 \times CBR^{0.664}) \times 144$

[1]ASTM D6951-03

[2]Powell et al. (1986)

[3]Portland Cement Assoc. (1955)



Dynamic Cone Penetrometer (DCP) Test Results

Project Name: Interstate 5: North County Coastal Test Sections

Project ID: TIC-00050

Location: Encinitas, California

Date of Test	8/1/2019	Test ID	I5_NCC_TX5_0.85_pt13	Operator	HG, LC	ASTM	D6951
Latitude, N	33.0469930	Longitude, W		117.286770		Elevation (ft)	NA
Location	I-5_NCC Test Sections	Station		NA			
Comments	Nominal 0.85 ft (measured = 9.75 in.) thick recycled aggregate base course layer over subgrade, with TX5 multiaxial georid at the base and subgrade interface.						

Parameter	DPI (mm/blow)	CBR (%)	E_{CBR}, Elastic Modulus (ksi) (non stress-dependent)	$S_{u\text{-}CBR}$, Bearing Capacity (psf)
Avg. Top Layer [0-9.75 in.]	4.7	52.2	32.1	7,548
Avg. Bottom Layer [9.75-24 in.]	4.5	54.2	32.9	7,739
Ratio of Avg.0-9.75 in./9.75-24 in.	1.0	1.0	1.0	1.0
Stdev Top Layer [0-9.75 in.]	4.7	32.7	23.8	5,532
Stdev. Bottom Layer [9.75-24 in.]	0.7	9.2	10.6	2,388

NOTES:

Subgrade is assumed as silty sand.

[1]$CBR = 292/DPI^{1.12}$

[1]$CBR = 1/(0.002871 \cdot DPI)$

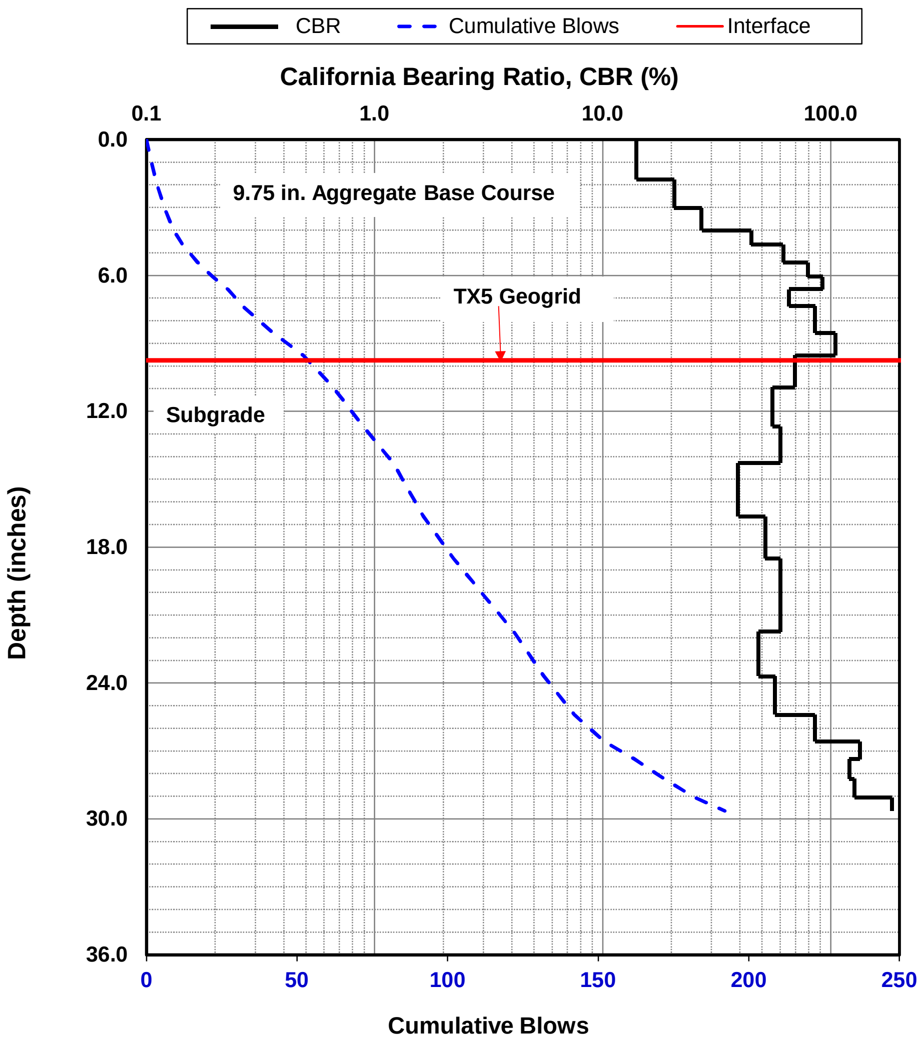
[2]$E\ (ksi) = (17.6\ CBR^{0.64}) \times 0.1450377$

[3]$S_u\ (psf) = (3.794 \times CBR^{0.664}) \times 144$

[1]ASTM D6951-03

[2]Powell et al. (1986)

[3]Portland Cement Assoc. (1955)



Dynamic Cone Penetrometer (DCP) Test Results

Project Name: Interstate 5: North County Coastal Test Sections

Project ID: TIC-00050

Location: Encinitas, California

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Date of Test	8/1/2019	Test ID	I5_NCC_TX5_0.85_pt14	Operator	HG, LC	ASTM	D6951
Latitude, N	33.0470160	Longitude, W	117.286790	Elevation (ft)	NA		
Location	I-5_NCC Test Sections	Station	NA				
Comments	Nominal 0.85 ft thick recycled aggregate base course layer over subgrade, with TX5 multiaxial georid at the base and subgrade interface.						

Parameter	DPI (mm/blow)	CBR (%)	E_{CBR}, Elastic Modulus (ksi) (non stress-dependent)	$S_{u\text{-}CBR}$, Bearing Capacity (psf)
Avg. Top Layer [0-9.75 in.]	4.9	49.0	30.8	7,242
Avg. Bottom Layer [9.75-24 in.]	5.3	45.5	29.4	6,894
Ratio of Avg.0-9.75 in./9.75-24 in.	0.9	1.1	1.0	1.1
Stdev Top Layer [0-9.75 in.]	3.4	23.6	19.3	4,452
Stdev. Bottom Layer [9.75-24 in.]	0.9	8.1	9.7	2,191

NOTES:

Subgrade is assumed as silty sand.

