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Tensar information bulletin
IB/Derivation_Trafficking
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Derivation of traffic improvement and equivalent performance factors for Tensar TriAx®

Introduction

Since 2001, Tensar International Ltd has carried out a regular series of trafficking trials at the Transport Research Laboratory (TRL) and has amassed a large amount of data on the performance of its stabilisation geogrids. The Pavement Test Facility (PTF) is the only full-scale facility in the UK enabling standard 40kN wheel loads to be applied to a prepared pavement construction under controlled conditions. The reputation of the TRL is recognised world-wide as a well-established and reliable organisation where all testing is carried out with utmost care and diligence.

Programme numbers TRL4 – TRL7 have included TriAx® geogrids, along with other Tensar geogrids, in order to increase the database of performance information on which the Tensar stabilisation factors are based.

Figure 1, Full scale trafficking tests at the TRL Pavement Test Facility

TRL Pavement Test Facility (PTF)

The PTF comprises a pit 10m wide by 25m long by 3m deep, containing a clay subgrade on which experimental pavements are constructed. A gantry, spanning the width of the pit, supports a rolling wheel that traverses back and forth across the full width of the test pavement, Figure 1. Trafficking lanes across the pit are 2.5m wide and there are three panels of approximately 3m length in each lane. The required vertical loading, direction of travel, speed and lateral position of the wheel may be selected as appropriate for different test scenarios.

Tensar International Ltd has carried out seven different test programmes and the early trials in 2001 and 2002 were reported at international conferences. The focus of the testing, since 2004, has been on generating data to assist in deriving the performance-based design parameters in the development of Tensar TriAx® geogrids.

Programme	Year	Comparisons	Tensar Product types
TRL1	2001	Different Biaxial geogrids	Biaxial geogrids
TRL2	2002	Different Biaxial geogrids	Biaxial geogrids
TRL3	2003	Different Biaxial geogrids	Biaxial geogrids
TRL4	2005	Biaxial and TriAx geogrids	Biaxial and TriAx geogrids
TRL5	2006	Biaxial and TriAx geogrids	Biaxial and TriAx geogrids
TRL6	2007	Biaxial and TriAx geogrids	Biaxial and TriAx™ geogrids
TRL7	2009	Biaxial and TriAx geogrids	Biaxial and TriAx™ geogrids

Schedule of Tensar's testing at the TRL

All the trials have been carried out with the same clay subgrade of grey silty London Clay, Type CH - a high plasticity clay obtained from a local quarry. The preparation of the subgrade is a critical component of any testing programme and great care is required to provide, and check, a consistent support to the construction above it.

All the trials have been carried out on unpaved sub-base construction using crushed granite aggregate with a grading that conforms to the requirements of the 800 Series of the UK Specification for Highway Works for a Type 1 sub-base aggregate for road construction.

Construction

The subgrade was prepared for each trial by conditioning the clay to a depth of at least 600mm by reworking it to achieve a reasonably consistent target subgrade CBR value. For some programmes, this required the clay to be removed from the pit and reconditioned externally; for others, tests indicated that it was possible to reuse the in-situ clay. When the clay had been reconditioned externally, it was then placed and compacted in accordance with Series 600 of the UK Specification for Highway Works.

Each test panel was approximately 2.5m square and the geogrids were placed directly onto the prepared subgrade.

The sub-base was placed in two layers, approximately 150mm per layer, and compacted to standard UK Highway Specification using an a combination of a Wacker DPU 2440H vibrating plate compactor and a Caterpillar CB224E Heavy Weight twin drum tandem vibrating roller. The vibrating plate had a mass of 1088kg/sqm of base plate and the roller had a roll mass of 1362kg/m.

Pre-trafficking Measurements

The CBR value of the subgrade was measured using a MEXE cone penetrometer both along the wheel path and at 0.75m each side of the wheel path before placement of the sub-base. The surface of the foundation clay was measured with level and staff to determine the datum and the levelling was repeated after placement and compaction of the sub-base surface to determine the sub-base thickness and surface profile.

