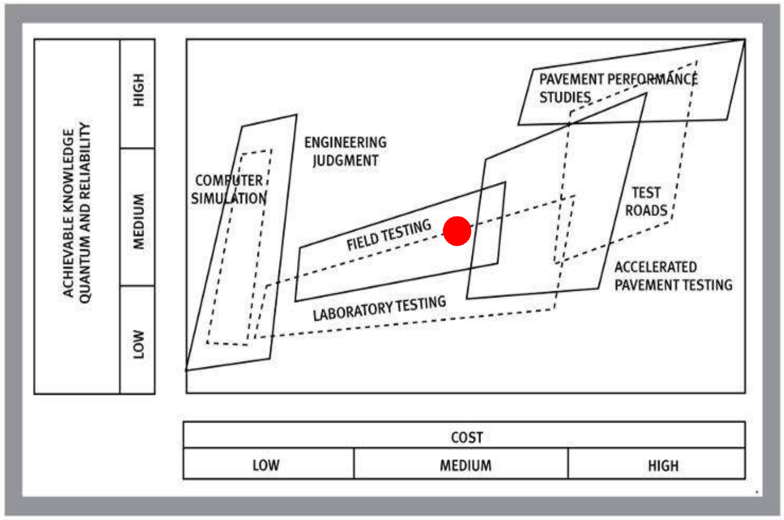
Research Summary

Topic: Evaluation of using TriAx geogrids for below Rigid Pavements
Caltrans Contract No.: 08-0A0204
Location: Scott Road/ Interstate 215 Interchange Project, Menifee, California



Application:

Rigid Pavements

Type:

Field Structural Performance Study

Geogrid Products Tested:

- Tensar TriAx Geogrid

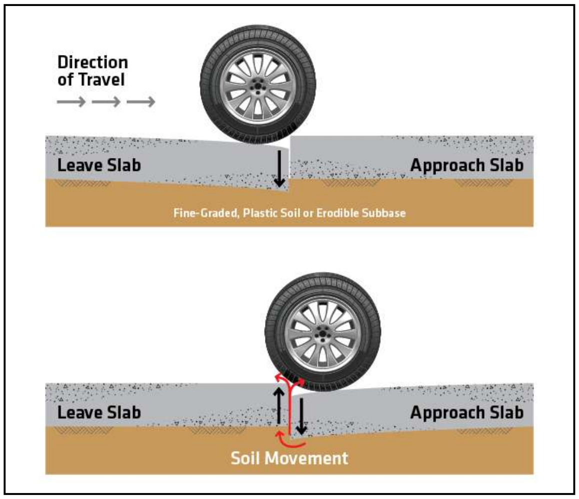
Section Profiles:

- Enhanced Section: 4 – 5 inches (0.40 feet) thick aggregate base stabilized with TriAx Geogrid
- Control Section: 9 – 10 inches (0.80 feet) aggregate base
- Both 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:

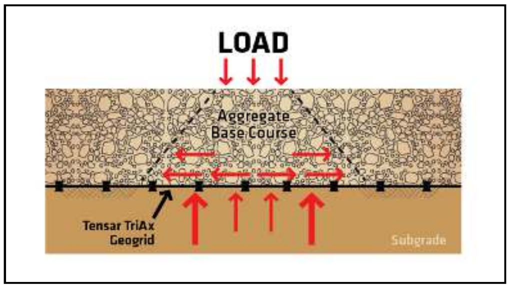
- Uniform support
- Additional load distribution; and
- Drainage



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.