[1]CBR = $292/DPI^{1.12}$

[1]CBR = 1/(0.002871*DPI)

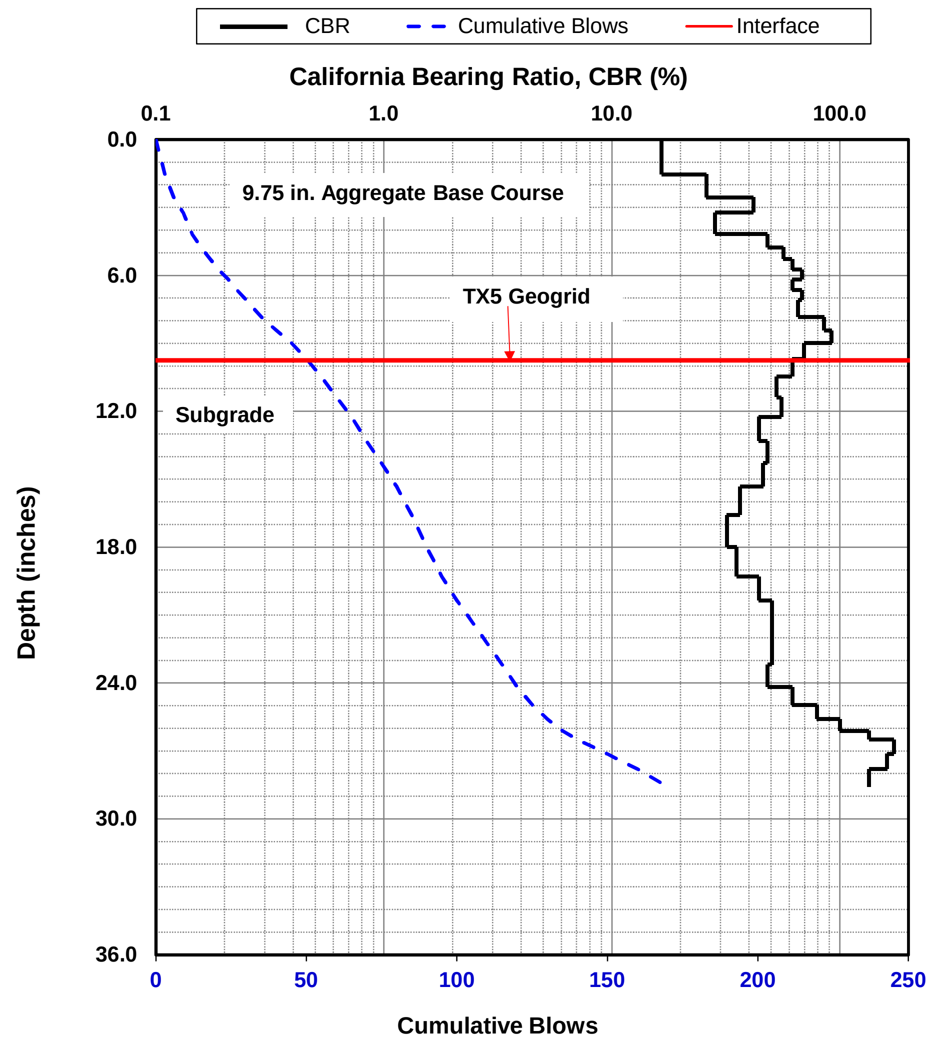
[2]E (ksi) = $(17.6\ CBR^{0.64}) \times 0.1450377$

[3]S_u (psf) = $(3.794 \times CBR^{0.664}) \times 144$

[1]ASTM D6951-03

[2]Powell et al. (1986)

[3]Portland Cement Assoc. (1955)



Dynamic Cone Penetrometer (DCP) Test Results	
Project Name:	Interstate 5: North County Coastal Test Sections
Project ID:	TIC-00050
Location:	Encinitas, California

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Date of Test	8/1/2019	Test ID	I5_NCC_TX5_0.85_pt15	Operator	HG, LC	ASTM	D6951
Latitude, N	33.0470310	Longitude, W	117.286790			Elevation (ft)	NA
Location	I-5_NCC Test Sections	Station	NA				
Comments	Nominal 0.85 ft thick recycled aggregate base course layer over subgrade, with TX5 multiaxial georid at the base and subgrade interface.						

Parameter	DPI (mm/blow)	CBR (%)	E_{CBR}, Elastic Modulus (ksi) (non stress-dependent)	$S_{u\text{-}CBR}$, Bearing Capacity (psf)
Avg. Top Layer [0-9.75 in.]	4.6	52.7	32.3	7,595
Avg. Bottom Layer [9.75-24 in.]	5.6	42.3	28.0	6,565
Ratio of Avg.0-9.75 in./9.75-24 in.	0.8	1.2	1.2	1.2
Stdev Top Layer [0-9.75 in.]	4.4	37.3	25.9	6,046
Stdev. Bottom Layer [9.75-24 in.]	0.9	7.4	9.2	2,059

NOTES:

Subgrade is assumed as silty sand.

[1]$CBR = 292/DPI^{1.12}$

[1]$CBR = 1/(0.002871*DPI)$

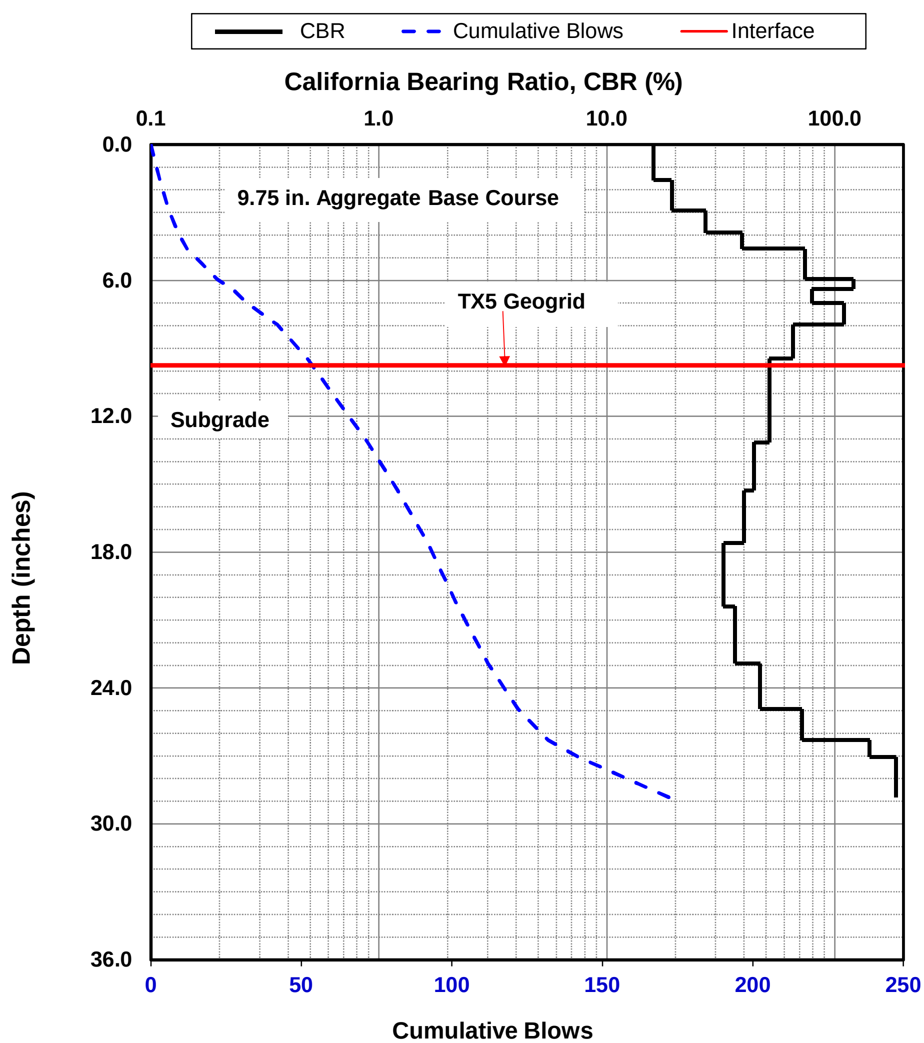
[2]$E\ (ksi) = (17.6\ CBR^{0.64}) \times 0.1450377$

