Project: Hayfield Road New Mills

Client:	**Atkinson Peck Ltd**
Contact:	**Martin Davenport**
Tensar Ref:	**P-33478**
Date:	**09 May 2016**
Tensar contact:	**Matthew Malone**
Objective:	The design of a reinforced sub-base that will provide short-term stability of the surface in the case of potential voids opening up in the subgrade.

Introduction

Tensar International Ltd has been contacted by Atkinson Peck Ltd to provide an Application Suggestion for the use of Tensar materials in a mechanically stabilised layer for the temporary spanning of potential voids.

The aim of the Application Suggestion is to specify how Tensar SS biaxial geogrids can be used to reinforce a granular sub-base that will provide short-term support to the surface in the case of voids opening up in the subgrade. This document is not intended to be a final and complete detailing of the proposed stabilisation construction. There are a number of other considerations that have to be made in the production of a complete design, e.g. drainage provisions, detailing at structures and boundaries. The Application Suggestion will need to be adapted before incorporation in a final design and unless otherwise shown or discussed, such features are not covered by this Application Suggestion.

Tensar SS biaxial geogrid reinforcement:

Tensar SS Geogrids are used to mechanically stabilise well-graded granular fill.

The unique Tensar manufacturing process produces a monolithic geogrid from a single sheet of polymer. This provides a geogrid with square-edged ribs and integral high strength junctions, which possess both geometrical and molecular symmetry.

This basic structure makes the geogrid inherently suitable to span voids whilst sustaining vertical loading. Due to the creep characteristic of polypropylene, this loading cannot be sustained for the long term. Between 48 and 72 hours can be a reasonable expectation.

The deformation that takes place under load is significant and will allow visual identification of a void having migrated to the surface and further action, by others, to be taken.

The shape of the geogrid ribs and the integral junctions give the benefit of lateral restraint to the aggregate particles that partially penetrate the geogrid apertures by a process of interlock. This means that simple overlaps are suitable between rolls of geogrid, but it is recommended that two layers of geogrid are used and laid orthogonal to one another. If, however, a single layer of geogrid the overlaps should be stitched with braid to ensure additional safety.

No other geogrid or geotextile, even with similar strengths and physical properties, may be substituted into this design without reducing the pavements performance and shortening the design life.

Research

In 1991 the University of Wales carried out a trial to investigate using Tensar biaxial geogrid reinforced granular layers to span across voids. The aim of this trial was to see if granular layers reinforced in this way could provide an early warning system of a void appearing unexpectedly beneath a road, for example, in areas of old mine workings. The requirement was that the void would create a depression in the ground surface sufficiently deep to be detected easily, but able to survive long enough for remedial measures to be taken safely.

The arrangement of the trial was a 3.0m diameter void was formed in between block work walls, and then filled with sand. A pavement consisting of 0.6m of granular sub-base was placed above the sand-filled void, reinforced with 2 layers of Tensar biaxial geogrid. Two layers of kerbstones were placed on top of the sub-base to give 5 kPa surcharge. The sand fill was then removed hydraulically to create the void. The geogrid was monitored with strain gauges at various distances from the centre of the void. It is important to note that the geogrid was not fixed or anchored to the top of the blockwork wall – it was just resting on top.

The results from this trial were as follows:

• Strain reached a maximum of 4% after completion of void formation, and increased very little until 72 hours were reached, when the trial was deemed complete.

• Tensioned membrane theory predicts that load in a membrane used in this way should be well above the breaking load of the geogrid – this was clearly not the case.

• Membrane theory and creep properties of the PP geogrid would suggest that grid strain should increase rapidly with time – this did not happen.

• Strain (and therefore load) measured in the geogrid at the two points resting on top of the blockwork wall (1.75m and 2.25m on Figure 24) is zero, indicating that the support mechanism does not rely on friction between the grid and the top of the blockwork wall.

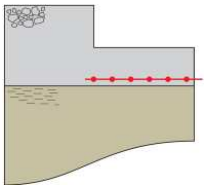
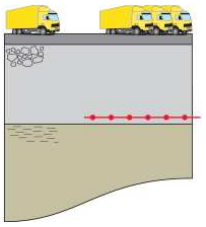
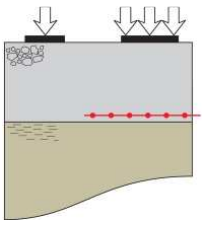
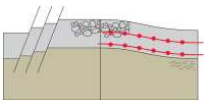
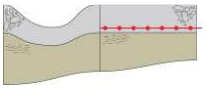
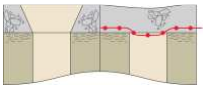
This trial showed how effective interlock is in creating a stiffened granular mattress, and how superior it is to a tensioned membrane. As a tensioned membrane, the granular pavement should have collapsed very quickly. However, the sub-base/geogrid composite created a 0.6m thick gravel mattress spanning 3m at strains well below failure.

This unique composite action can be used in all applications where granular layers are reinforced with Tensar biaxial geogrids.

More details of this work can be found in “The Properties and Performance of Tensar Biaxial Geogrids” available from Tensar International.