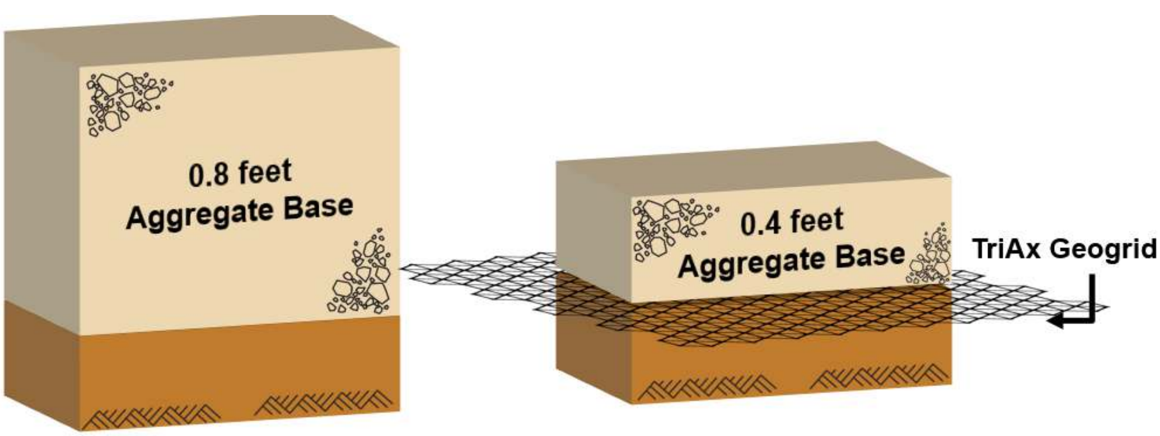
Benefits of the Geogrid Mechanically Stabilized Layer (MSL)



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. This is accomplished by the geogrid 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 along the west bound lanes of Scott Road west of State Route 215 in the Murrieta area of Southern California. A contractor constructed the test sections within the limits of project area. The diagrams below present the test sections:



Purpose/Objective:

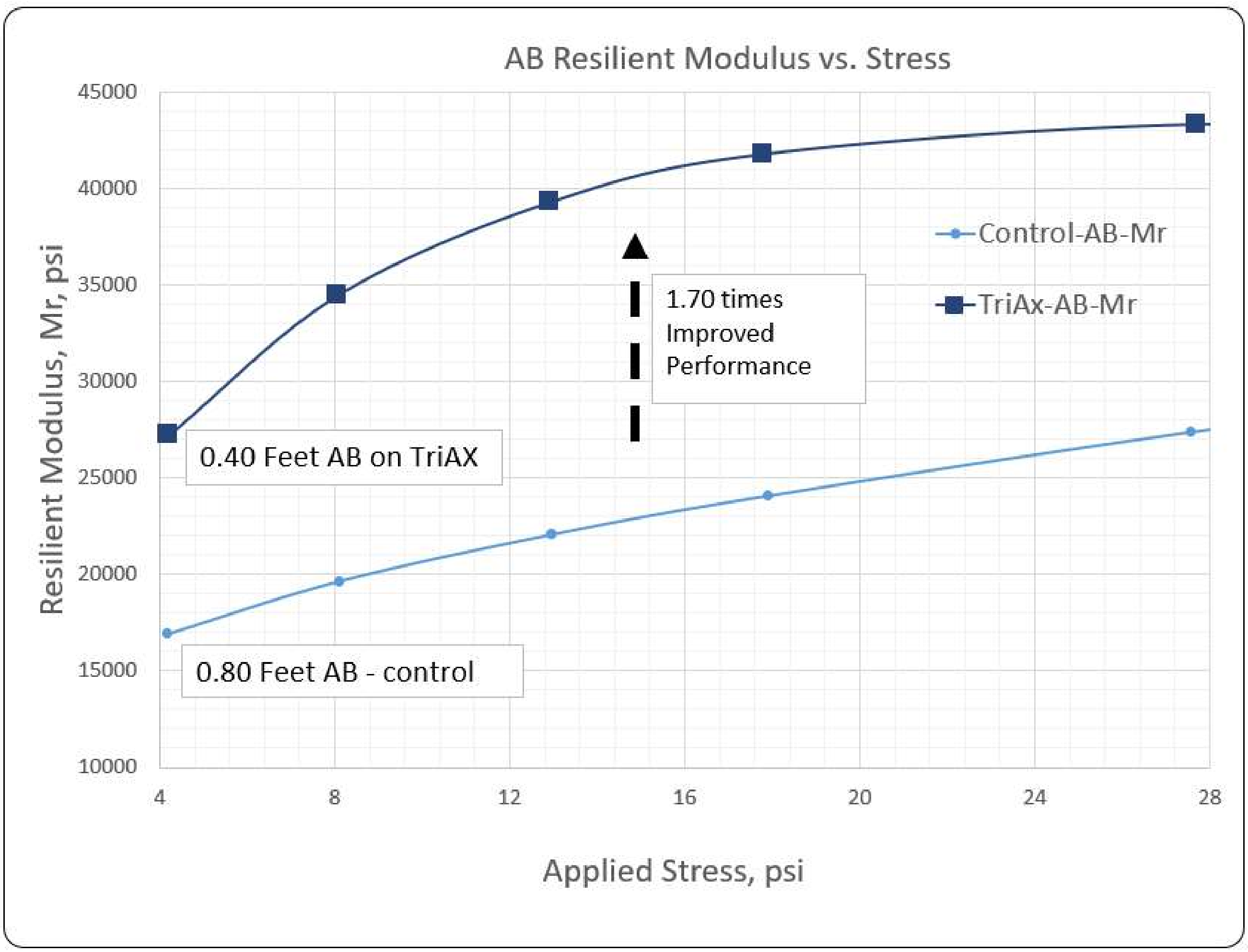
The purpose of the testing was to demonstrate that an MSL below a rigid pavement will reduce deformation better than a thicker aggregate base section creating more uniform support. Additionally, the MSL will create a more resilient foundation section and not lose strength over time.