[3]$S_u\ (psf) = (3.794 \times CBR^{0.664}) \times 144$

[1]ASTM D6951-03

[2]Powell et al. (1986)

[3]Portland Cement Assoc. (1955)



Dynamic Cone Penetrometer (DCP) Test Results

Project Name: Interstate 5: North County Coastal Test Sections

Project ID: TIC-00050

Location: Encinitas, California

Date of Test	8/1/2019	Test ID	I5_NCC_CTRL_2.25_pt16	Operator	HG, LC	ASTM	D6951
Latitude, N	33.0473100	Longitude, W	117.286880			Elevation (ft)	NA
Location	I-5_NCC Test Sections	Station	NA				
Comments	Nominal 2.25 ft thick recycled aggregate base course layer over subgrade (Control).						

Parameter	DPI (mm/blow)	CBR (%)	E_{CBR}, Elastic Modulus (ksi) (non stress-dependent)	S_{u-CBR}, Bearing Capacity (psf)
Avg. Top Layer [0-27 in.]	3.6	69.9	38.7	9,168
Avg. Bottom Layer [> 27 in.]	NA	NA	NA	NA
Ratio of Avg.0-27 in./> 27 in.	NA	NA	NA	NA
Stdev Top Layer [0-27 in.]	4.4	52.1	32.0	7,539
Stdev. Bottom Layer [> 27 in.]	NA	NA	NA	NA

NOTES:

Subgrade is assumed as silty sand.

[1] $CBR = 292/DPI^{1.12}$

[1] $CBR = 1/(0.002871 \cdot DPI)$

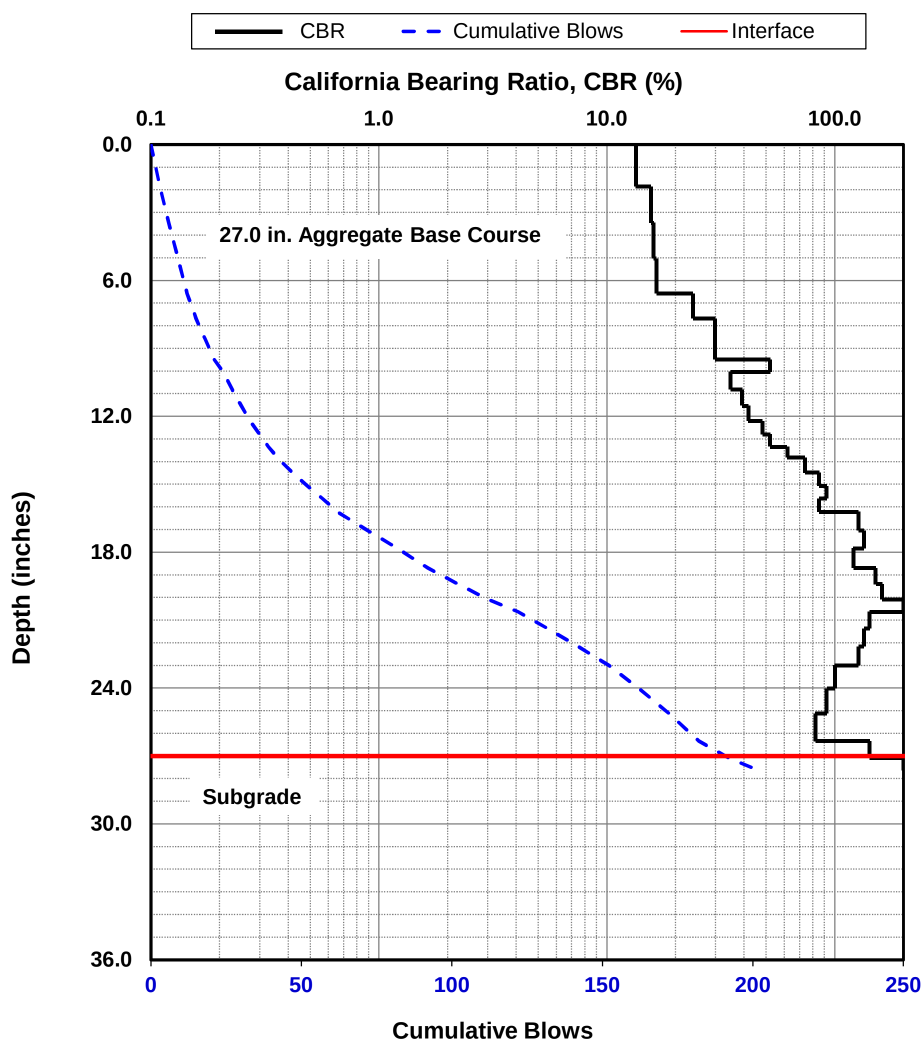
[2] $E\ (ksi) = (17.6\ CBR^{0.64}) \times 0.1450377$

[3] $S_u\ (psf) = (3.794 \times CBR^{0.664}) \times 144$

[1] ASTM D6951-03

[2] Powell et al. (1986)

[3] Portland Cement Assoc. (1955)



Dynamic Cone Penetrometer (DCP) Test Results

Project Name:	Interstate 5: North County Coastal Test Sections
Project ID:	TIC-00050
Location:	Encinitas, California

Date of Test	8/1/2019	Test ID	I5_NCC_CTRL_2.25_pt17	Operator	HG, LC	ASTM	D6951
Latitude, N	33.0473330	Longitude, W		117.286880		Elevation (ft)	NA
Location	I-5_NCC Test Sections	Station		NA			
Comments	Nominal 2.25 ft thick recycled aggregate base course layer over subgrade (Control).						

