# Full-Scale Accelerated Testing of Multi-axial Geogrid Stabilized Flexible Pavements

## Constructed over Very Stiff Soils

Tensar®

***Research Organization***

US Army Corps of Engineers

Engineer Research and Development Center

***Sections Tested/Compared***

4 inches (102 mm) HMA over 8 inches (203 mm) base (control)

3 inches (76 mm) HMA over 6 inches (152 mm) base over TX5

3 inches (76 mm) HMA over 6 inches (152 mm) base over TX8

***Testing Conducted***

Thickness Validation & Material Characterization

Instrumentation of sections

Pavement Characterization (post construction)

HVS-A Traffic testing, FWD analysis **(811,200 ESALs)**

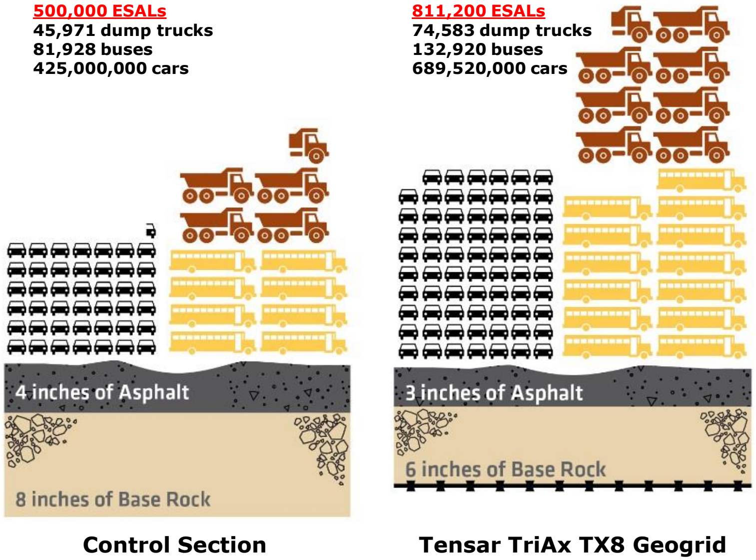
Post trafficking forensics (in-field CBR, rutting of layers,…)

## Key Findings

After 800,000+ ESALs, thinner TriAx stabilized sections, over stiff subgrade soils, had less than half as much rutting as the control.

Structural benefits of TriAx exceeded SP4Pro design values.

Estimates show TriAx provides ~16% savings in construction costs, ~19-25% improvement in performance (>60% improvement in this testing) and a savings in time of ~5.5 days per lane mile.



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US Army Corps of Engineers
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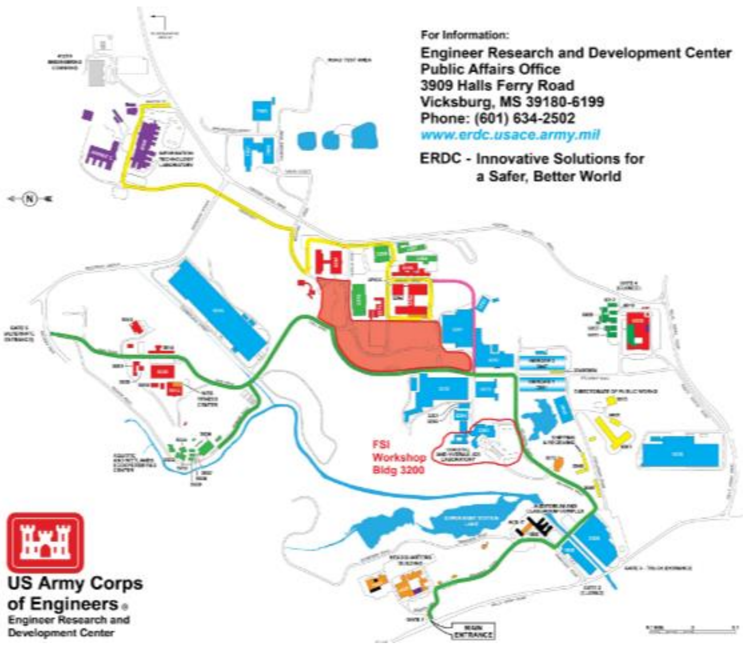
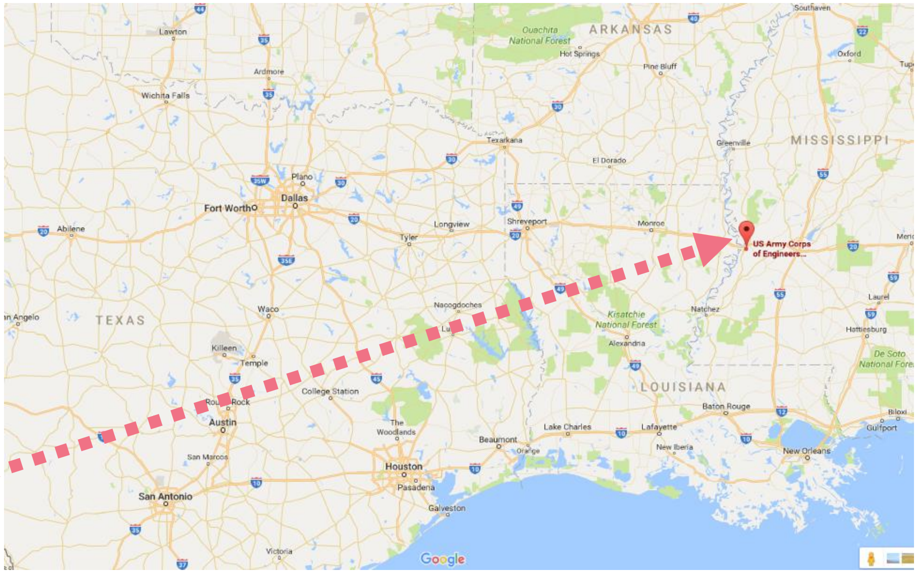
Hanger 2

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## Objectives of Testing

- Provide performance data of **paved sections** comparing Tensar TriAx geogrids to conventional methods **over very stiff soils**.
- Compare a **thicker asphalt** pavement to **thinner stabilized asphalt** pavement with a TriAx stabilized base.
- Record pavement response data in order to verify Tensar's mechanistic models currently available on the market.
- Verify SpectraPave4Pro design values.

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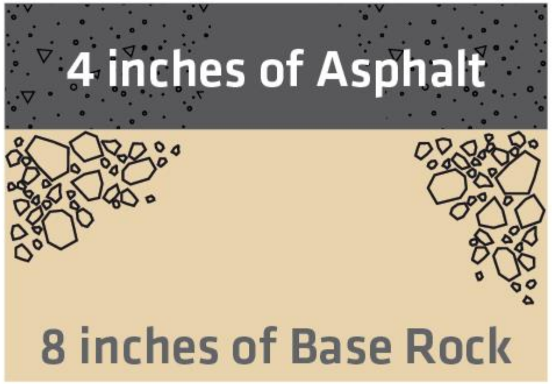
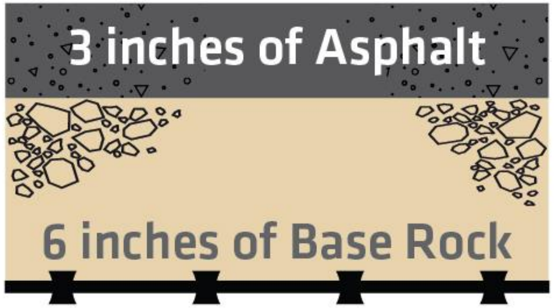
## Scope

- Construction, instrumentation and trafficking of test sections with TriAx stabilized bases and compare them to a control section.

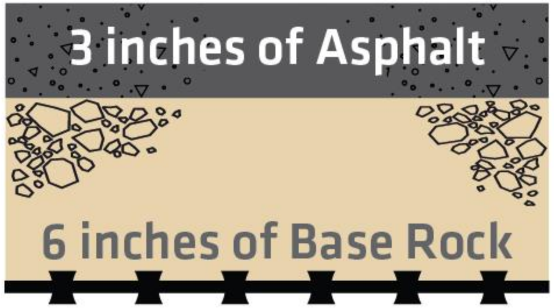
- Testing to be conducted using highly controlled and monitored Accelerated Pavement Testing (APT) to gather response data, limit the risk of variability and ensure proper comparisons.




**Control Section (Unstabilized)**



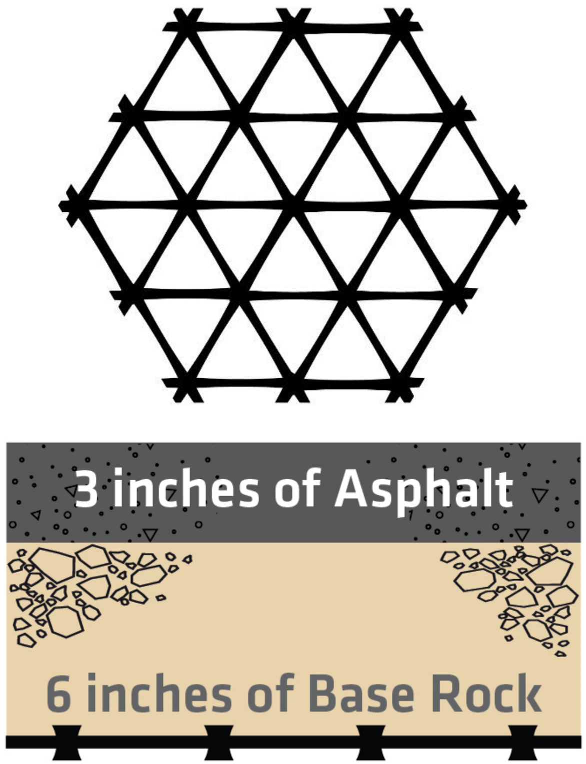

**Tensar TriAx TX5 Geogrid**



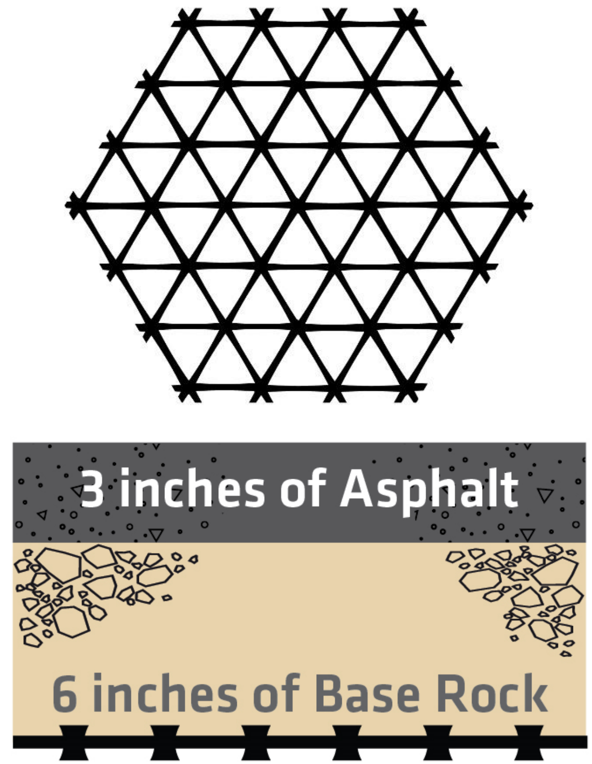

**Tensar TriAx TX8 Geogrid**

## TriAx Products

Standard Aperture (Opening) Size




**Tensar TriAx TX5 Geogrid**

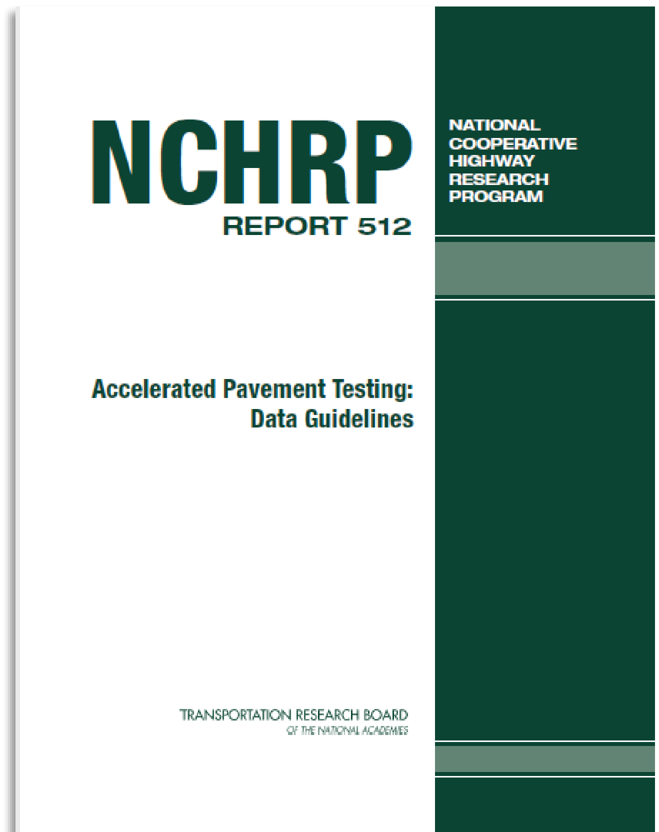



**Tensar TriAx TX8 Geogrid**

Smaller Aperture Size Designed for D50<= 22mm

# Test Section Development

- Test sections were 10’ wide by 50’ long.
- Sections were developed following guidelines outlined by NCHRP Report 512 – with high Quality Assurance and Quality Control for subgrade prep, base placement, instrumentation, climatic monitoring.
- To monitor TriAx benefits over more competent subgrade soils, this testing utilized moderate subgrade soils with a CBR of 6%.



# Full-Scale Accelerated Testing of Multi-axial Geogrid Stabilized Flexible Pavements

## Constructed over Very Stiff Soils

http://www.tensarcorp.com/Tensar-Videos/accelerated-pavement-testing

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# Full-Scale Accelerated Testing of Multi-axial Geogrid Stabilized Flexible Pavements

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## Loading

- 20,000 nominal load gear weight – verified with portable scales.
- Tire pressures of 120 psi maintained throughout trafficking

## Monitoring

- Instrumentation installed included earth pressure cells, Single depth deflectometers, asphalt strain gauges, pore water pressure sensors, temperature sensors, and moisture sensors.
- Pavement characterization was monitored though nuclear gauge testing, DCP testing and FWD testing.
- Instrumentation results, surface deformation, and FWD monitoring at specific intervals.