Trafficking

The PTF applied a 40kN wheel load through a standard dual wheel thereby replicating a standard axle. Measurements were taken by a straight edge and wedge to monitor the development of rutting as trafficking progressed. Levels were also taken in the wheel paths to enable the calculation of deformation.

Results of the development of rutting and deformation against the number of axle passes provide the raw data.

Interpretation

Each panel has its own unique set of conditions for the initial subgrade CBR and the sub-base thickness and so a normalisation procedure was required to be able to compare the different sets of results. Comparisons of raw data can only be made where the test conditions assumed to be similar.

In full scale testing, there can be a variation in the measured performance and so it is very important to gather as much information as possible in order to derive the representative performance and its adoption in design methods.

Traffic Improvement Factor (TIF)

The TIF is a measure of the increased trafficking performance of a stabilised aggregate layer compared with a non-stabilised layer of the same thickness. A typical plot of Rut depth vs Number of standard axle passes, Figure 2, gives the basic information to determine the TIF.

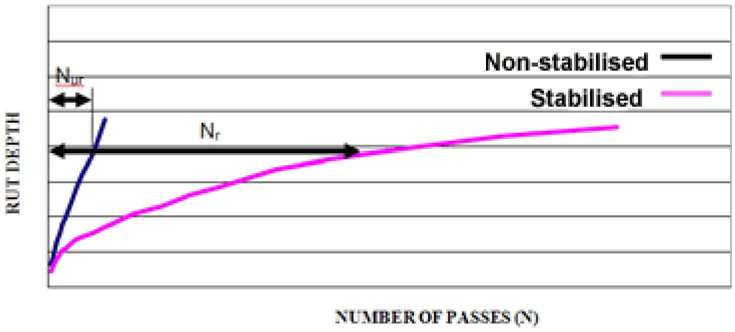

Figure 2, Indicative trafficking plots

The TIF is the ratio between the number of wheel passes over the stabilised section and the number of wheel passes over the unstabilised section that is required to generate the same rut depth. The TIF can therefore be used to calculate the amount of extra traffic that can be carried over a particular construction when stabilised by a geogrid.

Hence $$TIF = Nr/Nur$$

The TIF can be derived from the raw data as it is a direct comparison between the stabilised and control sections of a trial.

Equivalent Performance Factor (Dobie Factor)

An equivalent performance factor is a coefficient that can be applied to a stabilised aggregate layer thickness to determine the equivalent unstabilised layer thickness that would provide the same trafficking performance, i.e. the same number of standard wheel passes leading to the same rut depth. These factors can only be determined if the results can be normalised in some way so that all the input and output parameters are taken into account. The variables are:

a. Rut depth, r (mm)
b. Sub-base thickness, h (m)
c. Subgrade strength, Cu (kN/sqm), or CBR (%)
d. No. of Standard Axle passes, Ns

The approach taken is to first back analyse the performance of the unstabilised control sections to determine the structural contribution properties of the sub-base aggregate. An empirical predictive model is suitable for this exercise and AASHTO Flexible Pavement Structural Design (1993) was adopted. The properties from the control section can then be used to derive the improvement factors that are evident in the data from the stabilised sections.

The detailed procedure used is as follows:

1. Determine the number of standard axle passes to develop a 40mm deep rut in the unstabilised control sections.
2. Calculate the AASHTO layer coefficient "a" for the granular sub-base material by back-analysing the performance of the control section using the actual CBR value, the actual traffic count, the actual thickness. The ΔPSI value of 3.0 and the reliability value of 50% also need to be standardised. The latter two values are compatible with the 40mm rut generated, typically, by construction traffic vehicles.
3. Back-analyse the sections stabilised with Tensar geogrid to determine the "a" value that correlates to the actual CBR value, the actual traffic count, the actual thickness, the ΔPSI value of 3.0 and the reliability value of 50%.
4. The improvement factor, the "Dobie Factor", (named after the originator of deriving full scale trafficking data by this method), is then defined as the "a" value for the stabilised section divided by the "a" value for the corresponding control section.
5. From an enhanced 'a' value, equivalent thickness relationships can be derived such that a Dobie factor will indicate the equivalent thickness of an unstabilised layer, Figure 3.