Parameter	DPI (mm/blow)	CBR (%)	E_{CBR}, Elastic Modulus (ksi) (non stress-dependent)	$S_{u\text{-}CBR}$, Bearing Capacity (psf)
Avg. Top Layer [0-27 in.]	3.1	82.6	43.0	10,238
Avg. Bottom Layer [> 27 in.]	NA	NA	NA	NA
Ratio of Avg.0-27 in./> 27 in.	NA	NA	NA	NA
Stdev Top Layer [0-27 in.]	4.2	54.3	32.9	7,747
Stdev. Bottom Layer [> 27 in.]	NA	NA	NA	NA

NOTES:

Subgrade is assumed as silty sand.

[1]$CBR = 292/DPI^{1.12}$

[1]$CBR = 1/(0.002871 \cdot DPI)$

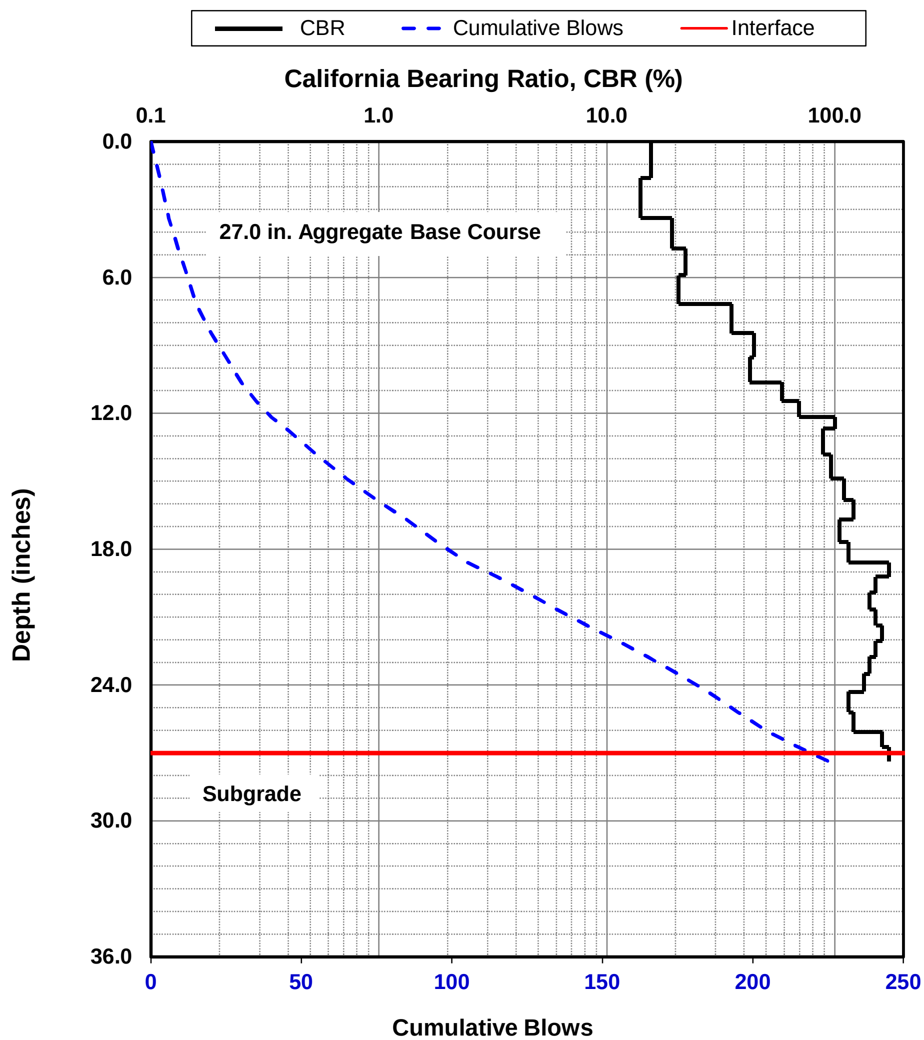
[2]$E\text{ (ksi)} = (17.6\ CBR^{0.64}) \times 0.1450377$

[3]$S_u\text{ (psf)} = (3.794 \times CBR^{0.664}) \times 144$

[1]ASTM D6951-03

[2]Powell et al. (1986)

[3]Portland Cement Assoc. (1955)



Dynamic Cone Penetrometer (DCP) Test Results	
Project Name:	Interstate 5: North County Coastal Test Sections
Project ID:	TIC-00050
Location:	Encinitas, California

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Date of Test	8/1/2019	Test ID	I5_NCC_CTRL_2.25_pt18	Operator	HG, LC	ASTM	D6951
Latitude, N	33.0473520	Longitude, W	117.286880			Elevation (ft)	NA
Location	I-5_NCC Test Sections	Station	NA				
Comments	Nominal 2.25 ft thick recycled aggregate base course layer over subgrade (Control).						

Parameter	DPI (mm/blow)	CBR (%)	E_{CBR}, Elastic Modulus (ksi) (non stress-dependent)	$S_{u\text{-}CBR}$, Bearing Capacity (psf)
Avg. Top Layer [0-27 in.]	2.9	87.4	44.6	10,631
Avg. Bottom Layer [> 27 in.]	NA	NA	NA	NA
Ratio of Avg.0-27 in./> 27 in.	NA	NA	NA	NA
Stdev Top Layer [0-27 in.]	3.4	51.2	31.7	7,453
Stdev. Bottom Layer [> 27 in.]	NA	NA	NA	NA

NOTES:

Subgrade is assumed as silty sand.