Scope

The six common uses of Tensar biaxial geogrids in stabilisation are shown here and comments relevant to this Application Suggestion are provided.

	Reducing layer thickness Not applicable in this case
	Increasing life Not applicable in this case
	Increasing bearing capacity Not applicable in this case
	Controlling differential settlement Not applicable in this case
	Capping weak deposits Not applicable in this case
	Spanning voids **Applicable in this case to span a <u>surface</u> void for between 48 and 72 hours based on the total loading as detailed in Table 1.**

Adopted Parameters

In the absence of an adequate design brief being supplied to Tensar, the following parameters have been assumed to form the basis of the assessment. The responsibility of providing the correct parameters lies with the Client.

1) Type of Application

Tensar mechanically stabilised layer (MSL) as a working platform for tracked plant.

2) Stabilised Area

Assumed as around: 150 m²
(Ref: Document "TENSAR" received via Atkinson Peck Ltd's email dated 29 April 2016)

3) Construction Material

Assumed to be well graded granular fill consisting of hard angular fill particles with a maximum particle size of 75mm to allow efficient interlock with the Tensar geogrids included to form a mechanically stabilised layer. Unit weight of construction material is assumed to be 20kN/m^3.

4) Ground Conditions

According to document "BH2" received via Atkinson Peck Ltd's email dated 29 April 2016, the subgrade is made ground with very loose to loose (soft) gravelly sand. SPT N value at 1.50-1.95m is 3. For the purpose of this assessment, a CBR value of 1.0% has been assumed.

Please note: Customer must verify the actual site conditions and inform Tensar for reassessment if different parameters should be adopted.

5) Construction load

For this illustration, a total of 300 equivalent standard 80kN axles (ESAL's) have been adopted to model construction and surfacing trafficking for each working platform.

6) Surfacing

Advised 50mm + 160mm thick Bitmac with assumed unit weight of 24kN/m^3.

7) Ground Water

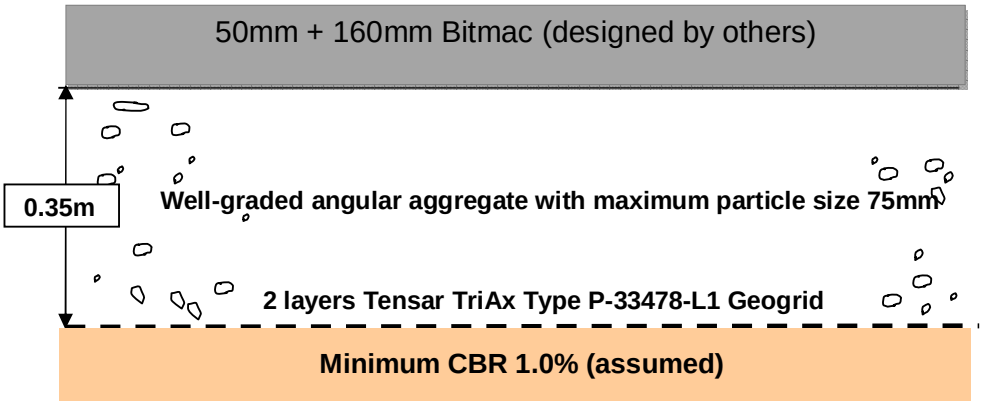
According to document "BH2" received via Atkinson Peck Ltd's email dated 29 April 2016, the groundwater is at 3.0m bgl.