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Heavy Vehicle Simulator (HVS-A). Capable of applying loads between 10,000 and 100,000 lbs.

Uniformly distributed traffic load with typical wander introduced.

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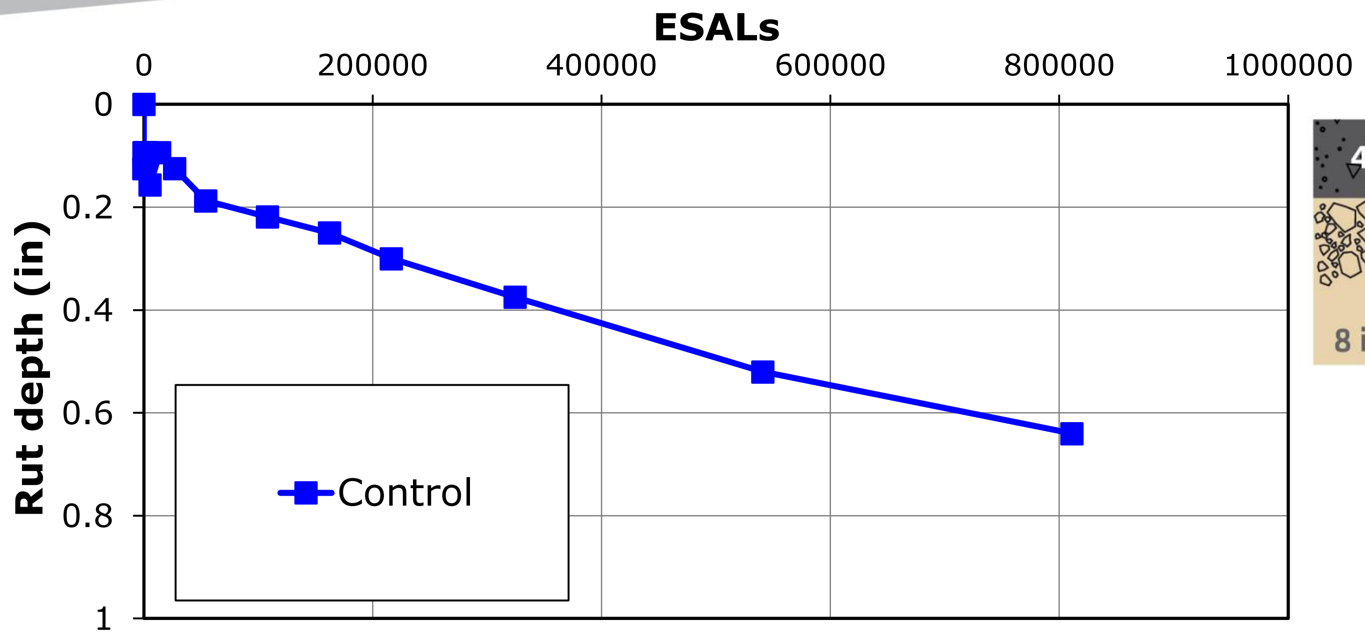


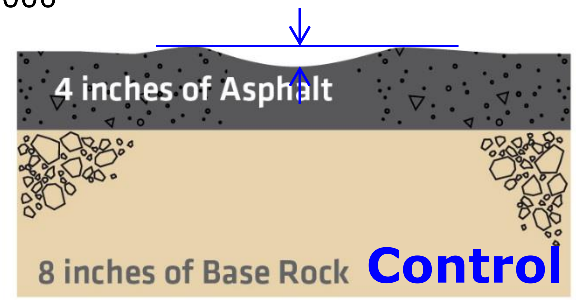


**Total Deformation/Rutting**

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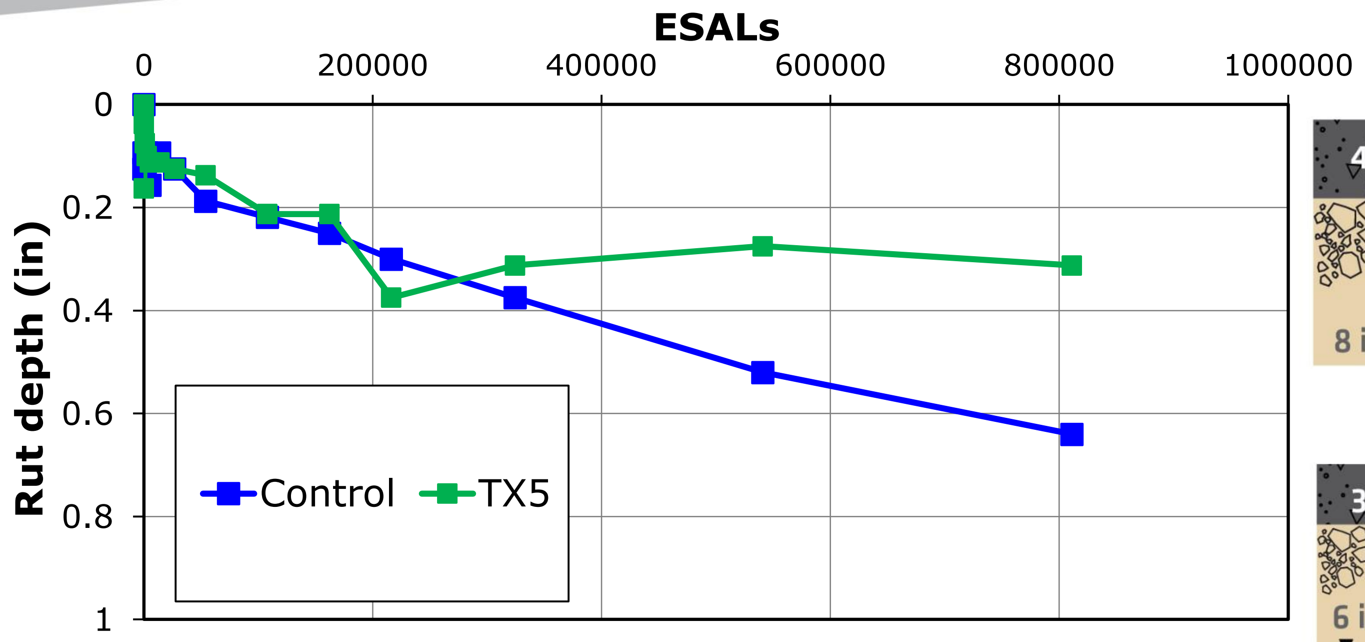


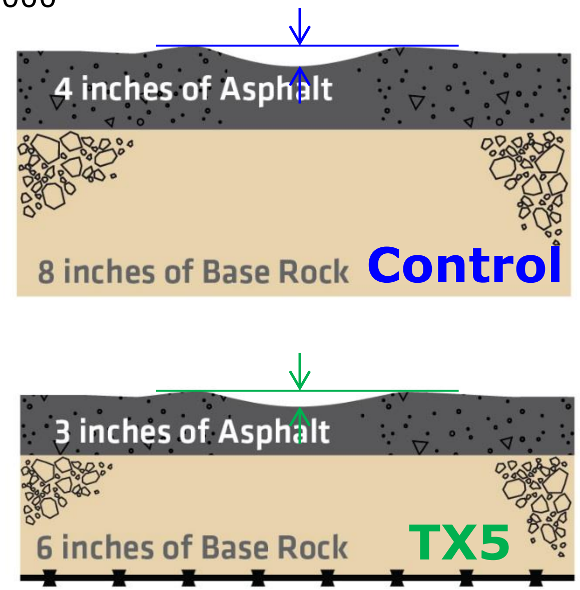


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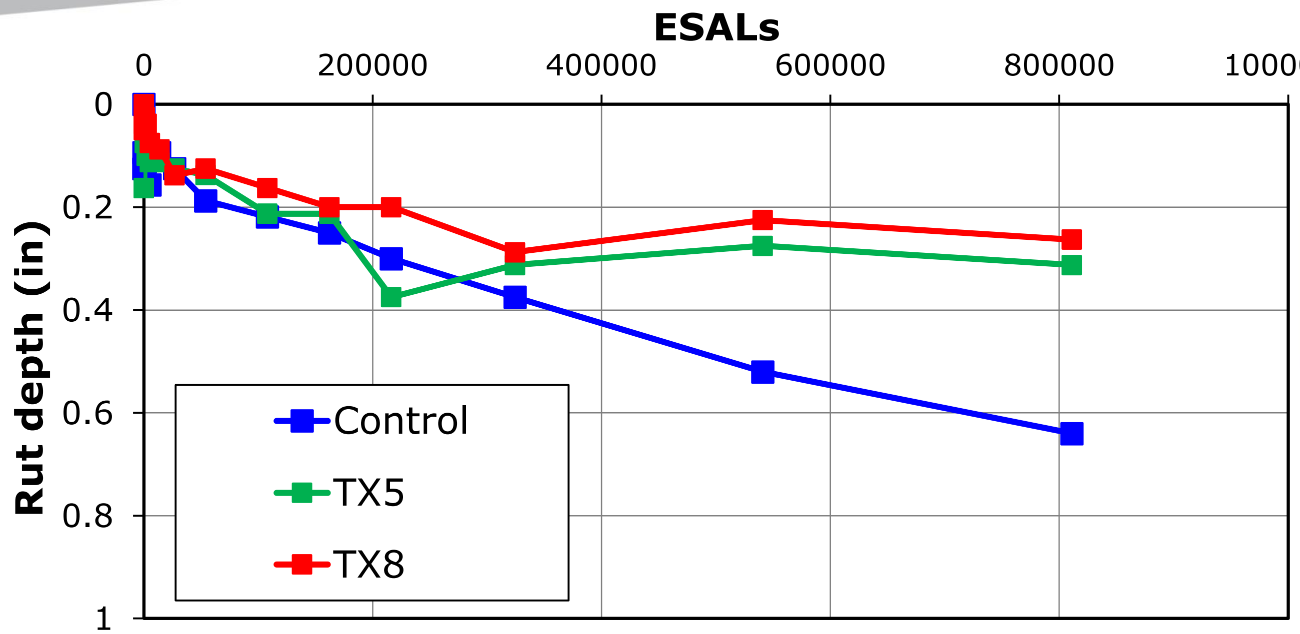


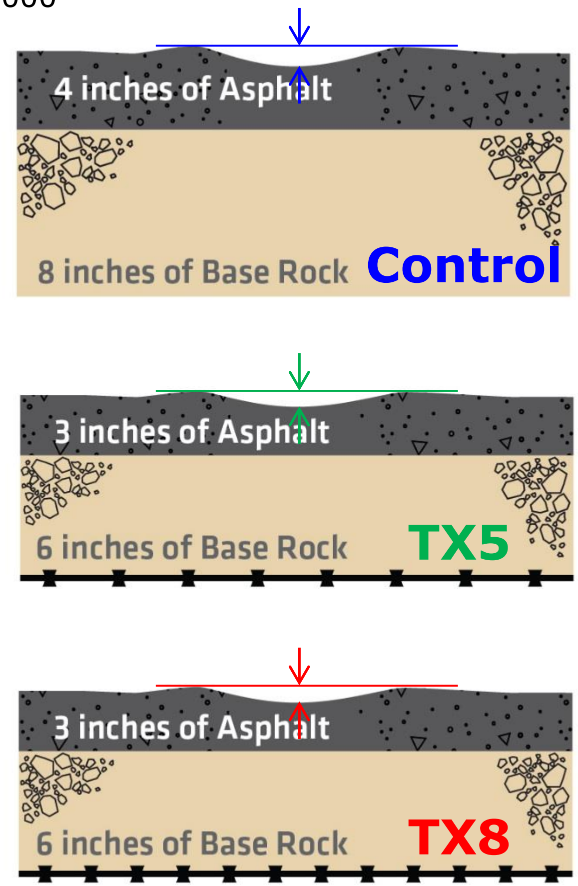


**Total Deformation/Rutting**

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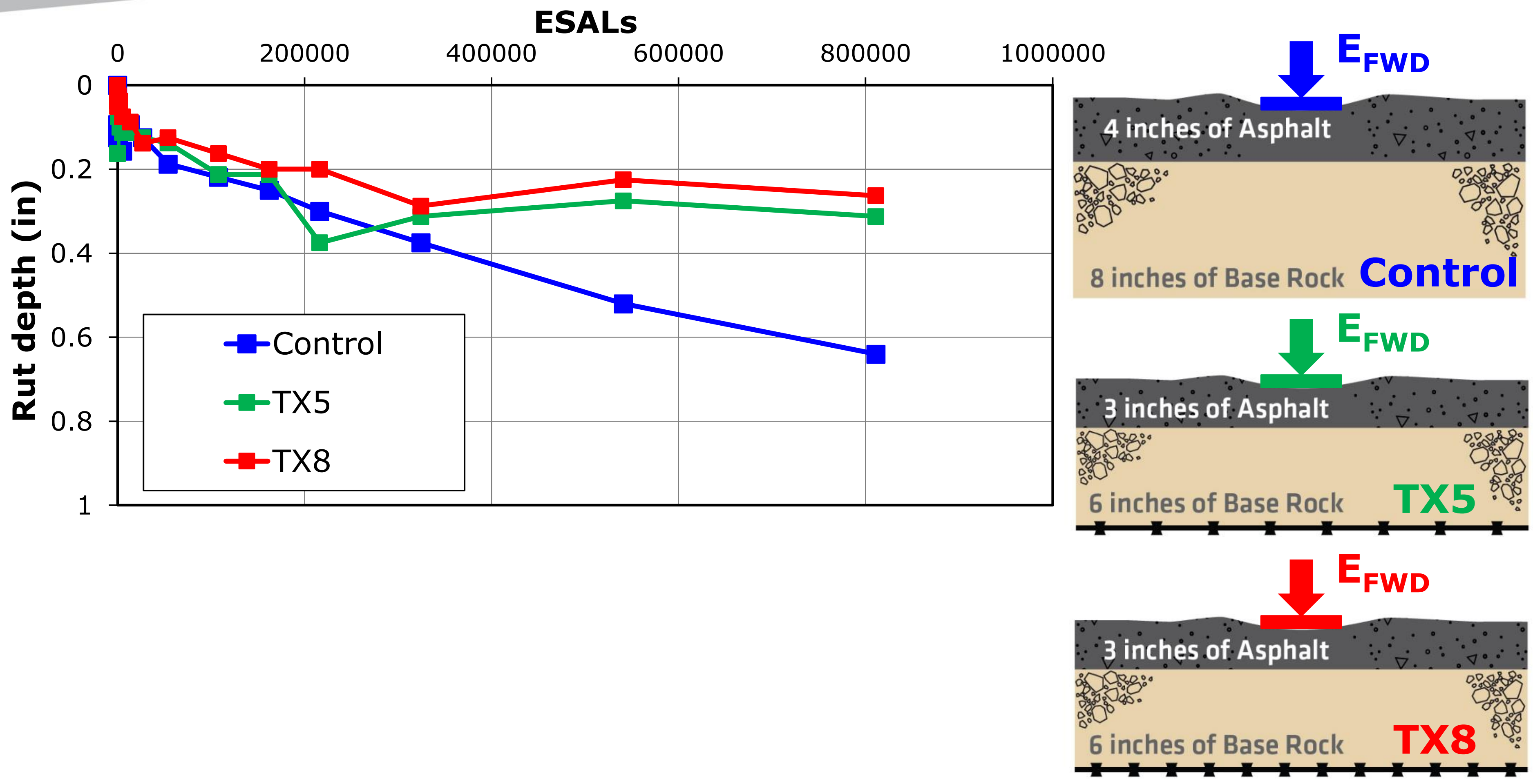