[1]$CBR = 292/DPI^{1.12}$

[1]$CBR = 1/(0.002871*DPI)$

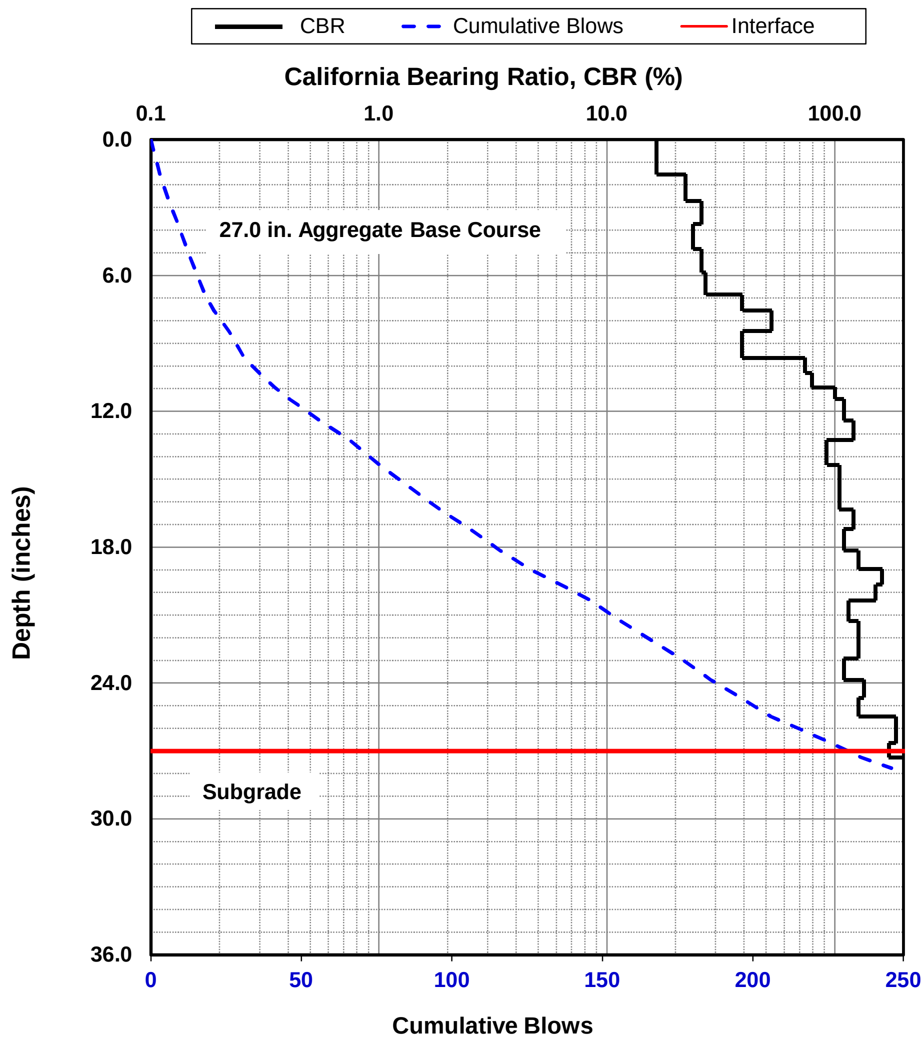
[2]$E\ (ksi) = (17.6\ CBR^{0.64}) \times 0.1450377$

[3]$S_u\ (psf) = (3.794 \times CBR^{0.664}) \times 144$

[1]ASTM D6951-03

[2]Powell et al. (1986)

[3]Portland Cement Assoc. (1955)



Dynamic Cone Penetrometer (DCP) Test Results	
Project Name:	Interstate 5: North County Coastal Test Sections
Project ID:	TIC-00050
Location:	Encinitas, California

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Date of Test	8/1/2019	Test ID	I5_NCC_CTRL_2.25_pt19	Operator	HG, LC	ASTM	D6951
Latitude, N	33.0473790	Longitude, W	117.286890			Elevation (ft)	NA
Location	I-5_NCC Test Sections	Station	NA				
Comments	Nominal 2.25 ft thick recycled aggregate base course layer over subgrade (Control).						

Parameter	DPI (mm/blow)	CBR (%)	E_{CBR}, Elastic Modulus (ksi) (non stress-dependent)	$S_{u\text{-}CBR}$, Bearing Capacity (psf)
Avg. Top Layer [0-27 in.]	2.9	90.1	45.5	10,849
Avg. Bottom Layer [> 27 in.]	NA	NA	NA	NA
Ratio of Avg.0-27 in./> 27 in.	NA	NA	NA	NA
Stdev Top Layer [0-27 in.]	2.7	46.0	29.6	6,938
Stdev. Bottom Layer [> 27 in.]	NA	NA	NA	NA

NOTES:

Subgrade is assumed as silty sand.

[1]$CBR = 292/DPI^{1.12}$

[1]$CBR = 1/(0.002871*DPI)$

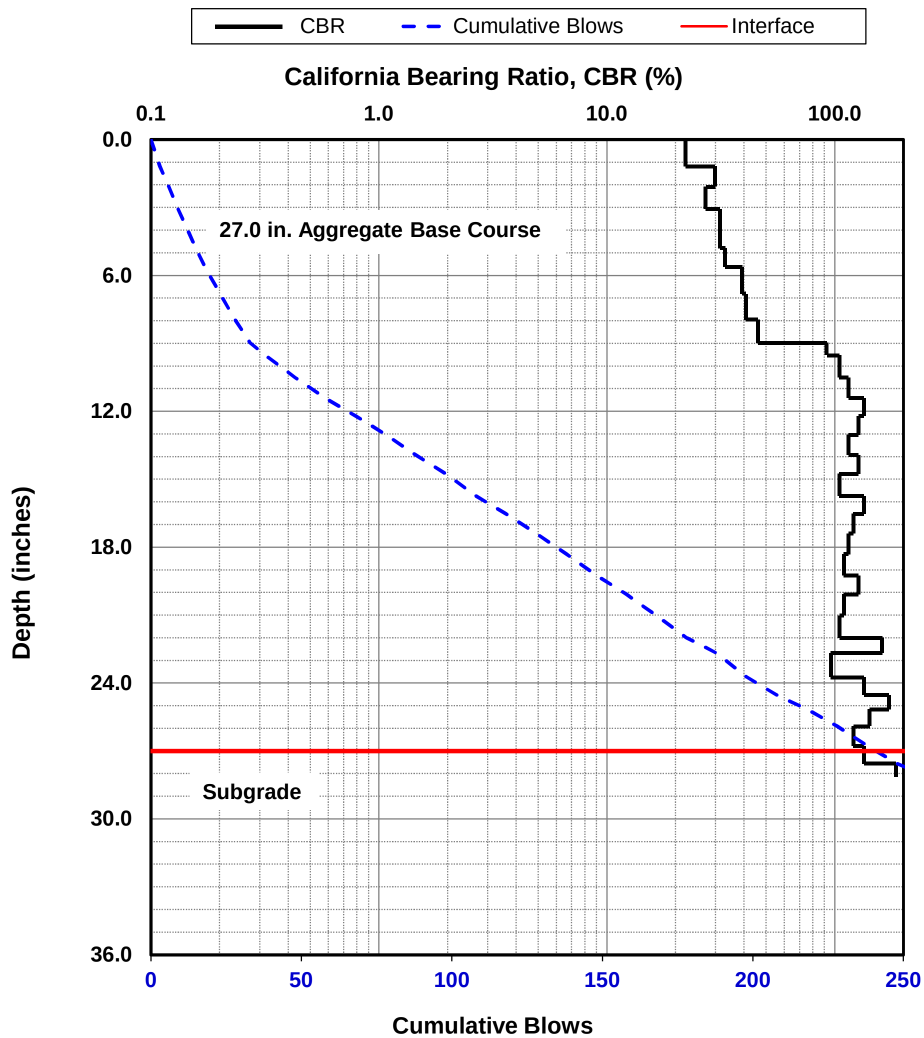
[2]$E\ (ksi) = (17.6\ CBR^{0.64}) \times 0.1450377$

[3]$S_u\ (psf) = (3.794 \times CBR^{0.664}) \times 144$

[1]ASTM D6951-03

[2]Powell et al. (1986)

[3]Portland Cement Assoc. (1955)



Dynamic Cone Penetrometer (DCP) Test Results

Project Name:	Interstate 5: North County Coastal Test Sections
Project ID:	TIC-00050
Location:	Encinitas, California

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Appendix IV: Summary of Caltrans Statewide Rigid Pavement Research, demonstrating 0.35 Feet aggregate placed on TriAx is superior to 0.70 Feet aggregate control sections.

