Accelerated Pavement Testing (APT) with Tensar TriAx® Geogrids

Since introducing geogrids in the early 1980's, Tensar have investigated how this form of geosynthetic can benefit roadway performance by conducting and commissioning full-scale trafficking performance research around the world. This investment has allowed unrivalled knowledge to be gathered by Tensar's engineers to inform how the inclusion of Tensar geogrids can benefit the performance of a roadway. This knowledge has been translated into quantifiable benefits and is applied using Tensar's roadway design software TensarPave™ and Spectra M-E®.

Key aspects of this research include nine work programmes at the Transport Research Laboratory (TRL) [(1)] in the UK as well as three programmes of accelerated full-scale trafficking trials carried out at the US Corps of Engineers (USCoE) Engineering Research Development Center (ERDC) at Vicksburg, USA. Using the Heavy Vehicle Simulator (HVS) at the ERDC facility has allowed Tensar to undertake trafficking trials of surfaced road pavements to observe and measure the benefits of including stabilisation geogrids in these heavily trafficked pavement sections.

Figure 1: USCoE Heavy Vehicle Simulator at ERDC, Vicksburg, USA

The benefits of including geosynthetics in road pavements have been recognised by the American Association of State Highways and Transportation Officials (AASHTO) but as with similar guidance and experience from around the world, they confirm that "…the benefits of geosynthetic reinforced pavement structures may not be derived theoretically, test sections are necessary to obtain benefit quantification"[(2)].

This guidance has been used by Tensar to develop a research programme to "obtain benefit quantification" for the performance of TriAx geogrids. Tensar commissioned the USCoE to carry out three phases of accelerated pavement testing (APT) which are summarised below. This work forms the most extensive investigation into the behaviour of geogrids in road pavements carried out worldwide.

Test section construction and loading

By using the ERDC facility to perform each of the three sets of trafficking tests, a high level of uniformity was built in across the three phases. Detailed "as built" data for each test section is available (3) (4) (7) but in summary the subgrade soils were clay, constructed to a depth of 710mm with a uniform dry density (Figure 2). Table 1 summarises the subgrade strength (CBR) values in each of the 3 phases.

Figure 2 – Subgrade under construction at ERDC

USCoE testing	Subgrade CBR
Phase 1	3.0%
Phase 2	6.0%
Phase 3	6.0%

Table 1 – Subgrade soil strength for each Phase

A well graded crushed limestone base material with a maximum aggregate size of around 40mm was used in all three phases of the USCoE work.

Trafficking of the pavement sections was conducted using a dual wheel tandem axle (Figure 3), with each pass equivalent to 2.08 equivalent standard axle loads (ESAL's).

Figure 3 – Dual tandem axle

USCoE Phase 1 (2010) (3)

Full scale flexible pavement sections were constructed in lanes, each being 2.4m wide and 15m long. Figure 4 shows three lanes constructed over a sub-grade with a CBR of 3.0%. All three lanes had the same aggregate base thickness. The standard lane (B) and the stabilised lane (A) had identical surfacing of 50mm asphalt. The stabilised lane (A) was identical to the standard lane (B) except for the addition of a layer of TriAx geogrid below the base. The third lane (C) had a thicker surfacing of 75mm of asphalt.