**Total Deformation/Rutting Related to FWD Surface Modulus**

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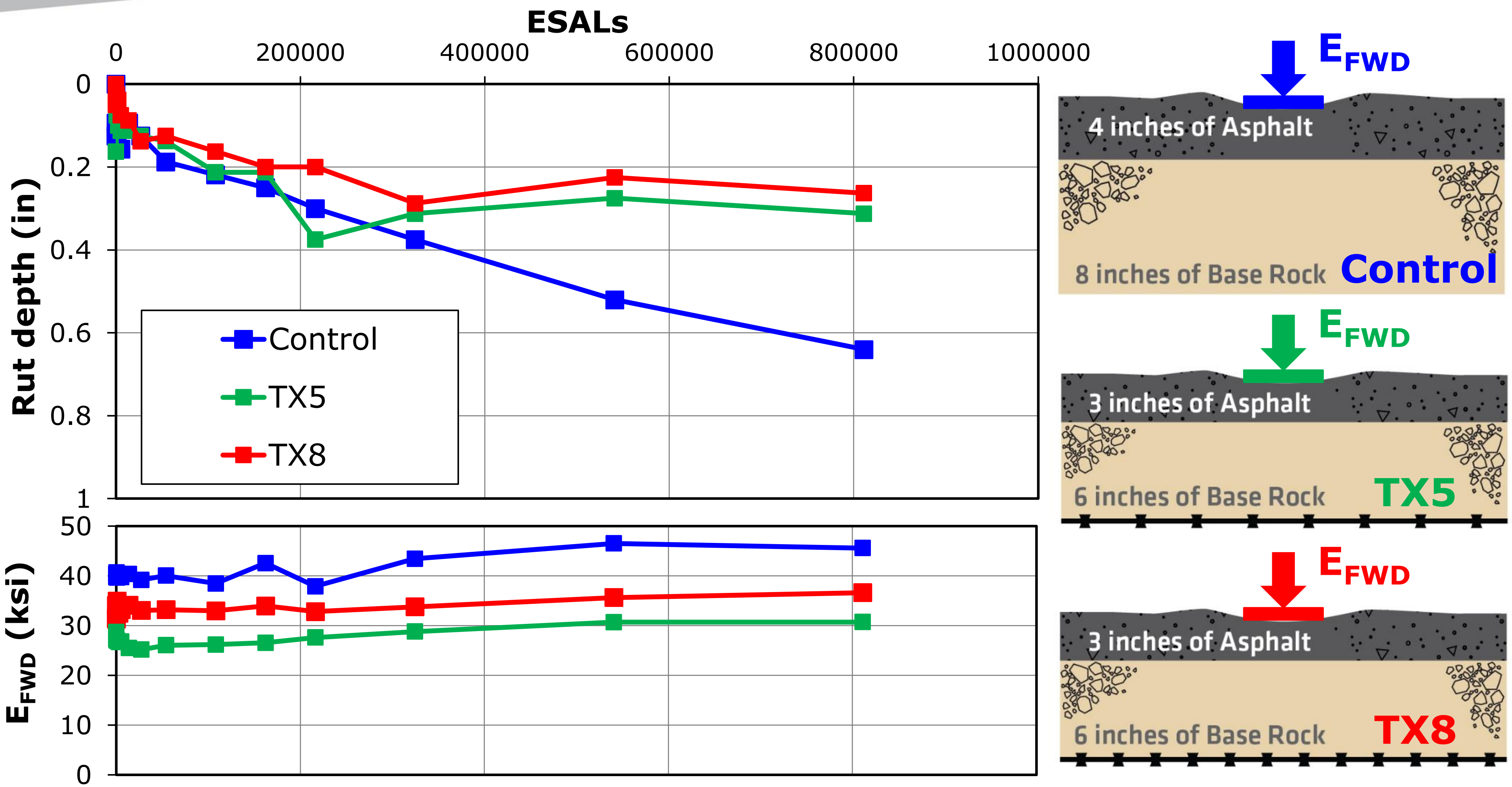
Constructed over Very Stiff Soils




**Total Deformation/Rutting Related to FWD Surface Modulus**

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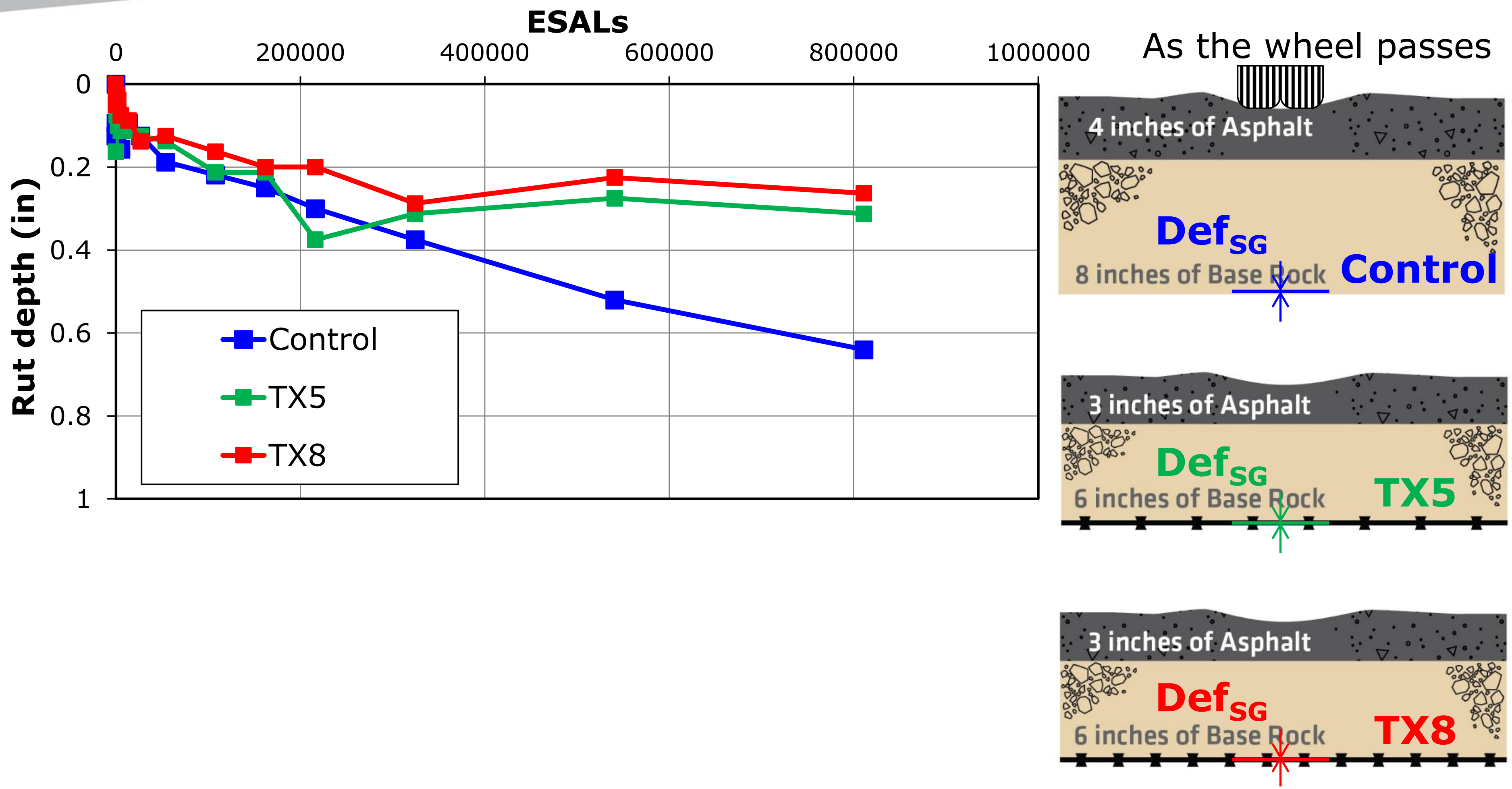


**Total Deformation/Rutting Related to Subgrade Deflection**

# Full-Scale Accelerated Testing of Multi-axial Geogrid Stabilized Flexible Pavements

Constructed over Very Stiff Soils

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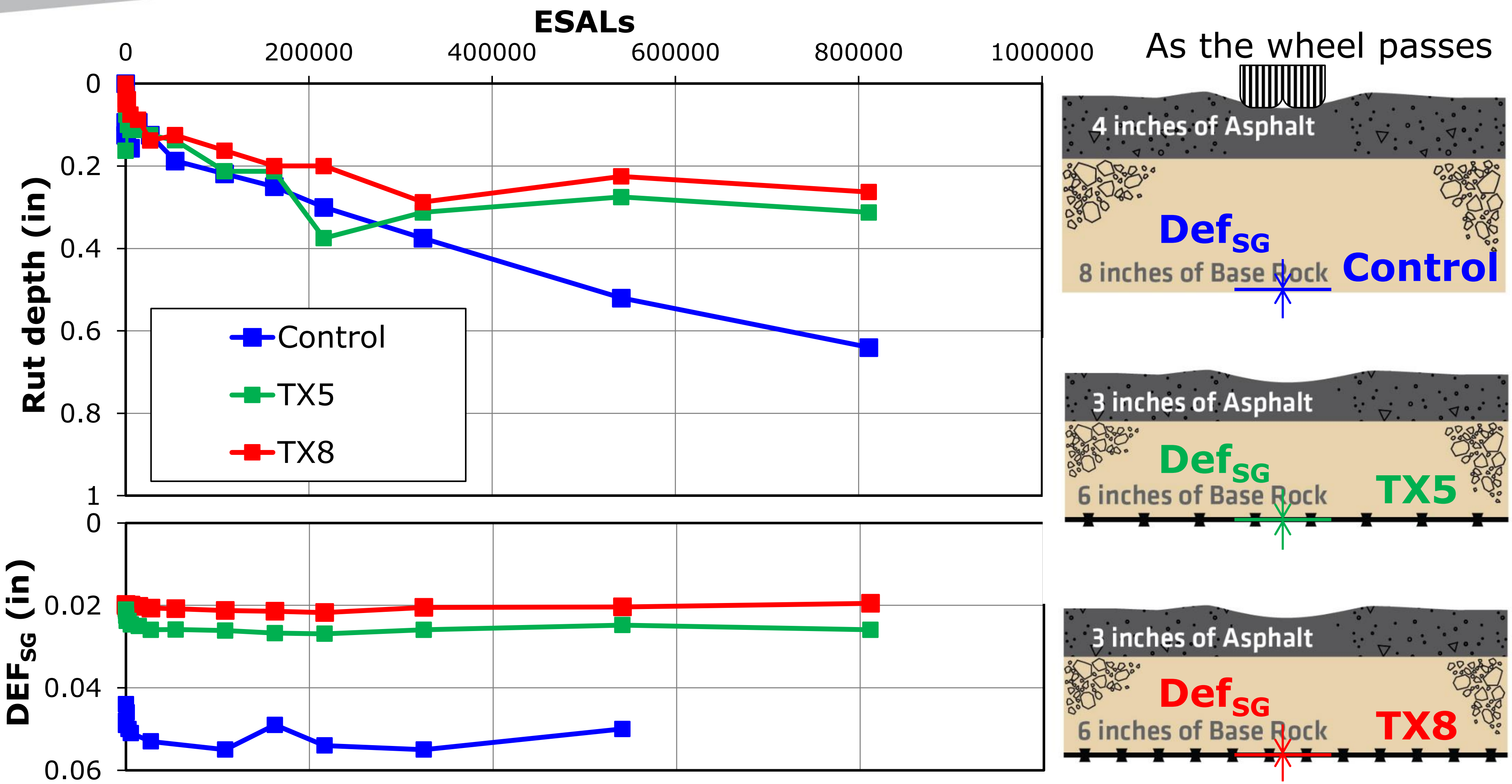