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 cycles 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 show the improved resilient modulus of the 0.40 feet aggregate base section underlain by TriAx geogrid compared to the control sections with 0.80 feet aggregate base.

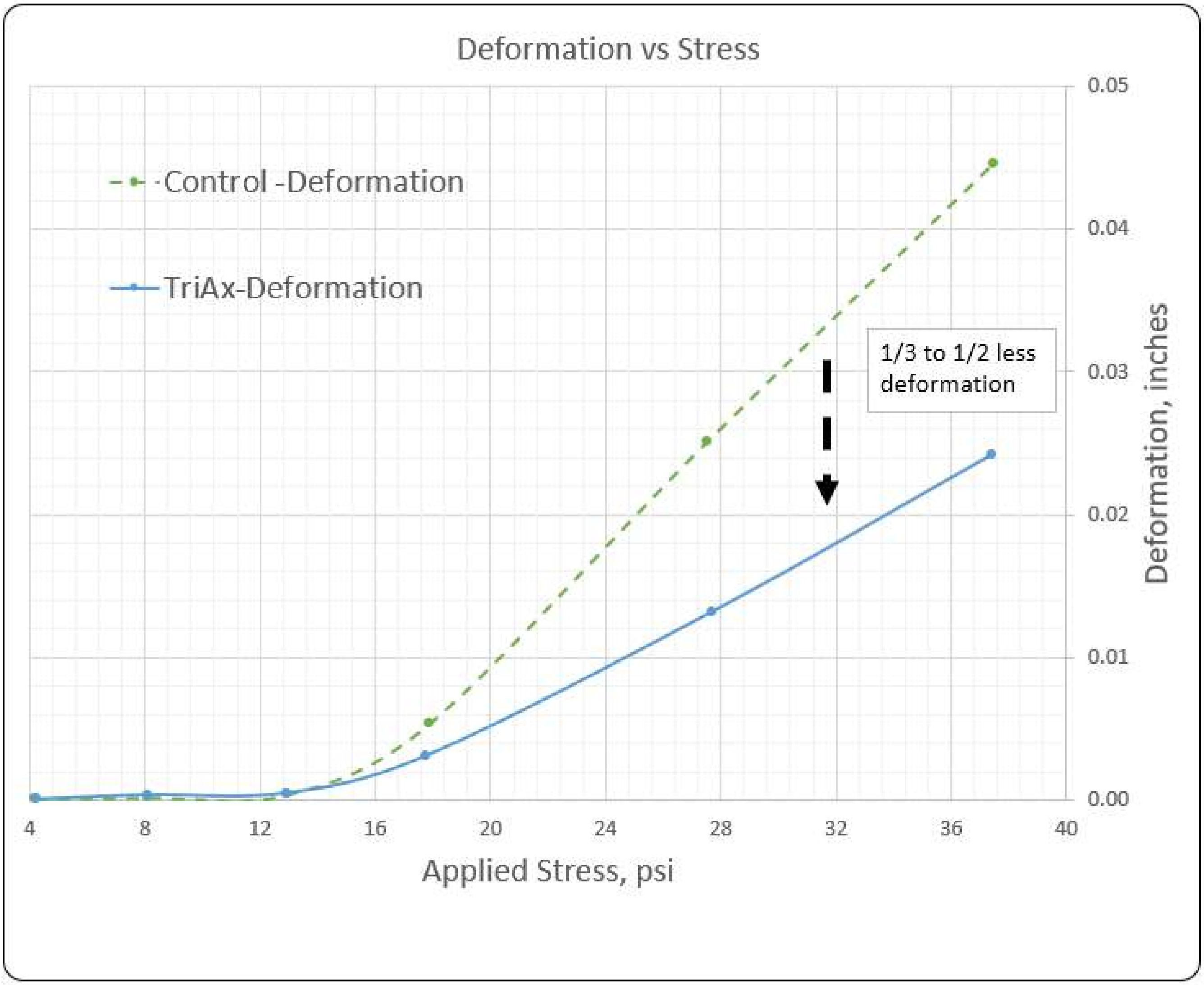


Why is this concept significant to the rigid pavement design?

The aggregate base within a rigid pavement section is a construction platform. The purpose of the construction platform is to provide an acceptable working surface for placement of the wearing surfaces consisting of asphalt concrete or Portland cement concrete above the aggregate base. 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 additional 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 intermixing is demonstrated with the results of the stress dependent resilient modulus testing with the APLT shown above. As the stress is increased there is only a slight increase in the resilient modulus test of the aggregate base. By placing a geogrid on the subgrade an MSL is created. The MSL acts as a composite system where the aggregate base is confined and the unable to become intermixed with the subgrade material or move. This is demonstrated with the results of the stress dependent resilient modulus testing with the APLT shown above. As the stress is increased the resilient modulus of the aggregate base increases. This occurs because the aggregate base is prevented from intermixing with the subgrade material and the aggregate base is confined.

Why is the deformation significant?

Less deformation creates a more uniform surface. This uniform surface creates a non-yielding surface for paving and ultimately provides a better foundation for the rigid pavement. Additionally, rigid pavement distress typically occurs when the foundation supporting the concrete loses strength and deforms. This is referred to as erosion. This is more critical in rigid pavements where faulting of 0.15 inches can be the threshold at the end of the design life. This test shows the reduced potential for deformation with an MSL.


Deformation vs Stress