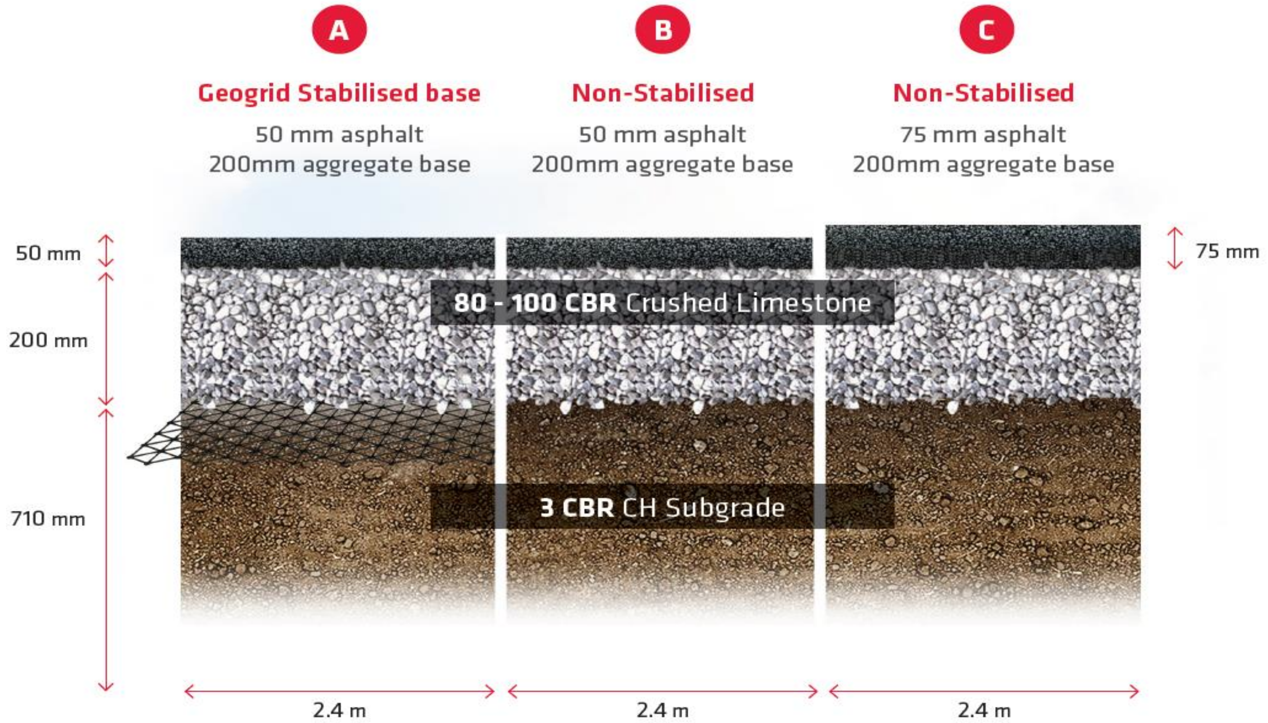

Figure 4 – Three test lanes for USCoE Phase 1

A traffic load equivalent to 100,000 ESAL's was imposed by the HVS to each of the three test lanes, Extensive monitoring was conducted and reported (3). This included measurements of surface deformation taken at predetermined intervals throughout the testing as trafficking progressed.

The results of the surface deformations are plotted in Figure 5 and show that:

- Stabilising the base with a layer of Tensar TriAx geogrid provided a significant increase in trafficking performance when compared with the equivalent non-stabilised section.
- The Tensar TriAx stabilised section performed better than a section with an additional 25mm of asphalt. The trafficking in lanes B and C was terminated when the surface deformation exceeded the maximum allowable. The TriAx stabilised section A did not reach this maximum with the testing terminated at 100,000 ESAL's.
- The TriAx stabilised pavement section improved trafficking performance and reduced the rate of degradation due to trafficking by maintaining the stiffness throughout the duration of trafficking.