**Total Deformation/Rutting Related to Subgrade Deflection**

# Full-Scale Accelerated Testing of Multi-axial Geogrid Stabilized Flexible Pavements

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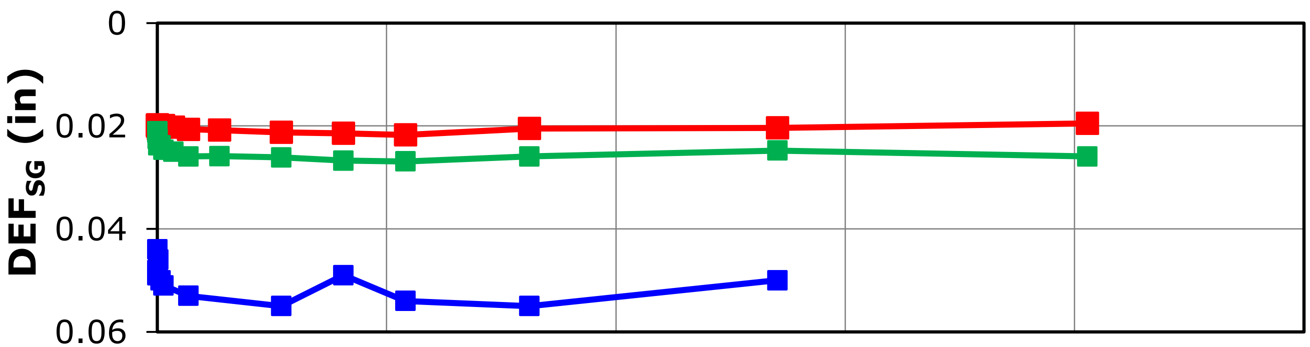
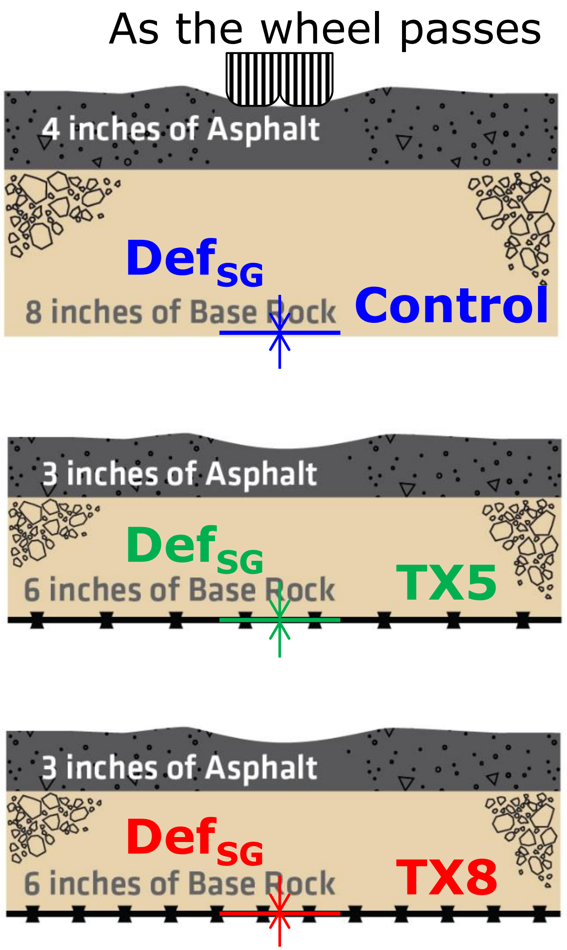
*"Measured deflections in the stabilized items were approximately ½ of that observed in the unstabilized section. This may be indicative of base stiffening due to aggregate interlock at the geogrid/aggregate interface."*

Corps 2017

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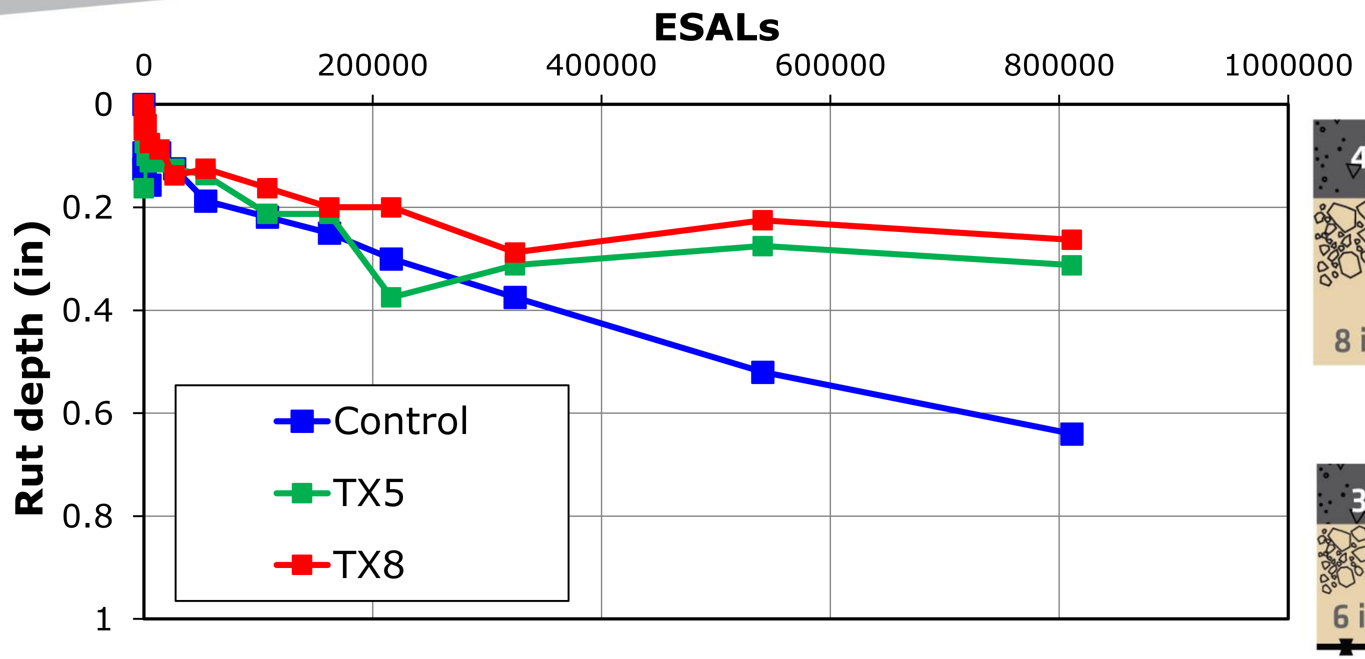


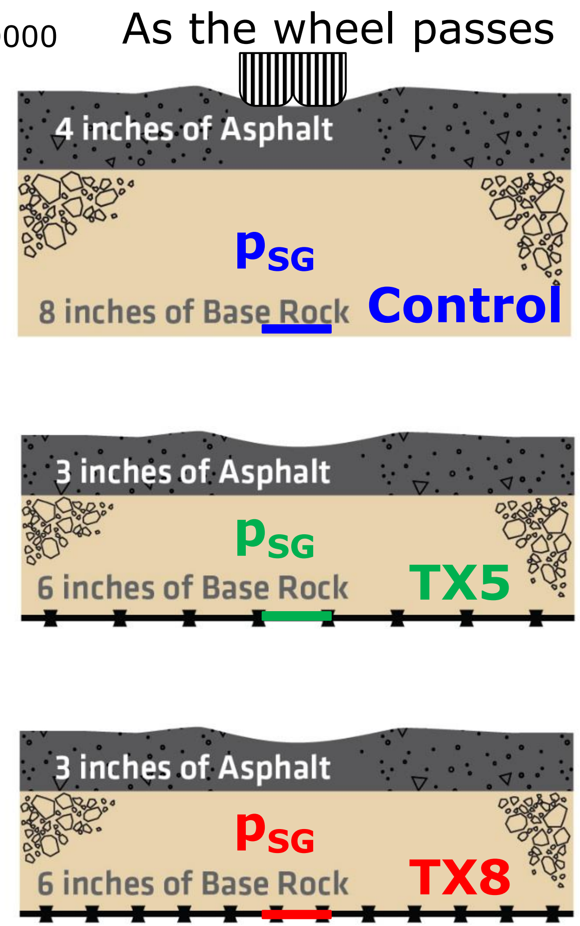


**Total Deformation/Rutting Related to Pressure on the Subgrade**

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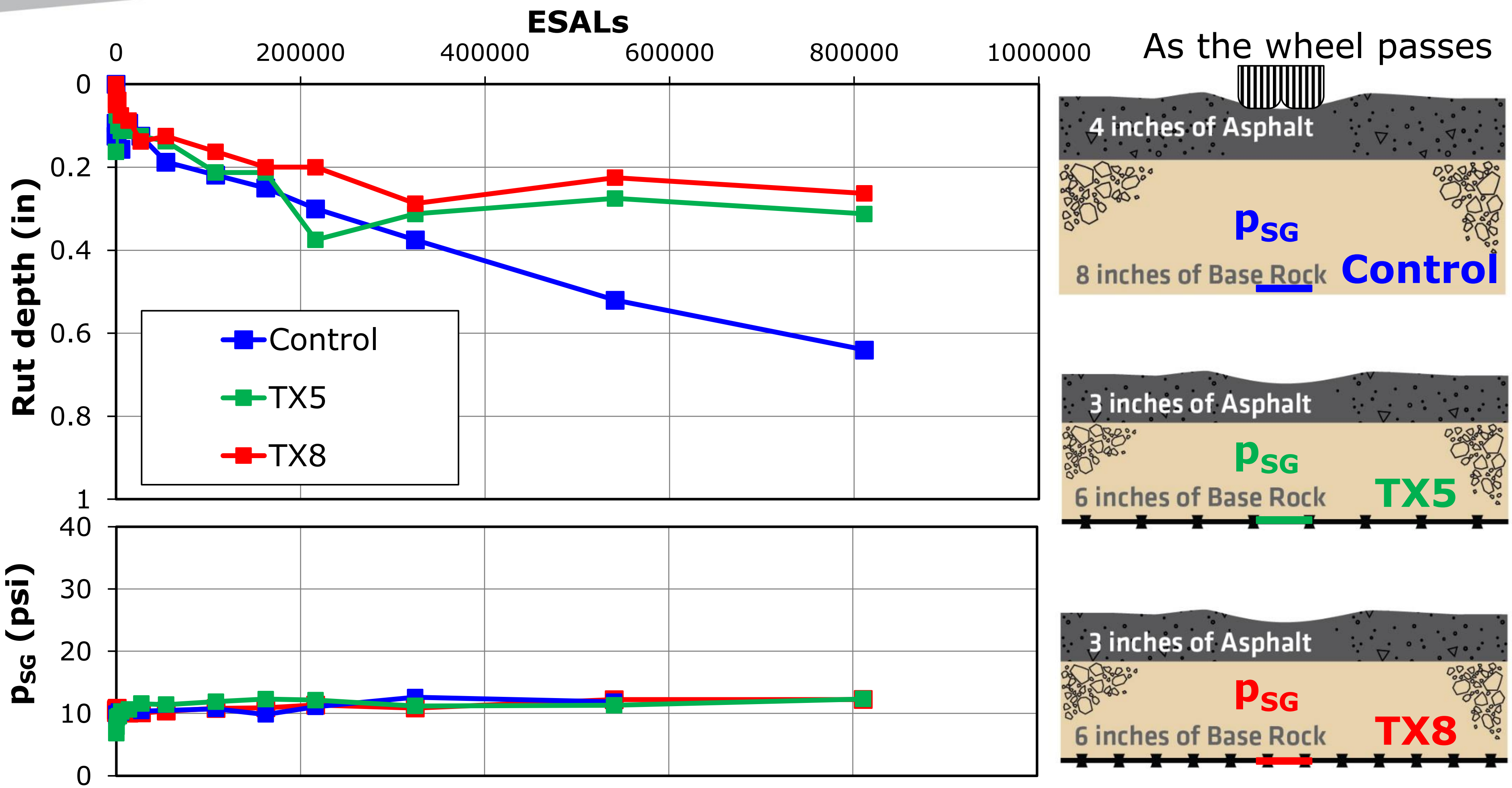