Control -Deformation
TriAx-Deformation
1/3 to 1/2 less deformation
0.05
0.04
0.03
0.02
0.01
0.00
Deformation, inches
4
8
12
16
20
24
28
32
36
40
Applied Stress, psi

How does TriAx geogrid help when yielding subgrades (Type III) are encountered?

When yielding subgrade conditions are encountered during construction, many times the project is delayed with expensive options. For example, typical recommendations to provide working construction platforms over soft soils (Type III Subgrade) range from 1.0 to 1.5 Feet of over-excavation and replacement with aggregate base material. With typical costs of $36/CY for AB and $36/CY for excavation, the result of 1.0 to 1.5 Feet over-excavation and AB replacement results in an additional cost of $24/SY to $36/SY.

Having geogrid already included in the design and available during construction provides a simple solution to mitigate differing site conditions. Many times, by placing 0.40 to 0.60 feet of aggregate base on geogrid on a yielding subgrade (Type III Subgrade), results in a composite surface that will exceed the stiffness of an R-Value 40 (Type I Subgrade). Therefore, minimal design changes are required, avoiding expensive change orders.

- ***See Appendix 2 Case Study: Caltrans EA No.: 11-413604, I-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.***
- ***Construction platform design curves are available in accordance with the FHWA Giroud Han Subgrade Improvement Design Method***
    - *Design curves compare AB thickness requirements with and without TriAx geogrid to create a firm and unyielding construction platform for construction traffic for various subgrade conditions.*

Conclusions

The testing here demonstrates that 0.40 feet AB placed on TriAx Geogrid provides superior performance compared to the control sections of 0.80 feet AB within a pavement's foundation by:

- Reducing deformation as compared to thicker aggregate base sections
- Providing more uniform support characteristics improving rigid 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.
- Mitigating expensive post-construction change orders when yielding subgrades are encountered.