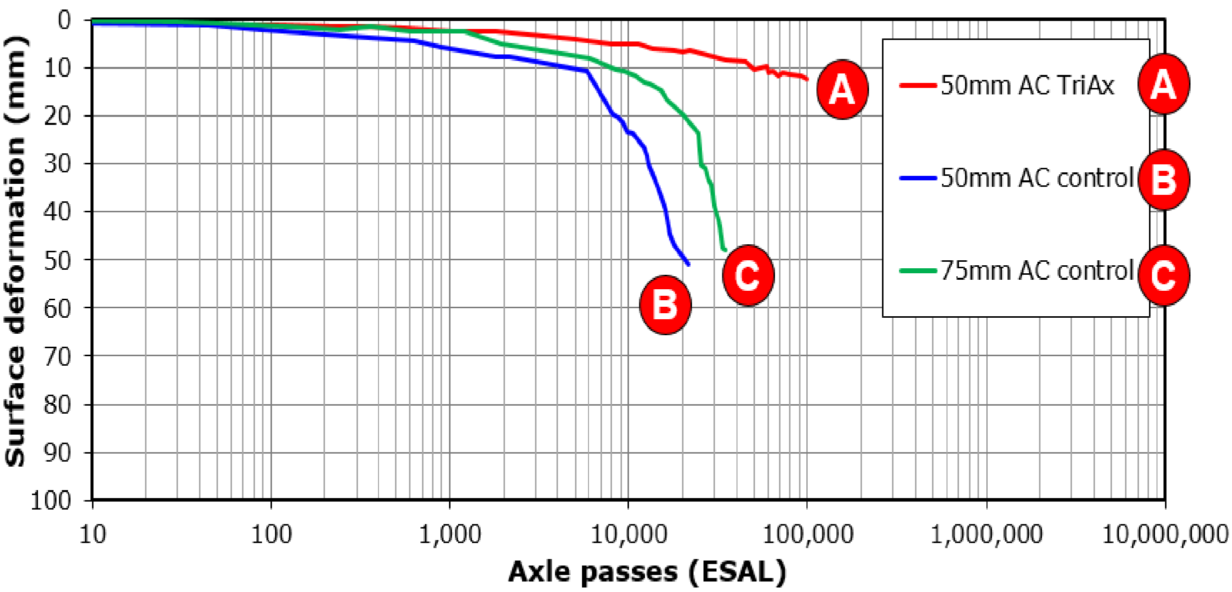

Figure 5 – Surface deformation from trafficking - USCoE Phase 1

USCoE Phase 2 (2012) [4]

The benefits of Tensar TriAx geogrids identified from the USCoE Phase 1 work were quantified. From this data combined with data obtained from a multi-phased APT test programme carried out at the UK Transportation and Research Laboratory (TRL), algorithms were developed to characterise the TriAx geogrid benefit in paved roads and incorporated into a beta version of Tensar's pavement design software.

To test the validity of the Tensar software, the second phase of work at the USCoE examined the performance of two new pavement sections. Both pavement sections were designed with Tensar's pavement software to deliver identical trafficking performance. A consistent subgrade was installed in a similar manner to Phase 1. However, for Phase 2 the sections varied in layer thickness. The lane with TriAx stabilisation geogrid had a thinner base and a thinner asphalt surfacing layer compared to the non-stabilised control lane (Figure 6).

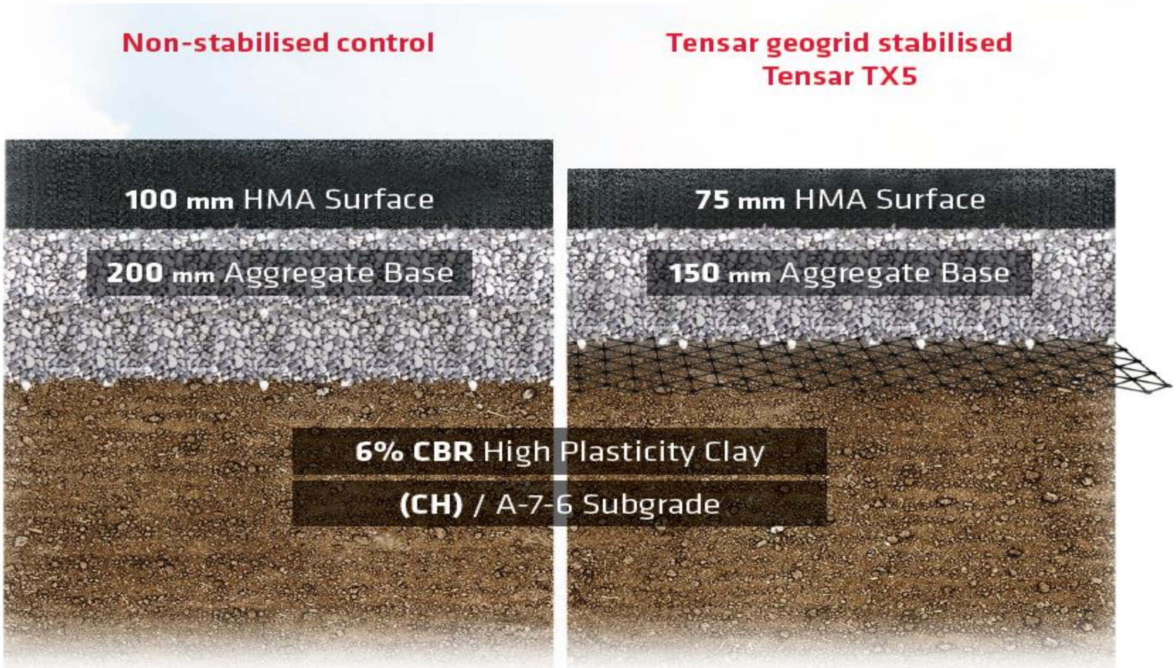

Figure 6 – Two test lanes of USCoE Phase 2, designed to deliver identical traffic life

Results from Phase 2 confirmed that the thinner section stabilised with TriAx geogrid performed equal to the thicker non-stabilised section after 200,000 ESAL's.