TITLE: RESEARCH DOCUMENTING TRIAX GEOGRID PERFORMANCE IN RIGID PAVEMENT APPLICATIONS SPECIFIC TO CALTRANS DESIGN METHODOLOGY

No.	Project	Location	TriAx Pavement Area	Section Description			Performance Comparison			Comments
				TriAx AS Section	Control AS Section (no geogrid)	Subgrade	TriAx Enhanced Sub-base Resilient Modulus	TriAx Reduction in Surface Deformation	Improved Uniformity	
			Square Feet	Feet	Feet	Type	% Improvement	% Reduction	Yes or No	
	1. PERFORMANCE COMPARING 0.35 Feet AS ENHANCED TRIAX SECTION to 0.70 Feet AS CONTROL SECTION									
1	Caltrans Contract No. 07-252624	Interstate 5 In Los Angeles County	5,000,000 (72 Lane Miles)	0.35 Feet AS / TriAx NSSP	Control 1: 0.70 Feet AS Control 2: 0.85 Feet AS	2	Control 1: 125% Control 2: 95%	Control 1: 50% Control 2: 50%	Yes	
2	Caltrans Contract No.: 08-0A0204	Scott Road/ Interstate 215 Interchange Project, Menifee, CA	600,000 (9 Lane Miles)	0.35 Feet AS / TriAx NSSP	0.70 Feet AS	2	46%	45%	Yes	Subgrade was 8% softer on the TriAx section compared to control section
3	Caltrans Contract No. 11-2T2184 (North Coast Corridor)	Interstate 5 in San Diego, CA		0.35 Feet AB / TriAx NSSP	0.70 Feet AB	2	14%	45%	Yes	
4	Caltrans Contract No. 07-286904	State Highway 60 From Rte. 605 Separation to 57/60 Separation	1,170,000 (17 Lane Miles)	0.35 Feet AS / TriAx NSSP	0.70 Feet AS	2	N/A	N/A	Yes	7 year performance monitoring. A control section (0.70 ft. AS without geogrid) was constructed as part of the construction of the pavement section. in 2016, Applied Research Associates (ARA) performed a pavement condition survey. The survey indicated that the TriAx NSSP Geogrid sections are performing as well or better than the control section with good Pavement Condition Index (PCI) ratings and International Roughness Index (IRI) values 50% better than the control section.
5	Weld County Colorado Road 47	Greeley Colorado		0.35 Feet AS / TriAx NSSP	0.70 Feet AS	2	42%	31%	Yes	Subgrade was 11% softer on the TriAx section compared to control section
6	Los Angeles Transporation Center (Union Pacific Railroad)	Los Angeles, CA		0.45 Feet AS / TriAx NSSP	1.0 Feet AS	2	15%	45%	Yes	
7	US Highway 89/ SR98/ Navajo Route 20	Page, Arizona	5,247,000	0.35 Feet AS / TriAx NSSP	N/A	2	N/A	N/A	Yes	6 year performance monitoring. Test results are showing that the road is meeting the design requirements with good IRI readings.
	2. PERFORMANCE COMPARING 0.50 Feet ENHANCED TRIAX SECTION ON PUMPING TYPE 3 SUBGRADE									
8	Caltrans Contract No. 11-413604	Interstate 8 in Imperial County near El Centro	1,800,000 (26 Lane Miles)	0.50 Feet placed on TriAx NSSP	N/A	3	N/A	N/A	Yes	Surface of 0.50 Feet AS placed on TriAx was firm and unyielding for HMA Paver. Average Composite Mr of 16,533 psi. (greater than an R-Value 50

Appendix V: Summary of research and Caltrans experience comparing TriAx Geogrid performance to Biaxial Geogrid

3. PERFORMANCE COMPARING TRIAX SECTION COMPARED TO BIAXIAL GEOGRID SECTION

No.	Research Study	Location	Section Description			Performance Comparison				
			TriAx Geogrid Section	Biaxial Geogrid Section	Control Section (no geogrid)	Subgrade	TriAx Enhanced Sub-base Resilient Modulus VS Biaxial	TriAx Reduction in Surface Deformation VS Biaxial	TriAx Reduction in Surface Deformation VS Control	Biaxial Reduction in Surface Deformation VS Control
			Feet	Feet		Type	% Improvement	% Reduction		
7	In-Situ Performance Comparison Testing of TriAx and BX1200 Stabilized Aggregate, 2018	Boone Test Bed, Boone, IA, USA, David J. White, Ph.D., P.E., Ingios Geotechnics, Inc.	0.50 Feet AS/ TriAx NSSP	0.50 Feet AS/ Biaxial Geogrid	N/A	3	35% better	45% less	N/A	N/A
		Laboratory/Plate Load	1.50 Feet AS/ TriAx NSSP	1.50 Feet AS/ Biaxial Geogrid	N/A	3	20% better	38% less	N/A	N/A
8	In-Situ Performance Comparison Testing of TriAx and BX1200 Stabilized Aggregate	Laboratory/Plate Load	0.70 Feet AS/ TriAx NSSP	0.70 Feet AS/ Biaxial Geogrid	N/A	3	30% better	65% less	N/A	N/A
9	NDOT Research Report No. 327-12-803, use of Geogrid for Strengthening and Reducing Roadway Structural Sections	UNLV Laboratory Tank Test for Nevada DOT	0.25 Feet HMA/ 1.0 Feet AS/ TriAx NSSP	0.25 Feet HMA/ 1.0 Feet AS/ TriAx NSSP	0.25 Feet HMA/ 1.0 Feet AS	3	Not Measured	13% Less	30% less	17% less
10	NCHRP 1-50	Various	Various			-	Not Measured	20% less	30%	12%

	Research Studies (Numerical Modeling)	Comments
11	"Numerical Analysis of Tensile Behavior of Geogrids with Rectangular and Triangular Apertures", Jie Han et al, Geotextiles and Geomembranes, 2010	Triangular Shaped Geogrids perform better than square or rectangular shaped geogrids.
12	Discrete element modeling of a trafficked sub-base stabilized with biaxial and multi-axial geogrids to compare stabilization mechanisms", 2015 Geosynthetics Conference.	