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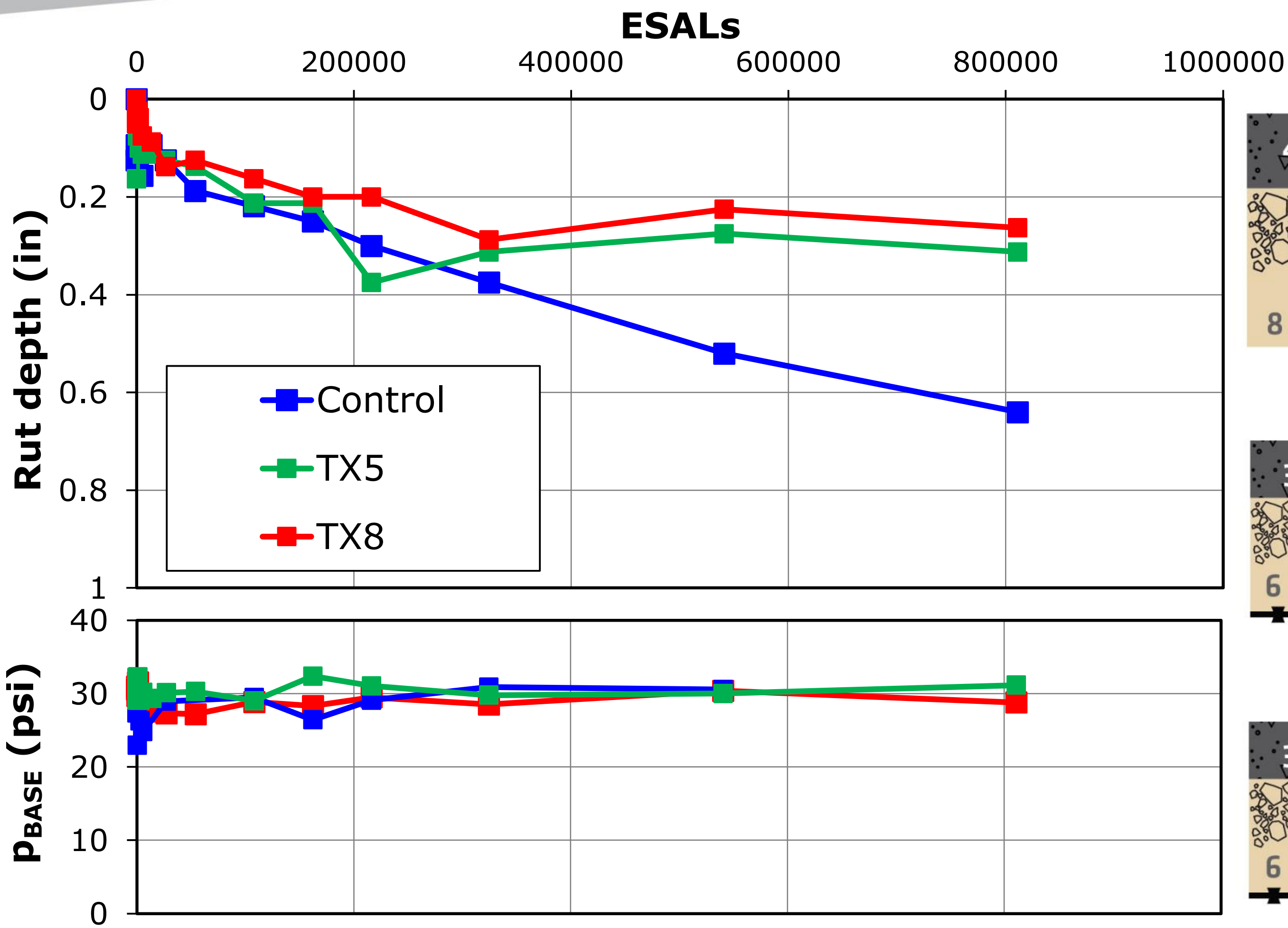
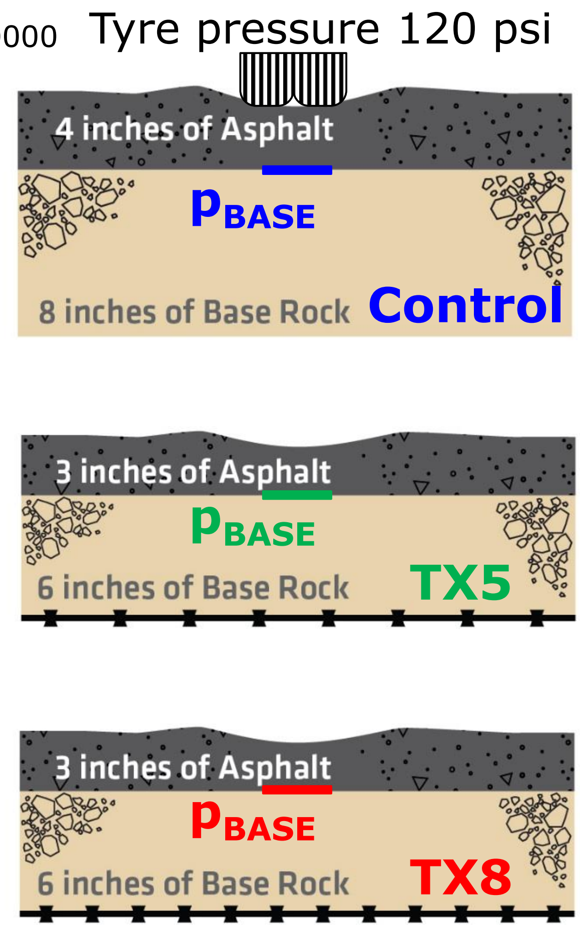
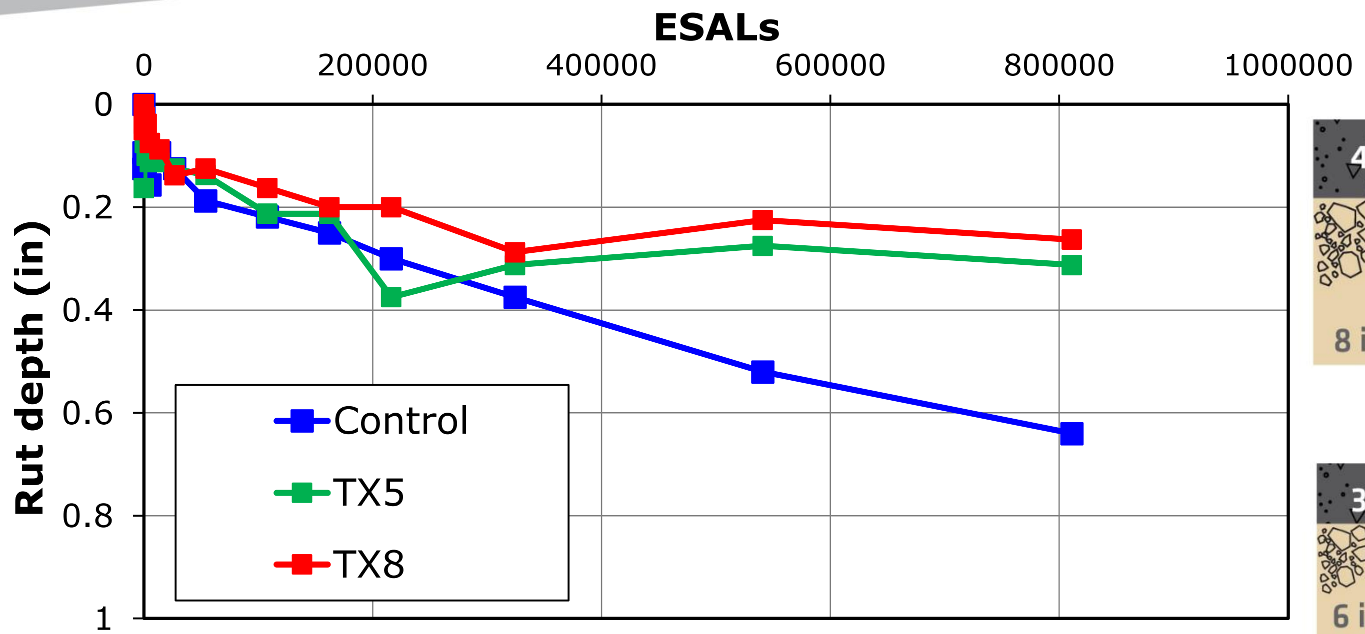


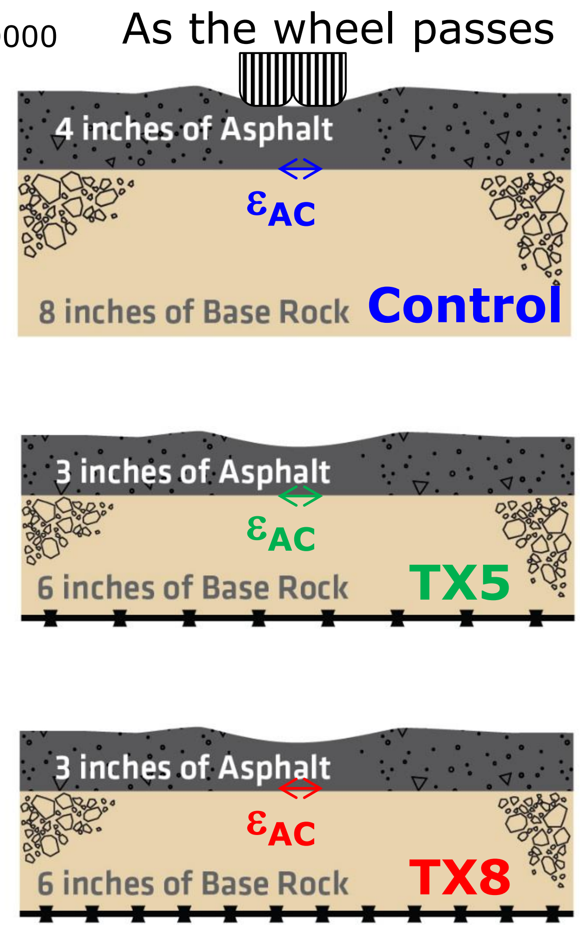




**Total Deformation/Rutting Related to Pressure on the Base**

# Full-Scale Accelerated Testing of Multi-axial Geogrid Stabilized Flexible Pavements

## Constructed over Very Stiff Soils




**Total Deformation/Rutting Related to Tensile Strain in the Asphalt**

# Full-Scale Accelerated Testing of Multi-axial Geogrid Stabilized Flexible Pavements

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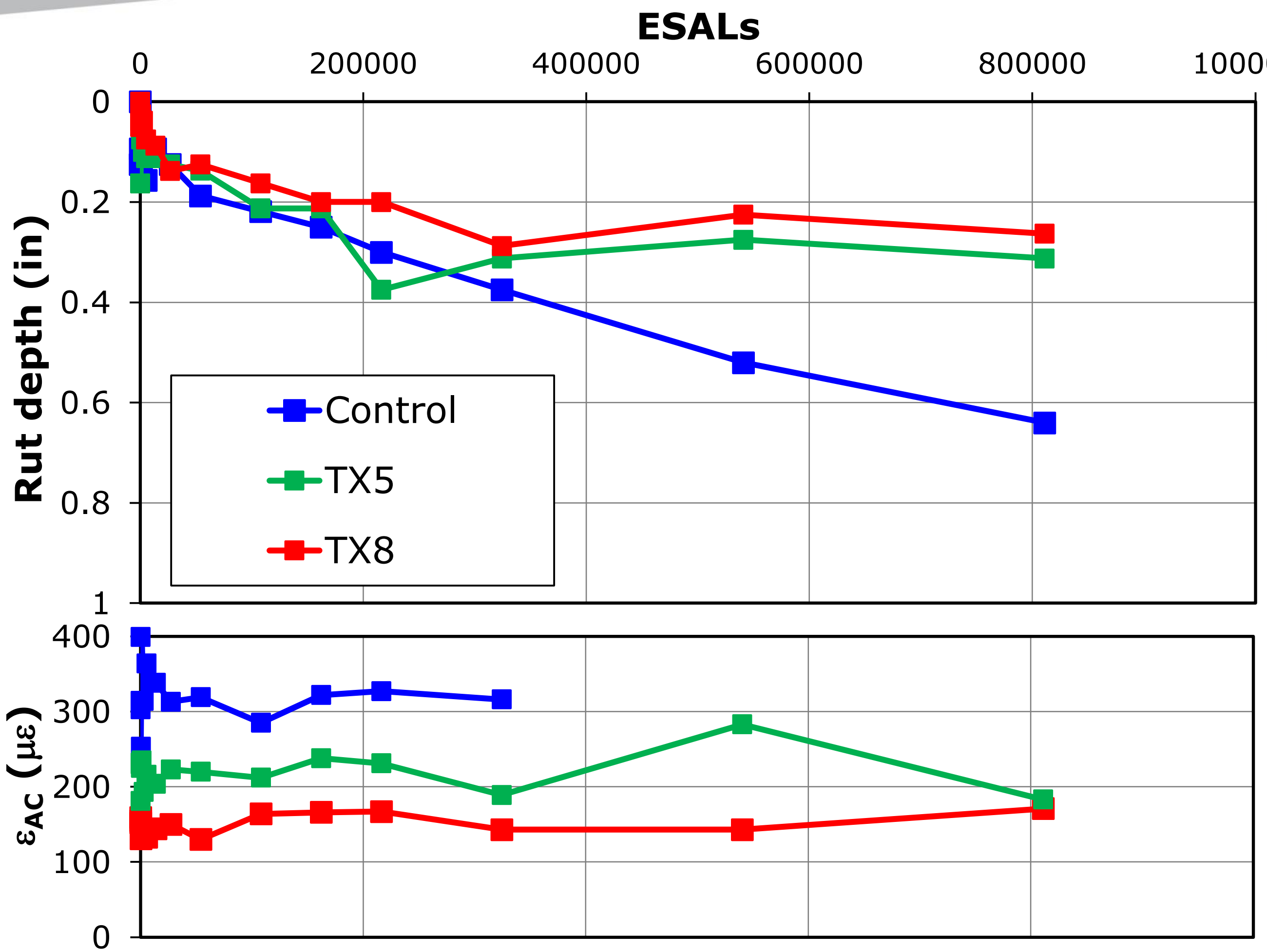


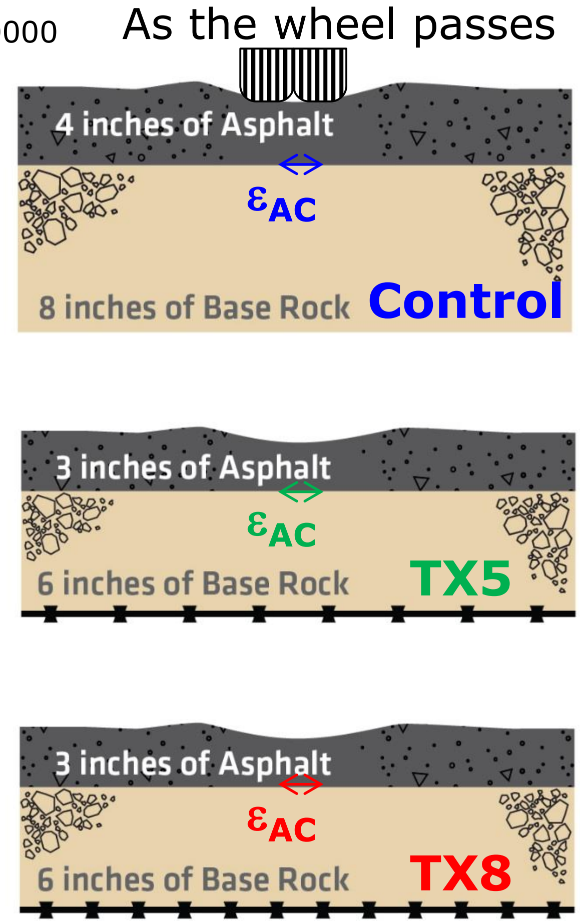


**Total Deformation/Rutting Related to Tensile Strain in the Asphalt**

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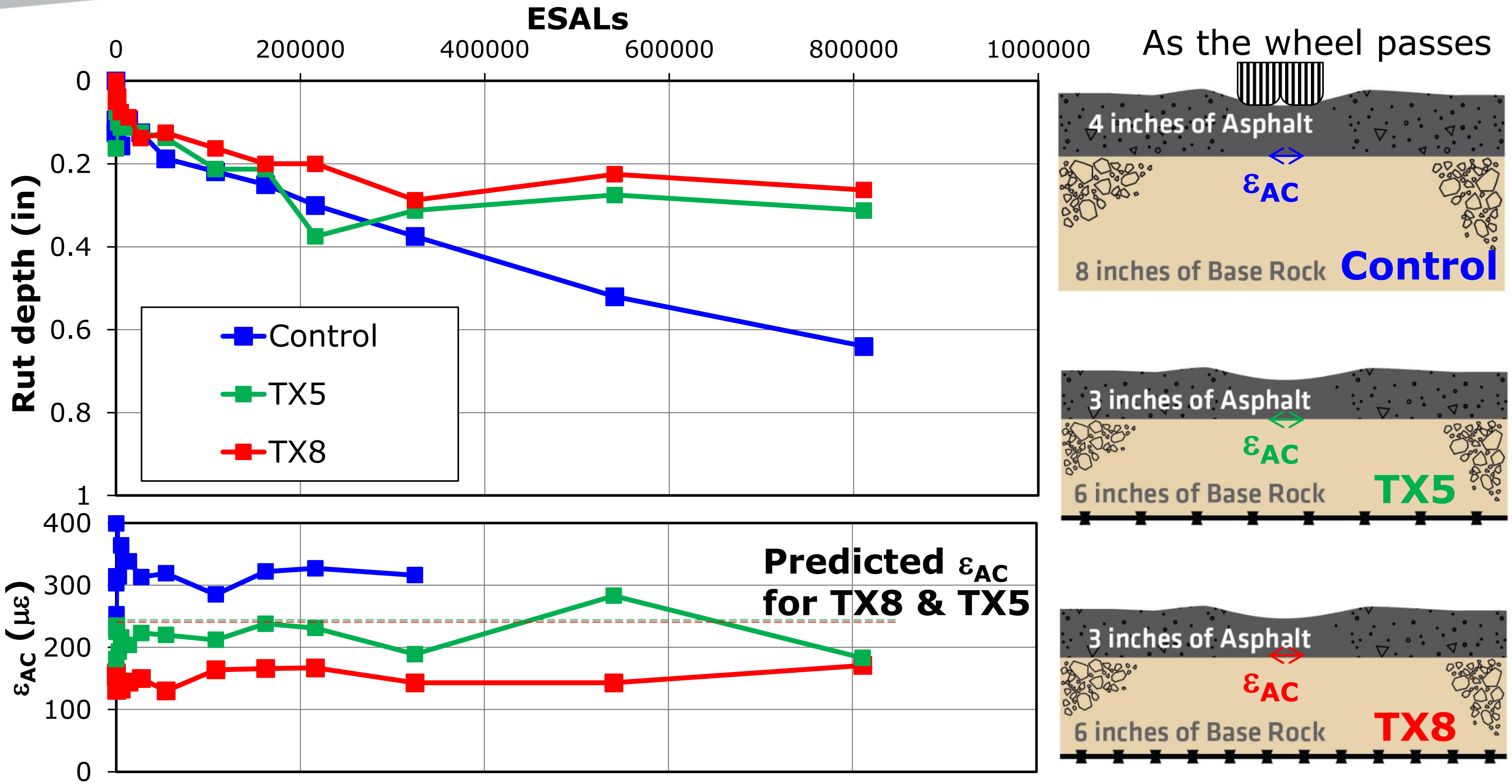