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.

Appendices:

1. **Testing Pictures at Scott Road/ Interstate 215 Interchange Project**
2. **Caltrans Yielding Subgrade Case Study: 11-413604, I-8**

References:

3. *"In Situ Performance Verification of Geogrid-Stabilized Aggregate Layer Using Automated Plate Load Testing, Interstate 5 Test Sections, Santa Clarita, California" prepared by David J. White, Ph.D., P. E. dated January 12, 2018.*
4. *AASHTO, MEPDG, 2015*
5. *Concrete Pavement Joints, Technical Advisory T 5040.30. Federal Highway Administration. Washington, D.C. http://www.fhwa.dot.gov/legsregs/directives/techadvs/t504030.htm.*
6. *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.*
7. *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.*
8. *Load Transfer Design on the Pavement Interactive web site.* http://www.pavementinteractive.org/article/joint-design/
9. *"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.*
10. *"Full-Scale Evaluation of Geogrid Reinforced Thin Flexible Pavements"* prepared by U.S Army Engineer Research and Development Center, dated August 2, 2011.
11. *"Performance of Geogrid-Stabilized Flexible Pavements"* prepared by U.S Army Engineer Research and Development Center, dated July 2014.
12. *"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*
13. *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*

APPENDIX 1: TESTING PICTURES

Project Location and Test Locations

Test Locations

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

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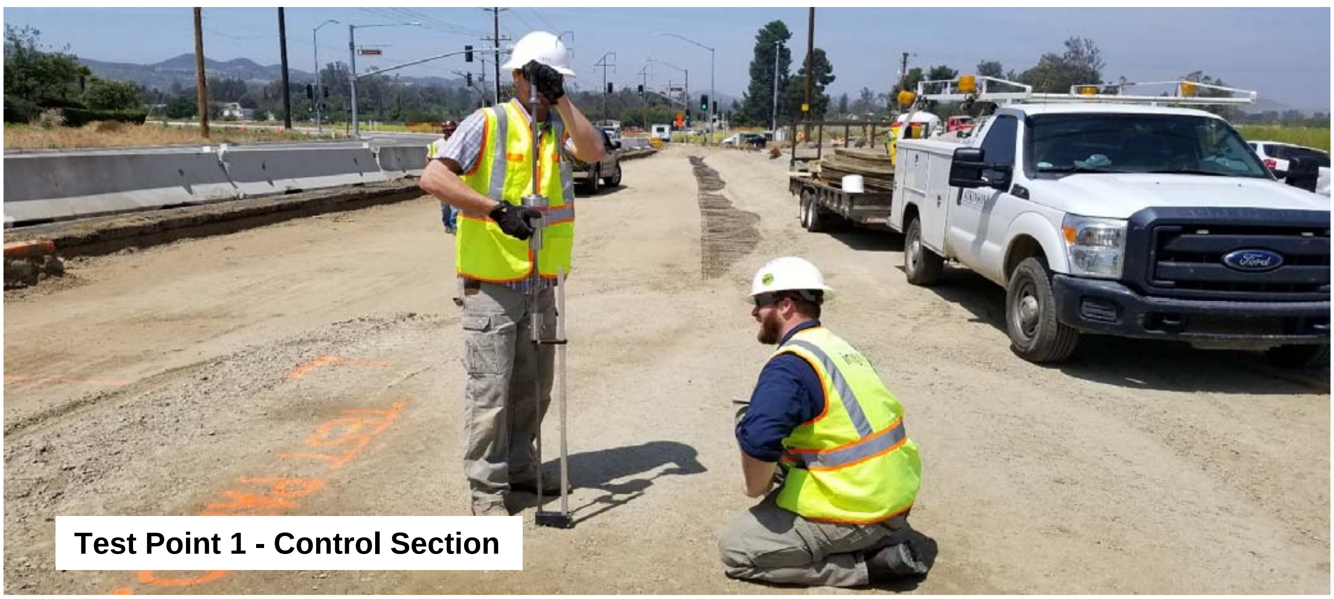
Site Conditions and Pictures

Test Point 1 - Control Section



Test Point 1 - Control Section

Pictures

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