Appendix VI: TriAx Geogrid Caltrans Example Project List (500+ Lane Miles)

Representative Caltrans Tensar TriAx Geogrid Non Standard Special Provision (NSSP) Approved Project List (500 + Lane Miles)

Item No.	Install Year	Caltrans Project Name	Caltrans Project No.	Description/ Location	Caltrans District	Quantity (SF)
STRUCTURAL SECTION REDUCTION/LIFE EXTENSION APPLICATIONS						
1	2009	HWY 905 in San Diego from 1.2km east of Route 905/805 separation to 0.3 km west of the United States – Mexico border/ (La Media Undercrossing, FROM Otay Mesa Rd. to Airway Rd.)	11-091834	Hwy 905 (La Media Undercrossing, FROM Otay Mesa Rd. to Airway Rd.)	11	135,000
2	2010	I15 Managed Lanes Project State of California, Statewide/ Hwy 15 Shoulders (FROM Hwy 78 TO East Via Rancho Pkwy)	11-2T0814	Shoulders	11	405,000
3	2010	Hwy 710 (From 105N to Firestone) - Place Rubberized HMA C13 AB Concrete Barrier and Approach Slabs	07-259904	Mainline	7	162,000
4	2010	Imperial County near Brawley on Rte. 78, 86	11-167894	Frontage Roads	11	225,000
5	2011	Route 405/605/22 Route Overcrossings	12-071634, 12-071624	I405/22, Orange County	12	180,000
6	2011	State Hwy 710 LA County in Southgate From .6 miles S Firestone Blvd. Overcrossing to .2 miles S Slausen Ave. Overcrossing	07-269004	Maineline	7	180,000
7	2011	I-5 Concrete Panel Replacement & Lane Reconstruction (Buttonwillow)	06-0M6804	Mainline	6	90,000
8	2012	HWY 805 South HOV Lanes (Euclid To Olympic Ave)	11-2T1804	South HOV Lanes/ South of 94	11	400,000
9	2012	HWY 805 North HOV Lanes (Division to Euclid)	11-2T1804	South HOV Lanes/ South of 94	11	585,000
10	2012-2013	Construction of State Highway 60 From Rte. 605 Separation to 57/60 Separation	07-286904	Mainline	7	1,170,000
11	2012-2014	I-405 Sepulveda Pass Widening Project	Design Build	Ramps HOV Lanes	7	N/A

Representative Caltrans Tensar TriAx Geogrid Non Standard Special Provision (NSSP) Approved Project List (500+ Lane Miles)

Item No.	Install Year	Caltrans Project Name	Caltrans Project No.	Description/ Location	Caltrans District	Quantity (SF)
STRUCTURAL SECTION REDUCTION/LIFE EXTENSION APPLICATIONS						
12	2015	SR 91 Corridor Improvement Project	Design Build, 08-RIV-91, Project No. 08000001361, EA No. 0f5404	Mainline	8	855,000
				City/County Local Streets Flexible Pavements	8	3,312,000
13	2015	PCC Rehabilitation Interstate 5	11-406704	Hwy 15 Shoulders (FROM Hwy 78 TO East Via Rancho Pkwy)	11	350,000
14	2015	Interstate 5	11-0223U4	I-5 (HOV Lanes)	11	135,000
15	2016	Interstate 8 in Imperial County near El Centro From 0.6 Mile West of Anderholt Road Overcrossing To 0.5 Mile East of East Highline Canal Bridge	11-413604	Mainline	11	1,800,000
16	2016	Pavement and Slab Replacement Project on the Foothill Freeway (I-210)	07-2881U4	Mainline	7	1,350,000
17	2017	State Route 98	11-080234	Mainline	11	216,000
18	2017-18	I-5 In Los Angeles at Castaic FROM 0.2 Mile South of Route 5/ 14 Separation TO 0.7 Mile North of Palomas Wah Bridge	07-252624	Temporary	7	360,000
				Mainline	7	4,950,000
19	2017-18	Route 60 in Los Angeles County in Diamond Bar FROM 0.40 Mile West of Lemon Avenue undercrossing to Old Brea Canyon Road Undercrossing	07-224104	On and Off Ramps (Lemon Avenue)	7	350,000
				Mainline		
20	2018	Route 138, In Los Angeles County at Pearblossom 0.3 Mile West of 121st Street to Longview Road	07-293504	Mainline	7	720,000

Representative Caltrans Tensar TriAx Geogrid Non Standard Special Provision (NSSP) Approved Project List (500+ Lane Miles)

Item No.	Install Year	Caltrans Project Name	Caltrans Project No.	Description/ Location	Caltrans District	Quantity (SF)
STRUCTURAL SECTION REDUCTION/LIFE EXTENSION APPLICATIONS						
21	2017-2019	Interstate 10 in and near West Covina, Covina, San Dimas, and Pomona From 0.2 Mile East of Hollenbeck Street Undercrossing To Route 57/10 Separation	07-1193U4	On and Off Ramps	7	4,500,000
				Temporary Sections		
				Arterial Streets		
				Mainline		
22	2018-2019	Limonite Ave at Interstate 15 Interchange Improvements Project No. A3-0393 Riverside County Transportation Department		On and Off Ramps	8	1,125,000
				Arterial Streets		
				Mainline		
23	2018-2019	Interstate 5 North Coast Corridor Contract 11-2T2184 - Segments 1B, 2 and 3 San Diego County, California	11-2T2184	On and Off Ramps	11	3,150,000
				Temporary		
				Mainline		
24	2019	Scott Road/ Interstate 215 Interchange Project, Menifee, California	08-0A0204	On and Off Ramps	8	603,000
				Arterial Streets		
25	2019	Route 10 in Yucaipa	08-OK2934, Route 10 in Yucaipa	Temporary	8	450,000
26	2019	CONSTRUCTION ON STATE HIGHWAY IN KERN COUNTY NEAR LOST HILLS FROM 1.0 MILE EAST OF LOST HILLS ROAD TO 0.7 MILE EAST OF ROUTE 46/5 SEPARATION In District 06 on Route 46	06-442544	Mainline	6	139,815
					Total (SF)	**32,864,915**
					Total (Lane Miles)	**519**

Appendix VII: Summary letter of District 11 project and research experience with Tensar TrIAx geogrid for the last 10 years and how District 11 will continue to use TriAx geogrid to provide value on future pavement designs.

DEPARTMENT OF TRANSPORTATION

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Making Conservation
a California Way of Life.

November 1, 2019

Subject: Tensar TriAx Geogrid for Mechanically Stabilized Layer (MSL) Geogrid Non-Standard Special Provision (NSSP) – 10 Years of Project Experience

To Whom It May Concern,

District 11 has extensive experience with the Tensar TriAx Geogrid. To date, our district has recommended and installed over 8.5+ million square feet (130+ lane miles). The TriAx geogrid was installed without difficulty and is performing well. Some of the larger projects are listed below:

- Caltrans Contract No. 11-091824 Hwy 905 (La Media Undercrossing, from Otay Mesa Rd. to Airway Rd.)
- Caltrans Contract No. 11-413604, Interstate 8 in Imperial County near El Centro From 0.6 Mile West of Anderholt Road Overcrossing To 0.5 Mile East of East Highline Canal Bridge. Implemented by Caltrans as a cost savings measure.
- Caltrans Contract No. 11-2T1804, Hwy 805 South
- Caltrans Contract No. 11-2T0814, I15 Managed Lanes Project
- Caltrans Contract No. 11-091834, HWY 905 in San Diego from 1.2km east of Route 905/805 separation to 0.3 km west of the United States – Mexico border
- Caltrans Contract No. 11-080234, State Route 98
- Caltrans Contractor No. 11-2T2184 Interstate 5 North Coast Corridor Project, which will be an additional 50 lane miles.