**Total Deformation/Rutting Related to Tensile Strain in the Asphalt**

# Full-Scale Accelerated Testing of Multi-axial Geogrid Stabilized Flexible Pavements

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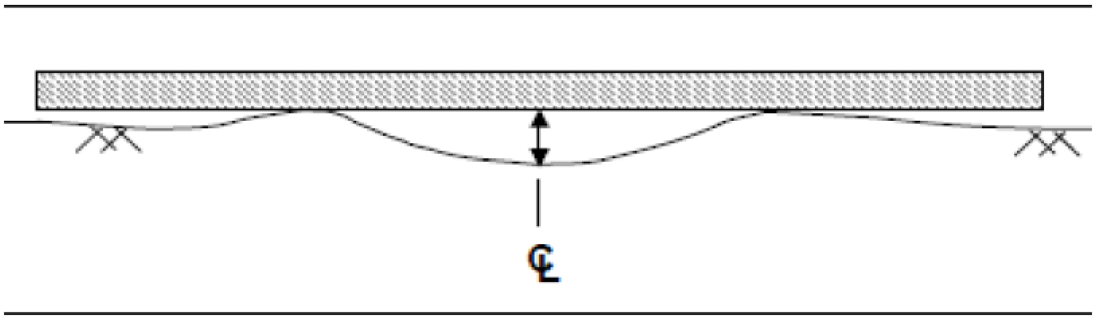
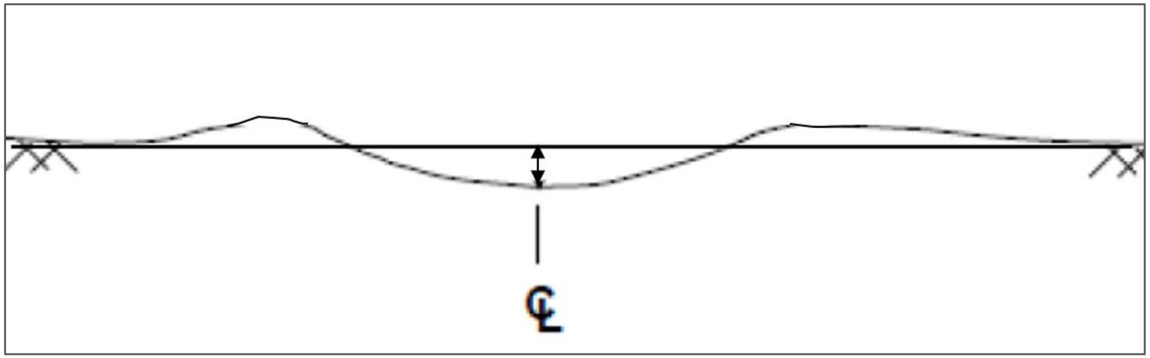
**Total Deformation/Rutting**
Surface deformation and upheaval at edge of trafficking pattern




**Surface deformation**
Changes in surface elevation along the centerline

Difference between total deformation and surface deformation represents the heave due to lateral spread of pavement materials.

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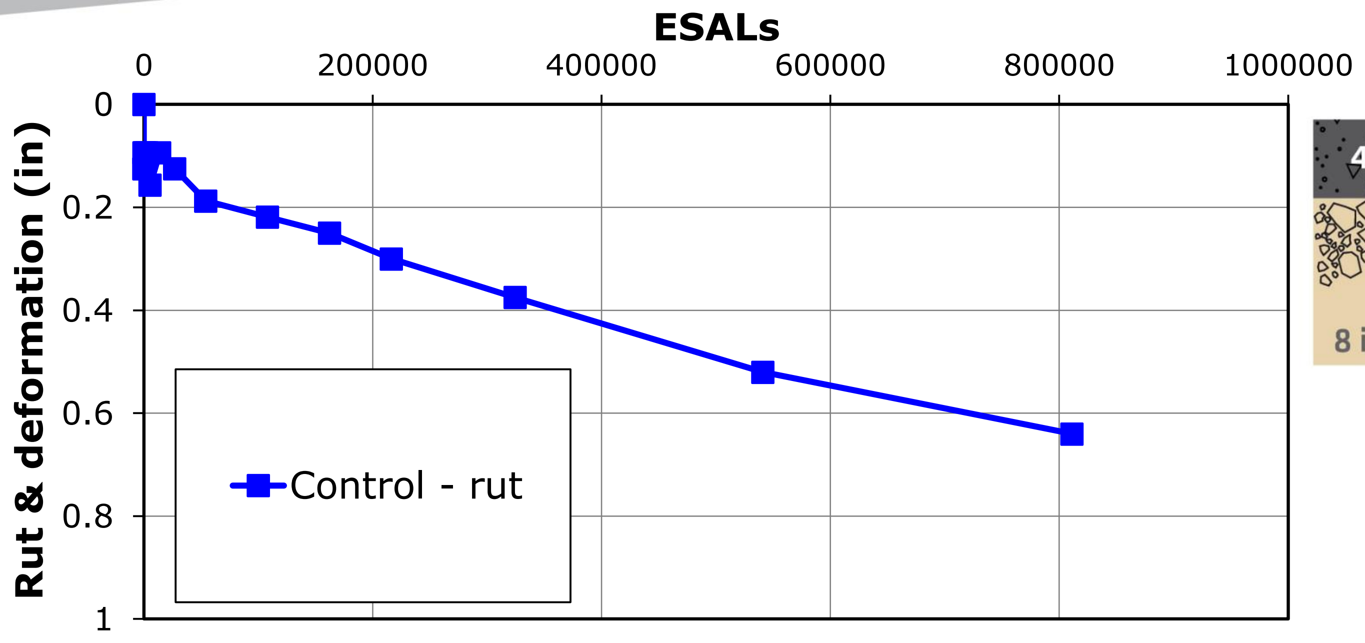


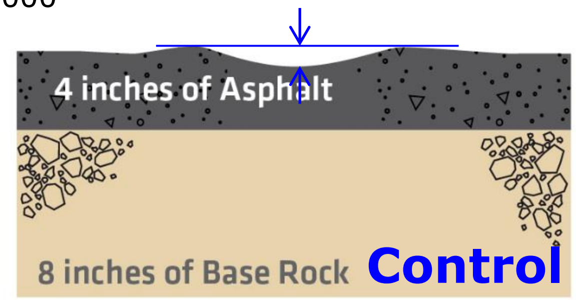


**Total Deformation/Rutting Related to Surface Deformation**

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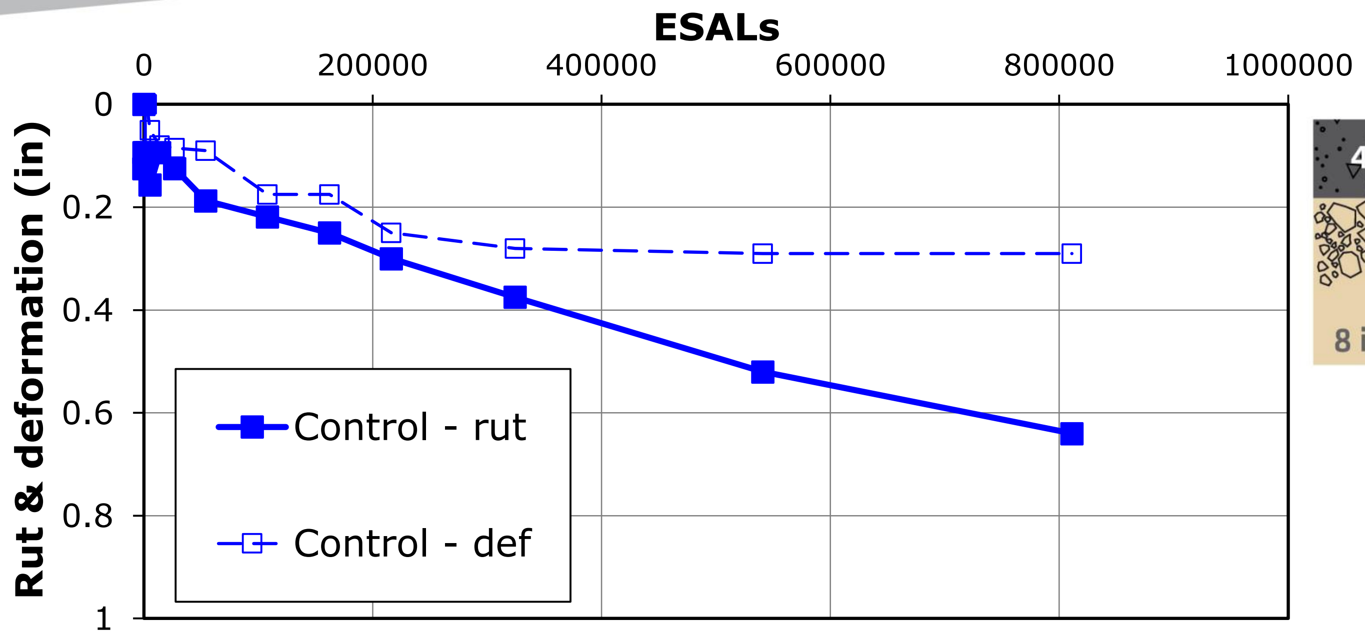


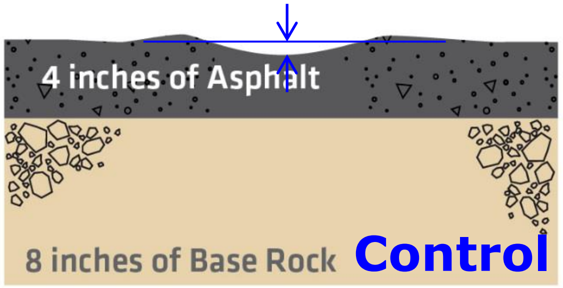


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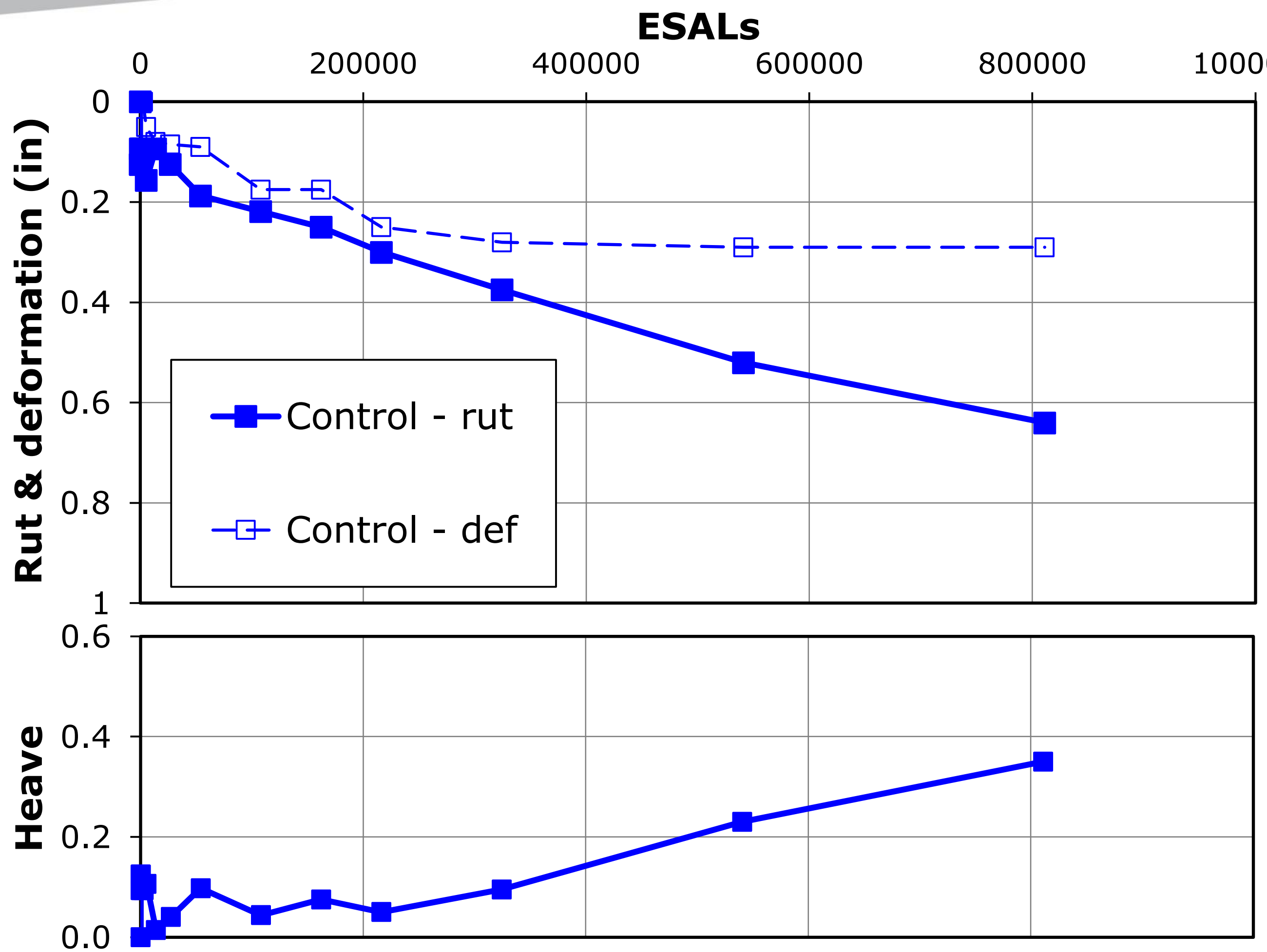