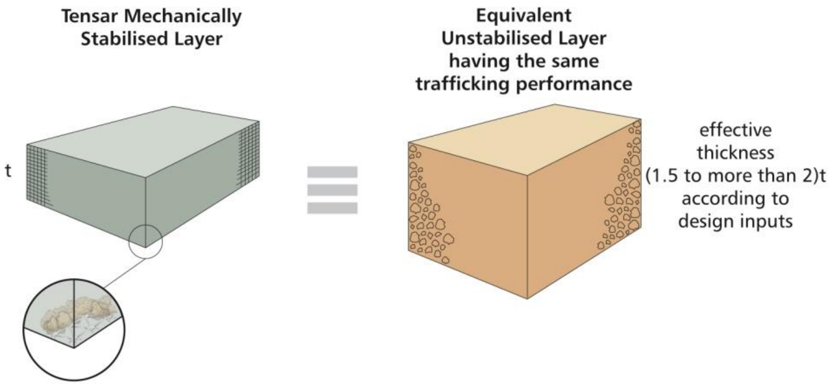

Figure 3, Illustration of the equivalence between a Tensar msl and an unstabilised layer

It is important to note that rut depth is used in the analysis. There is often some confusion between the definition of rut depth and deformation. Figure 4 defines the terms.

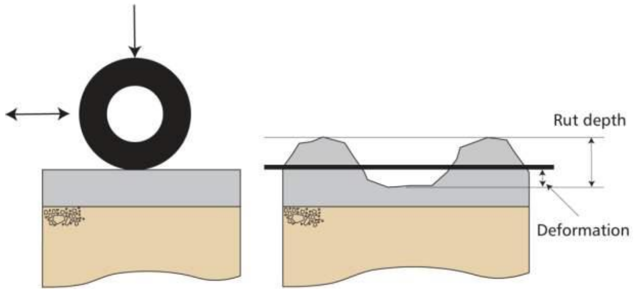

Figure 4, Rut and deformation depth definition

Typical Trafficking Results

The trafficking performance from different geogrids is unique. In the quest to obtain improved trafficking performance, Figure 5 shows a "snapshot" trafficking test for TriAx, during its development stage, compared with a Tensar biaxial geogrid.