In the above projects, our recommendations for using TriAx Geogrid include the following:

- Mainline Rigid pavement:
    - TriAx geogrid has been recommended to reduce the thickness of the aggregate base layer, placing a minimum 0.35’ aggregate base on top of the TriAx geogrid, when Type 2 Subgrades (firm) are encountered. When Type 3 subgrades (pumping) are encountered on contract No.11-413604, District 11 has used TriAx geogrid with a minimum of 0.50’ aggregate base to provide a firm construction platform for the paving machines.
- Flexible pavement shoulders/ramps/Port of Entry (POE)/ State Highways: TriAx geogrid has been used on various projects to reduce the thickness of the Hot Mix Asphalt and Aggregate Base layers.

Caltrans District 11 used the MSL non-standard special provision (NSSP) for the TriAx geogrid on the above projects. In part 2 of the MSL NSSP, the performance requirements were established using the CAL/APT Program validation process. The enhanced pavement sections with TriAx geogrid utilizing the MSL NSSP have been compared to traditional control sections (no geogrid) to quantify the benefit of the geogrid. The TriAx geogrid has been tested on three separate phases of Accelerated Pavement Testing (APT) in accordance with National Cooperative Highway Research Program (NCHRP) standards.

District 11 has participated in the below research studies utilizing the MSL NSSP. Research studies are available upon request.

- Caltrans Contract No. 11-091824 Hwy 905 (La Media Undercrossing, from Otay Mesa Rd. to Airway Rd.). Published research study (GeoCongress 2012) at the location of the City of San Diego La Media Undercrossing on the 905, installed in 2010. After 9 years of monitoring, the TriAx geogrid pavement sections are performing well.
    - Control Section: 0.60’ HMA/ 2.45’ AB CL2
    - MSL Section: 0.50’ HMA/ 0.50’AB CL2/TriAx nSSP/ 0.90’ AB CL2/ TriAx nSSP
- Caltrans Contract No. 11-413604: Automated Plate Load Testing (APLT) Research underneath the mainline rigid pavements of Interstate 8 measuring resilient modulus and permanent deformation performance with 0.50 Feet AB placed on TriAx placed on Type III pumping subgrade soils. 0.50 Feet AB on TriAx provided a Type 1 Subgrade firm and unyielding surface for the paver.
- Caltrans Contract No. 11-2T2184 Interstate 5 North Coast Corridor Project: Automated Plate Load Testing (APLT) Research underneath mainline rigid pavement and flexible pavement measuring resilient modulus and permanent deformation performance of AB layers with and without TriAx Geogrid. Thinner geogrid sections performed superior to thicker non-geogrid control sections.
    - Flexible Control Section: 0.60’ HMA/ 2.25’ AB CL2
    - Flexible MSL Section: 0.60’ HMA/ 0.85’ Class 2 AB/ TriAx nSSP
    - Rigid Control Section: 0.85’ JPCP/ 0.25’ HMA/ 0.70’ AB CL2
    - Rigid MSL Section: 0.85’ JPCP/ 0.25’ HMA/ 0.35’ AB CL2/ TriAx nSSP

The main reasons District 11 uses TriAx geogrid utilizing the NSSP to enhance the pavement sections are as follows:

- Cost Benefits: Thinner hot mix asphalt and aggregate base sections are constructed on MSL with equal or better performance compared to thicker hot mix asphalt and aggregate base sections without geogrid. The MSL enhanced pavement sections have saved the District millions of dollars, thousands of trucks, and increased the speed of construction, which is important to the tax payers.

- Performance, Operation and Maintenance Benefits: The MSL interlocks and stiffens the aggregate base making it more uniform during construction and retains the stiffness during the life of the pavement.
    - This improves the pavement wearing surface. Risk is reduced by minimizing the potential for pavement stress over non-uniform subgrades and base materials.
    - Due to short working windows for the ramps (10 to 30 days) and aggressive schedules, the MSL enhanced pavement sections improve construction efficiencies by allowing our District to stay on or ahead of our construction schedule, opening roads sooner to the public
- Environmental Benefits: The enhanced MSL pavement section designs allow our team to create a sustainable project meeting several of the goals in the Caltrans Sustainability Policy DP-33, such as Planet, Prosperity, and Innovation.
    - Truck reduction
    - Less impact on surrounding streets.
    - Water reduction
    - Carbon emission reduction
    - Improved safety

Sincerely,

David Evans, P.E.
District Pavement Engineer
District 11 Materials Engineering (MS 63)

Appendix VIII: Example TriAx Geogrid nSSP

Replace *Reserved* section 96-1.02S TRIAX TX5 GEOGRID

TriAx TX5 Geogrid Geogrid must be a punched and drawn polypropylene material formed into a radially stable network open equilateral apertures with six intersecting ribs at each junction.

96-1.02T MATERIALS

TriAx TX5 geogrid must comply with the requirements shown in the following table.

TriAx TX5 Geogrid

Property	Test Reference	TriAx TX5 Geogrid[1]		
		Longitudinal	Diagonal	General
Aperture Shape	Observation			Triangular
Rib Pitch (min and max, inch)	Calipered	1.3 -1.6	1.3 -1.6	
Mid-rib depth	Calipered		0.05	
Mid-rib width	Calipered		0.03	
Mid-rib aspect ratio	Observation[2]		≥ 1.5	
Radial Stiffness ratio	ASTM D6637[3]			> 0.60
Junction Strength at 0.5% strain (lbs.)	ASTM D7737[4]			50
Ultraviolet Stability, @500 hrs. (%)	ASTM D4355-05			100

1 Calipered values are nominal. Unless indicated otherwise, all values in the table represent minimum average roll values (MARV) as defined in ASTM D4439.
2 Ratio of the mid-rib depth to the mid-rib width of the diagonal ribs.
3 Ratio of the minimum to maximum MARV values of radial stiffness at 0.5% strain. Radial stiffness is measured on both the rib directions and the mid-rib directions (directions that bisect the angles between ribs).
4 Load transfer capability determined in accordance with ASTM D7737 in longitudinal and diagonal directions

Replace the 2nd paragraph of section 25-1.03C with:

Geosynthetic materials includes TriAx TX5 geogrid.