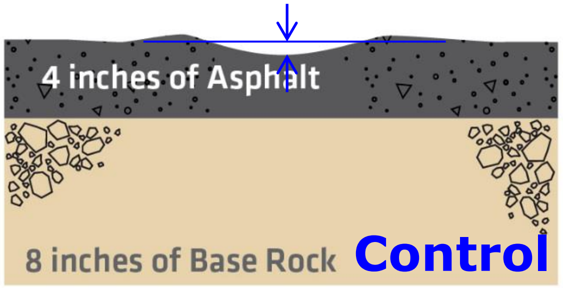


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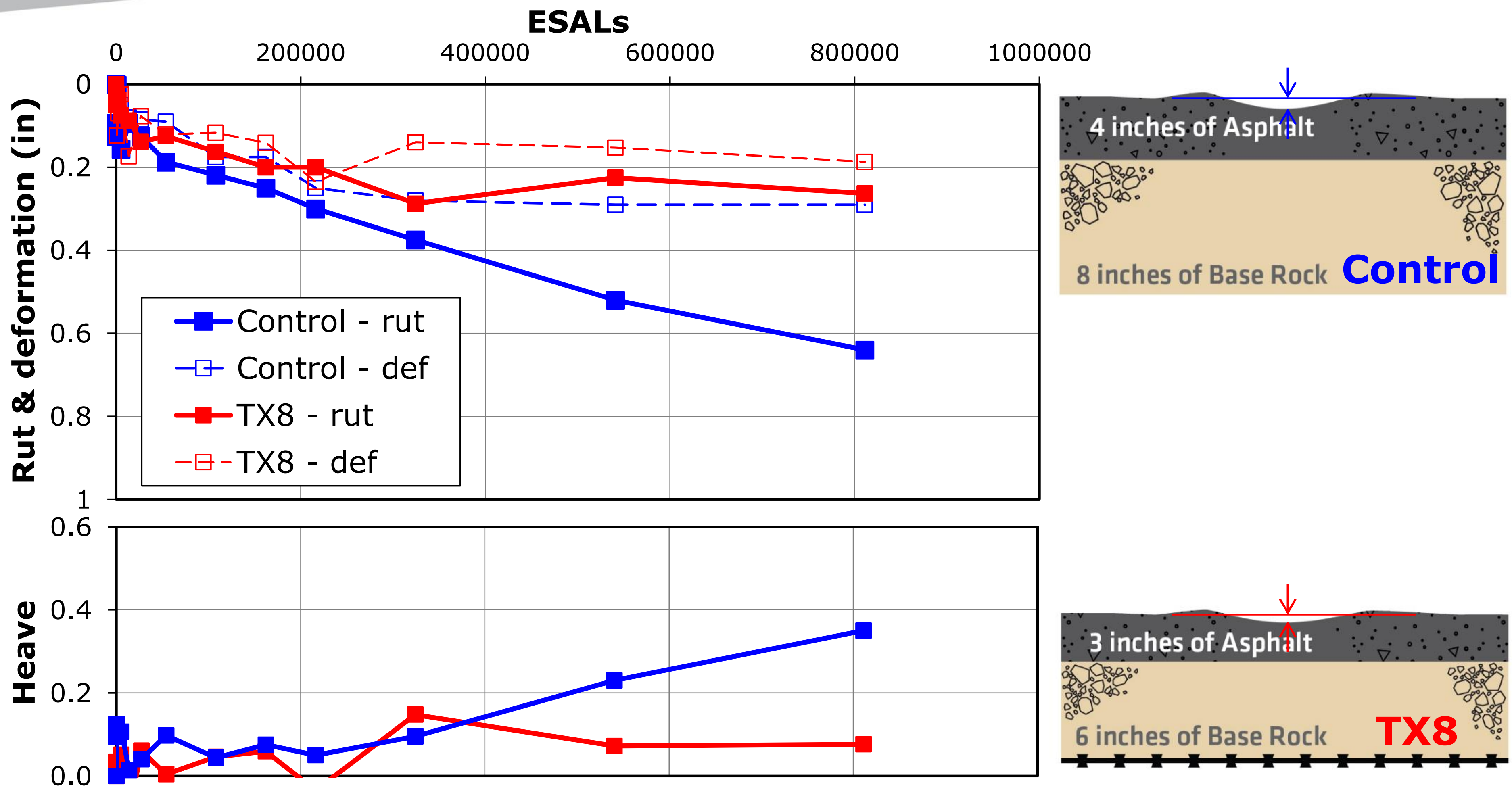


**Total Deformation/Rutting Related to Surface Deformation**

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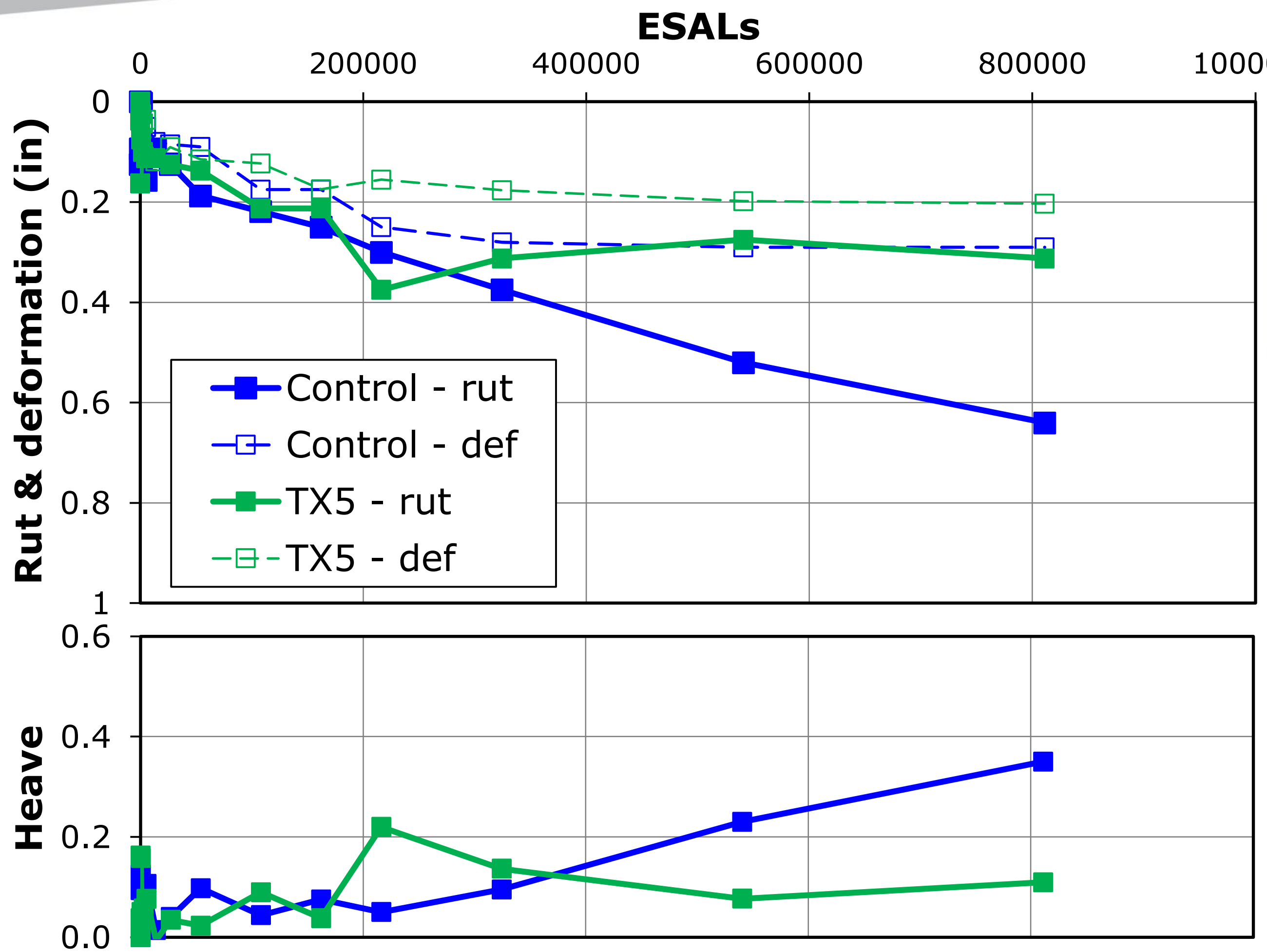


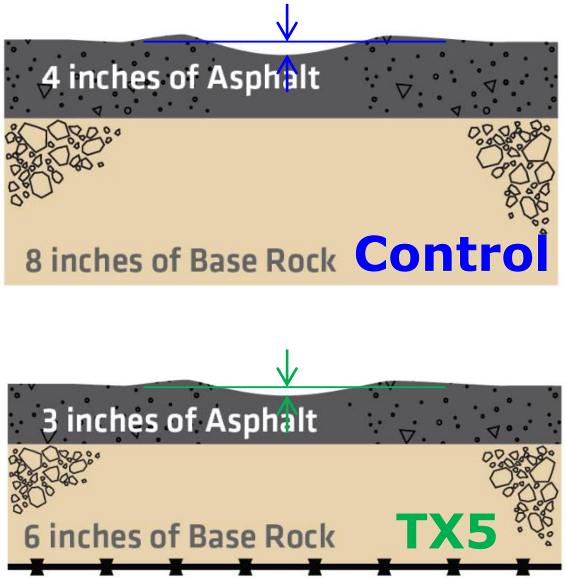


**Total Deformation/Rutting Related to Surface Deformation**

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Constructed over Very Stiff Soils

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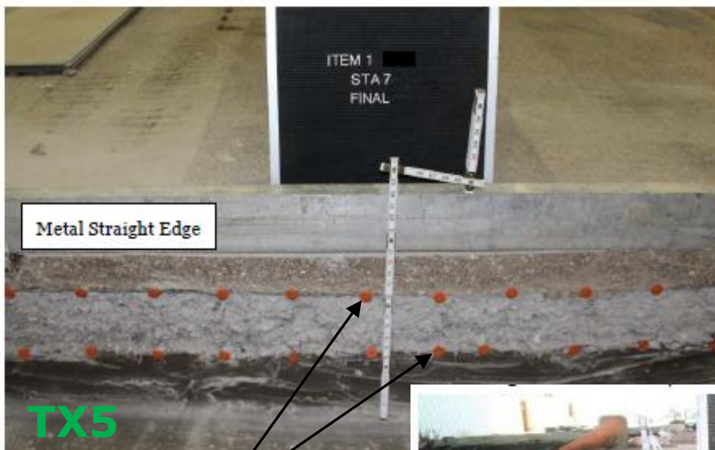
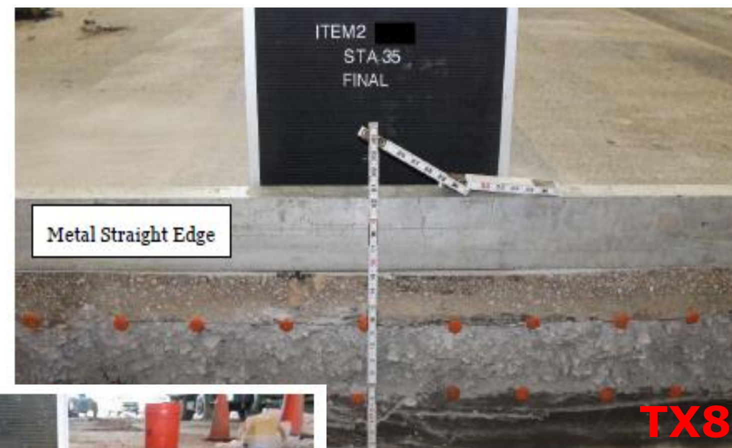
No significant deformation was observed in the subgrade. Accumulated deformation was found in the asphalt and base layers.




Orange markers delineate boundaries between asphalt, base and subgrade.

# Full-Scale Accelerated Testing of Multi-axial Geogrid Stabilized Flexible Pavements

Constructed over Very Stiff Soils

## Why does the rutting/ deformation occur?


Stresses from wheel loading produce lateral movement in the pavement materials, allowing for deformation.

*"Major Findings from AASHO testing…"*


"… About 91% of the rutting occurred in the pavement itself: 32% in the surface, 14% in the base, and 45% in the subbase. Thus, only 9% of the surface rut could be accounted for by rutting of the embankment [subgrade]. Data also showed that changes in thickness of the component layers were caused not by the increase in density, but primarily by lateral movements of the materials."

(*Pavement Analysis and Design*, Yang H. Huang)

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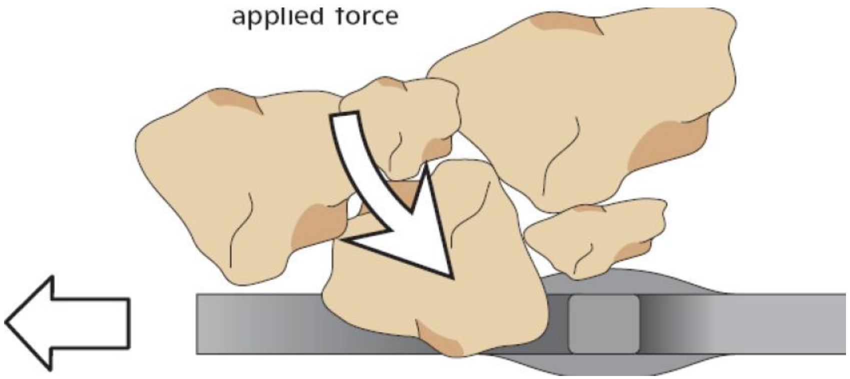
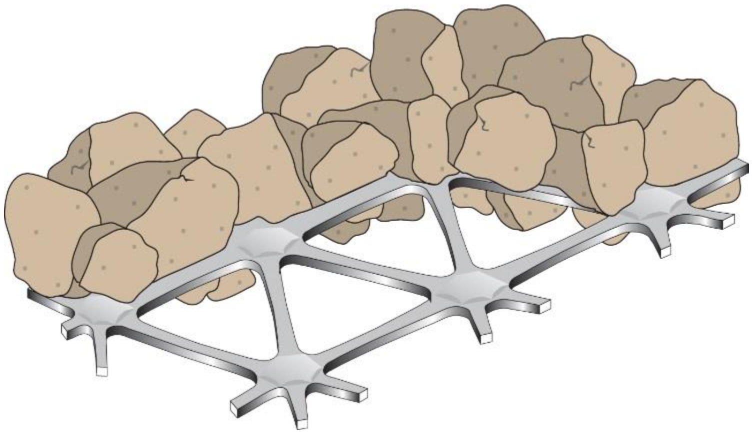
Geogrid stabilizes aggregate by allowing rock particles to strike through the openings in the geogrid (apertures). When a load is applied to an aggregate that is held in place by a geogrid, less movement occurs.