Following this result, further verification of the Tensar design software was provided after a third party review of the software by Applied Research Associates (ARA)[5], [6]

USCoE Phase 3 (2016) [7]

The third phase of work at the ERDC in 2016 extended the traffic loading in the full-scale accelerated pavement testing to a much higher level. The test lanes were constructed in the same way as in Phase 2. The same base layer and asphalt surfacing thicknesses were used, but with two TriAx stabilised lanes as shown in Figure 7 below, incorporating different TriAx products; TriAx TX5 and TriAx TX8. It is important to note that in this third phase the traffic load imposed exceeded 800,000 ESAL's.

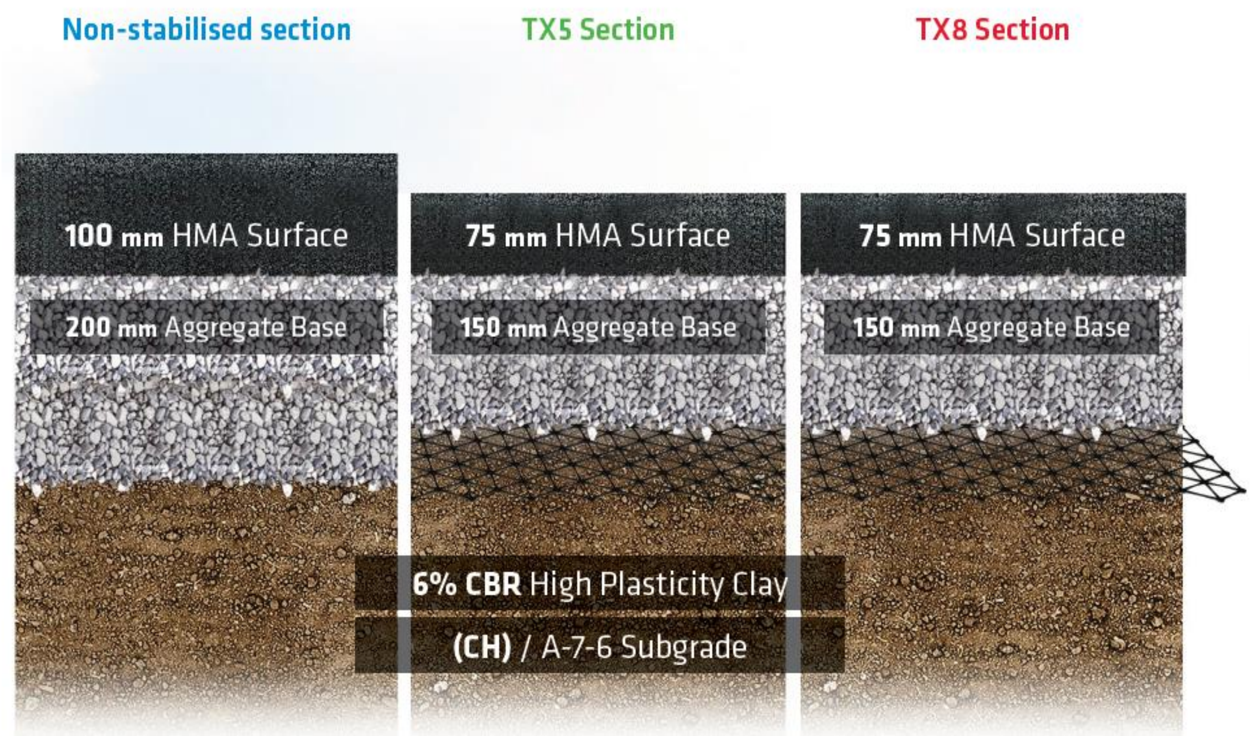

Figure 7 – Three test lanes of USCoE Phase 3: All designed to deliver the same design life

Once again, the traffic load using the HVS was imposed in turn onto the three different pavement sections, with measurements of surface rut depth were taken at predetermined intervals throughout the testing as trafficking progressed. The results are shown in Figure 9.