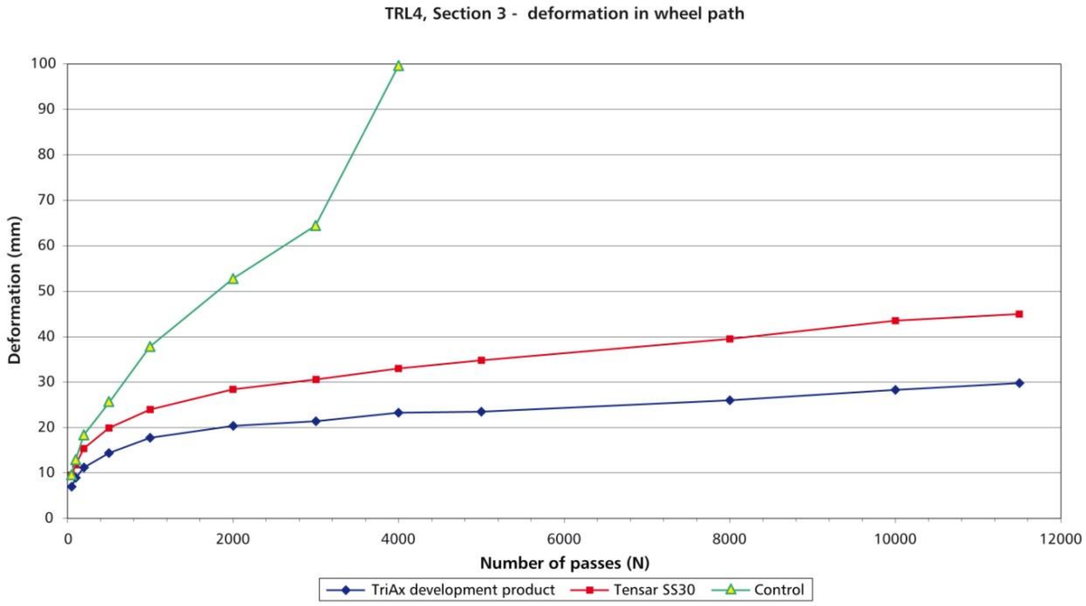

Figure 5, Deformation plots

Transverse profiles at surface and subgrade levels need to show the relatively small deformations which would then agree with the model of interlock and lateral confinement rather than the tensioned membrane mechanism which would require much larger and narrower deformation profiles. Figure 6 shows cross sections of trench excavations to examine the deformation profiles and confirm the stabilisation mechanism as being one of lateral confinement of the aggregate.

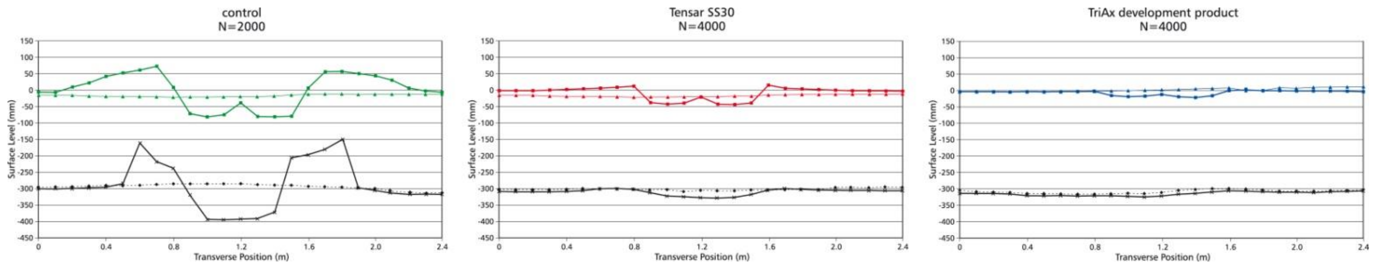

Figure 6, Deformation profiles, TRL 4, Section 2

Figure 6 shows the extreme deformation of the unstabilised layer with the test terminated at 2000 passes. The expected performance has been achieved by the biaxial geogrid Tensar SS30 and the lateral confinement mechanism is confirmed. At the same trafficking stage, the TriAx product indicated that improved performances are achievable.

The assessment of the unstabilised control sections results in an average "a" value for the sub-base of 0.097 which is very close to the value which is conventionally used in the AASHTO design of 0.09 – 0.11. This indicates an acceptable level of agreement with AASHTO 1993. Therefore, by the process outlined above, stabilisation factors of equivalent thickness for the same trafficking performance have been incorporated in Tensar software.

Note that the factors used in Tensar stabilisation applications vary with thickness as a thin stabilisation layer performs more effectively than a thicker layer.

Conclusions

The seven trials at TRL have produced a vast wealth of data which is essential if dependable design factors are to be derived from the results. In full scale testing, even under very controlled conditions, there are significant variations between tests and therefore reliable and confident interpretation requires such a large body of data.

This large body of data gives Tensar International a high level of confidence in using the factors derived by these methods for the design of stabilised aggregate layers in roads and to provide the technical and economic benefits that are available.

The factors incorporated into Tensar's bespoke pavement design software are derived in this way. Users of the software can be confident that the factors are derived from rigourous analysis and interpretation of a large body of performance data that has been obtained from large scale testing, validated against 25 years of real project performance.

Endorsement

The derivation of the Tensar TriAx stabilisation factors was presented to the University of Nottingham for external review. The endorsement letter states:

> *"I confirm that, in my view, interpretation in terms of a layer coefficient related to the 1993 AASHTO pavement design method is a sensible approach. Furthermore, the computations appear to have been carried out correctly. The results in terms of the so-called "Dobie" factor are therefore appropriate and, as illustrated in Tensar's document, they match the previously proposed design predictions reasonably well."*

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