Differences in junction efficiency, aperture size, all impact ability to confine… (Giroud, 2009)

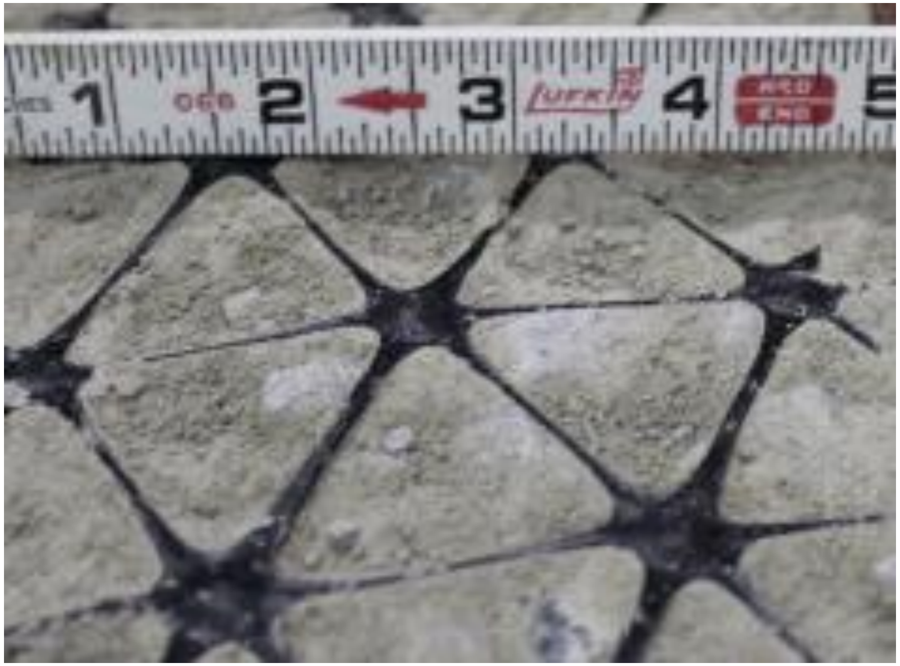


Tensar

# **Interlock**

*"Visual investigation revealed indentions were present in the subgrade of both test items, indicating aggregate strike-through and inter-lock with the geogrid. Visual inspection indicated the geogrid was intact and no damage was sustained during construction or trafficking."*

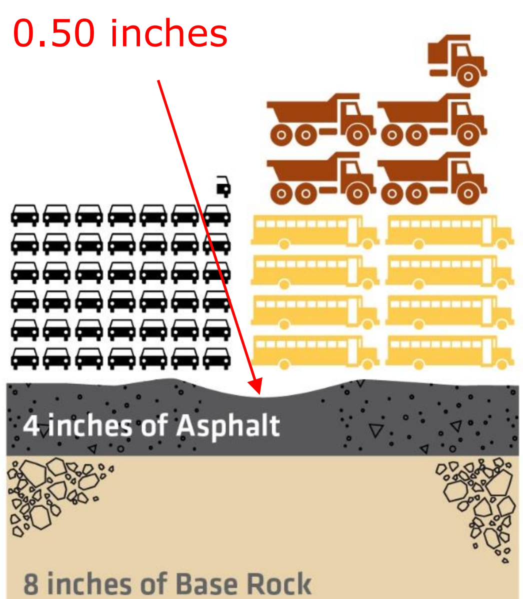
Corps 2017



# Full-Scale Accelerated Testing of Multi-axial Geogrid Stabilized Flexible Pavements

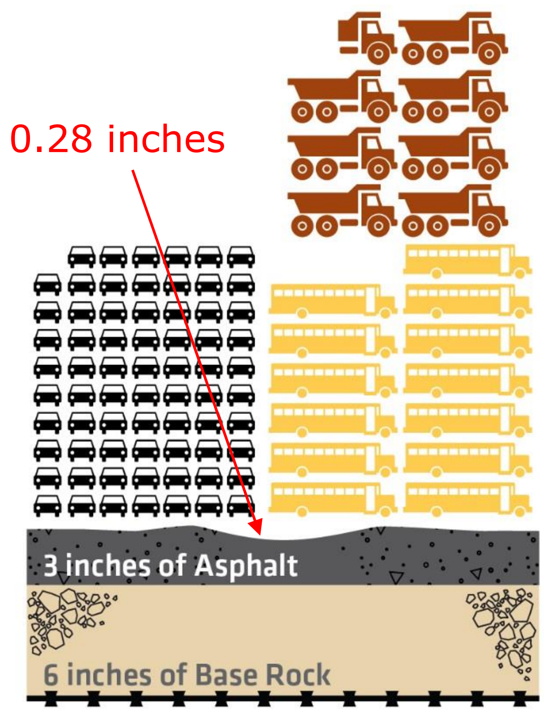
## Constructed over Very Stiff Soils

**500,000 ESALs**
**45,971 dump trucks**
**81,928 buses**
**425,000,000 cars**




**Control Section**

**811,200 ESALs**
**74,583 dump trucks**
**132,920 buses**
**689,520,000 cars**




**Tensar TriAx TX8 Geogrid**

**TX8**
**Stabilized Pavement**

Reduction of AC by 1 inch

Reduction of base by 2 inches

Traffic increase of >62%

Decrease in deformation by >44%

~16% in cost savings

Time Savings of ~ 5.5 days per lane mile

# Full-Scale Accelerated Testing of Multi-axial Geogrid Stabilized Flexible Pavements

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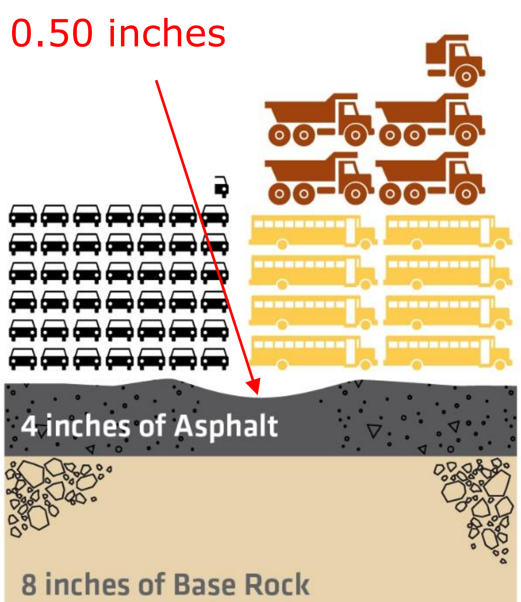
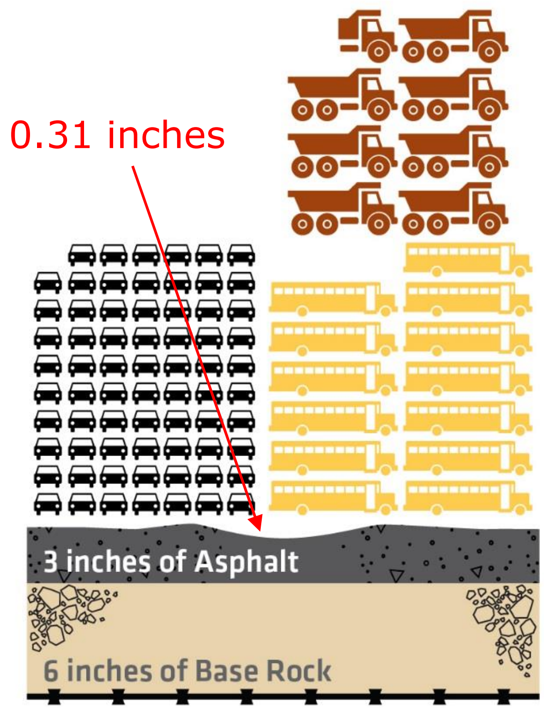
**45,971 dump trucks**
**81,928 buses**
**425,000,000 cars**




**Control Section**

**811,200 ESALs**
**74,583 dump trucks**
**132,920 buses**
**689,520,000 cars**




**Tensar TriAx TX5 Geogrid**

**TX5**
**Stabilized Pavement**

Reduction of AC by 1 inch

Reduction of base by 2 inches

Traffic increase of >62%

Decrease in deformation by >38%

~16% in cost savings

Time Savings of ~ 5.5 days per lane mile

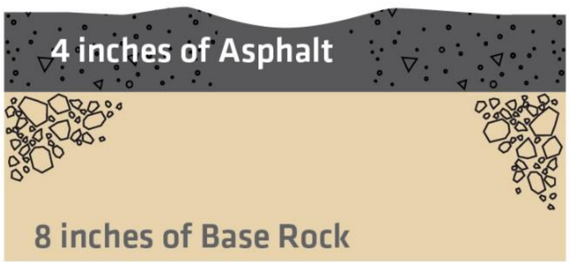
# Full-Scale Accelerated Testing of Multi-axial Geogrid Stabilized Flexible Pavements

Constructed over Very Stiff Soils

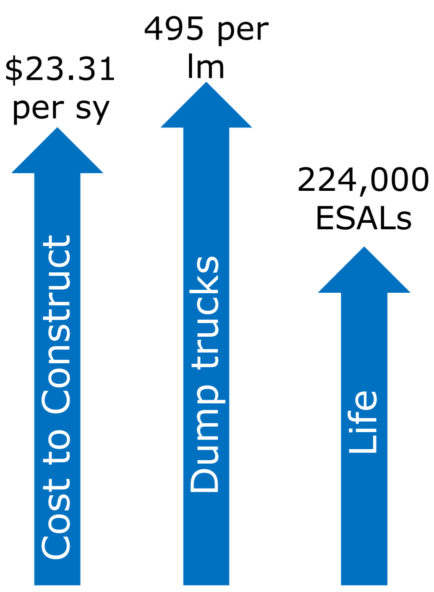
Tensar

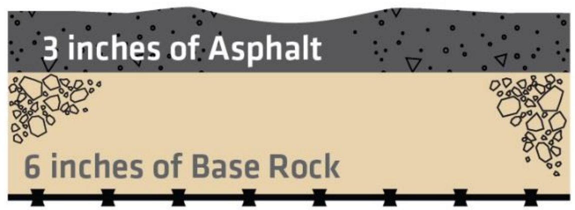
| Asphalt | $65/ton |
|---|---|
| Base | $18/cy |
| Excavation | $5/cy |

## Cost/Value (SP4 Modeling)

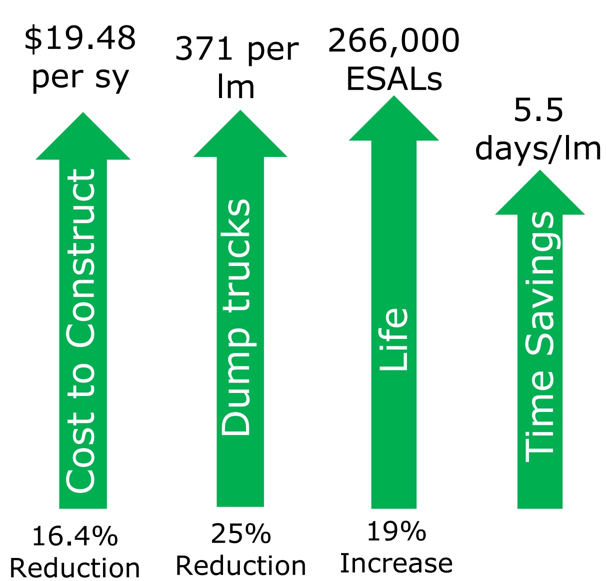


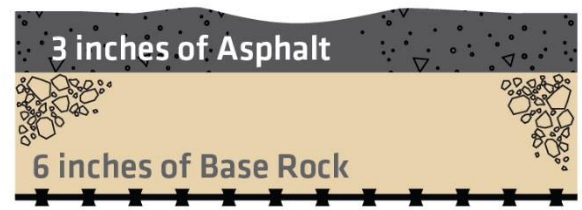

**Control Section**



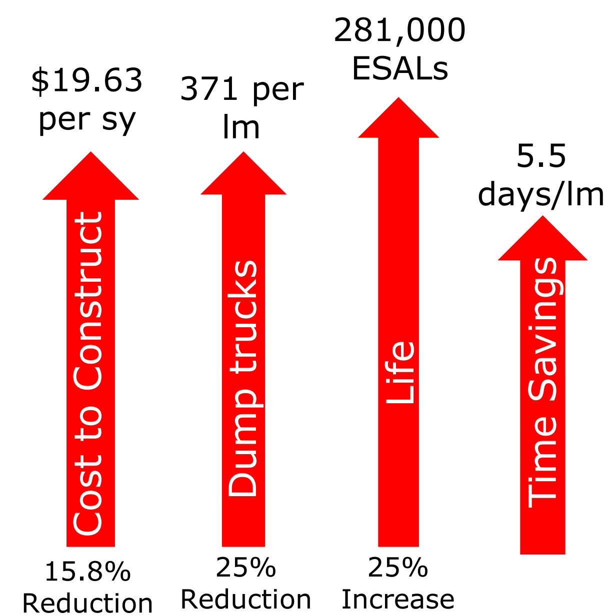




**Tensar TriAx TX5 Geogrid**




**Tensar TriAx TX8 Geogrid**



Tensar

## Summary of Testing

- TriAx stabilized sections, constructed with 25% less asphalt and base rock, allowed for significantly greater traffic and less deformation than a thicker control section.
- TriAx stabilized sections apply to pavements constructed over competent subgrades, not only in areas of soft soils.
- Estimates show TriAx provides ~16% savings in construction costs, ~19-25% improvement in performance and a savings in time of ~5.5 days per lane mile.

*"…incorporation of a multi-axial geogrid in a flexible pavement base course provides a significant structural benefit."*
*-- Corps 2017*