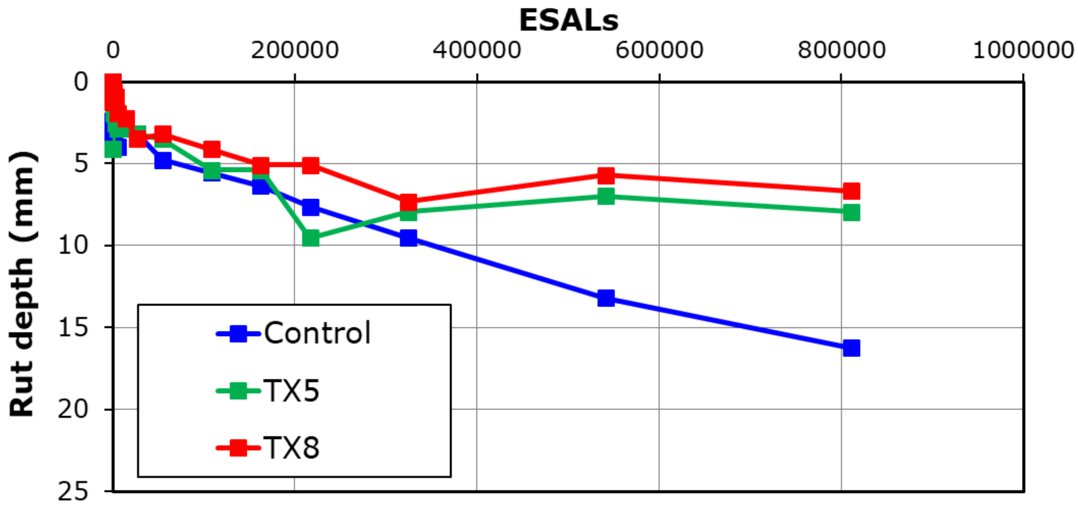

Figure 8 – Surface rut development to 800,000 ESAL's - USCoE Phase 3

A comparison of rut depth development over 800,000 ESAL's confirms:

- **Both of the Tensar TriAx stabilised lanes performed significantly better than the thicker control lane.**
- **Maximum rut depths in the TriAx stabilised lanes are approximately 60% less than that in the control lane.**
- **In this base material, TriAx TX8 provided a marginal benefit over TriAx TX5.**

As well as measurements of surface rutting as the trafficking progressed, a more extensive suite of monitoring was included in the pavement lanes to investigate the effect of including Tensar TriAx stabilisation geogrids. More details are available (7) relating to these additional tests but in summary:

- Deformation at the base/subgrade interface was less in both the TriAx stabilised lanes, demonstrating the protection offered to the subgrade soils with the inclusion of a Tensar TriAx geogrid
- Measured horizontal strains at the base of the asphalt surfacing were lower in the Tensar TriAx stabilised lanes.
- Falling weight deflectometer (FWD) readings showed higher values for the thicker non-stabilised pavement section. This suggests that the use of FWD readings to predict the traffic capacity of a geogrid stabilised flexible road cannot be relied upon.

The USCoE researchers confirmed that **"…incorporation of a multi-axial geogrid in a flexible pavement base course provides a significant structural benefit."**

Practical application of Tensar research

The beneficial effect of TriAx geogrid in paved roads is represented by a complex algorithm that takes account of specific, geogrid grade, base layer thickness, geogrid location and asphalt layer thickness. The benefit has been characterised by consideration of a matrix of data obtained from a number of APT tests, both paved and unpaved. This differentiates the rigorous engineering approach adopted by Tensar from those deriving a single Traffic Benefit Ratio (TBR) or Traffic Improvement Factor (TIF), from a limited number of tests, or even in some cases a single set of test results.

The work summarised above forms the basis of the design methodology used for the Spectra Pavement Optimisation module within TensarPave software and Tensar Spectra M-E software. Both have been independently validated (6)(8).

References:

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