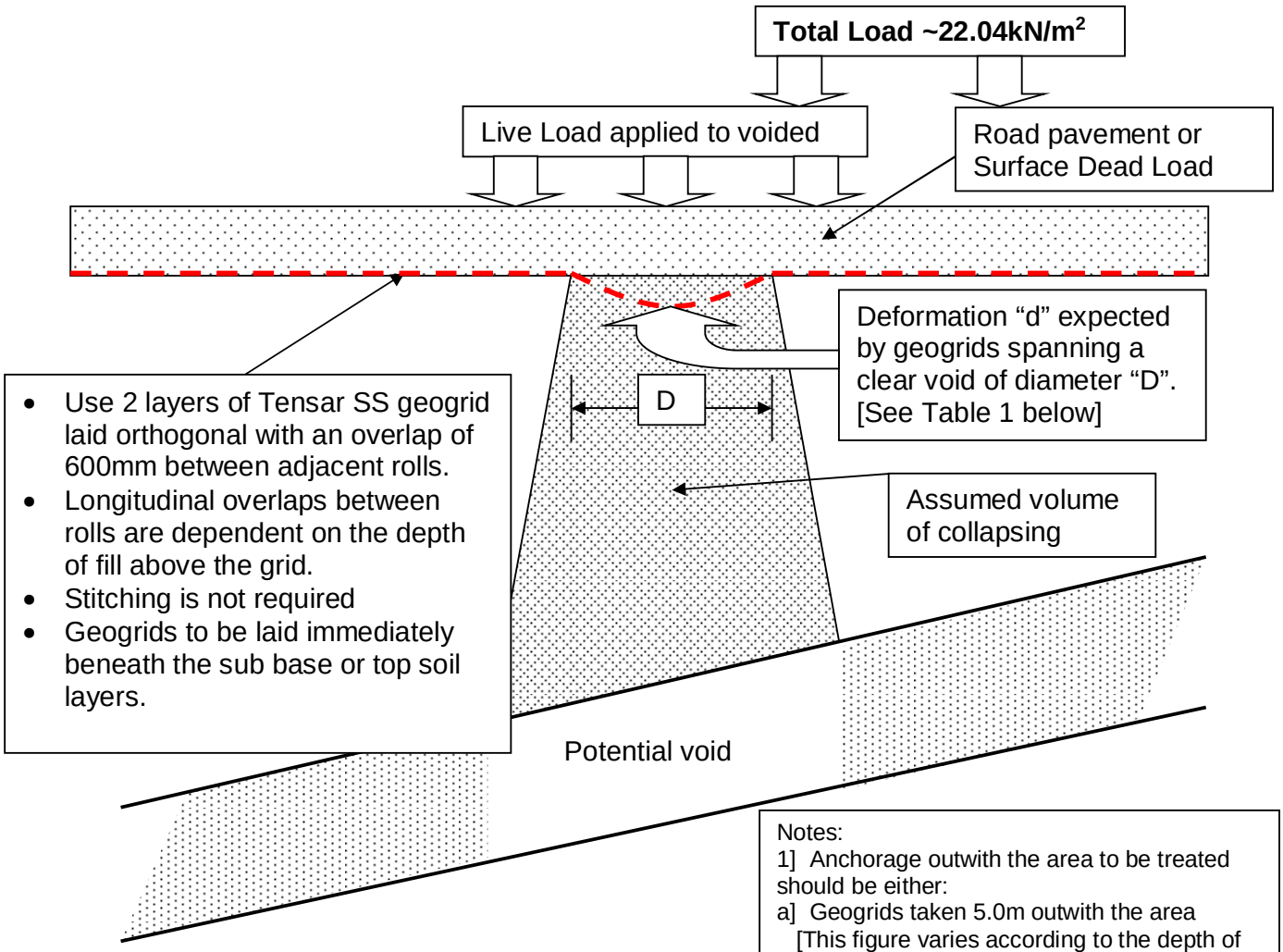
Please note: the actual groundwater conditions must be verified by customer prior to final design.

		Appropriate drainage needs to be provided (designed by others) to ensure that the platform remain adequately drained, to avoid water ponding and so that the MSL and the formation also remain reasonably dry. The drainage ditch and measures should not cause any global stability issues for the constructed. The global stability should be assessed by others.
8)	**Voids Dimension**	Assumed to be 1.0m diameter at the surface, to be confirmed by customer
9)	**Traffic Loading**	Assumed to be 10kN/m^2, to be confirmed.

If these parameters are not correct, please contact Tensar International for a re-assessment.

Proposal





- Use 2 layers of Tensar SS geogrid laid orthogonal with an overlap of 600mm between adjacent rolls.
- Longitudinal overlaps between rolls are dependent on the depth of fill above the grid.
- Stitching is not required
- Geogrids to be laid immediately beneath the sub base or top soil layers.

Notes:
1] Anchorage outwith the area to be treated should be either:
a] Geogrids taken 5.0m outwith the area
[This figure varies according to the depth of installation]
or
b] Geogrids anchored into a 750mm deep by 450mm wide trench 1.0m outwith the perimeter of the affected area.

Table 1

Diameter of Void Deformation "D" m	Total Load Capacity of 2 layers P-33478-L1 geogrid	"d" mm
1.0 m	24.78 kN/m^2	200 mm

Benefits

- Cost effective method of providing short term support
- No pressure grouting or other infilling operations required.
- Very simple to install.
- Can be installed without skilled labour.
- Suitable for highways, car parks, leisure surfaces or open areas.
- Accelerated construction programme.

Specification

MS_geogridperformance/23.11.07

Appendices

"Installation Guidelines for Tensar SS Geogrids in Areas Underlain by Voids" CS/SSVoids/05/02/02

Tensar model specification
MS_GeogridPerformance/23.10.07

Model Specification Geogrid Performance

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1. Geogrids shall be Tensar SS biaxial grids or alternative products for which equivalent structural performance in the pavement can be demonstrated.
2. Independent, empirical full-scale trials and monitored projects have shown the Structural Improvement Factor for Tensar reinforced sub-bases compared with unreinforced sub-bases to be 2.0 and 1.5 for the subgrade CBR range of 1.0 to 5.0%, respectively (interpolating for intermediate CBR values). Reinforced pavements in this Contract have been designed accordingly.
3. Trials have demonstrated that geosynthetic products, which appear to share some similar index properties, such as tensile strength and even having similar methods of manufacture, produce highly unpredictable and variable structural improvement performances. Isolated index properties will therefore not be accepted as a demonstration of structural equivalence.
4. The Contractor shall submit to the Designer details of independent, empirical full-scale trials and monitored projects of any alternative products as evidence of their structural performance, durability and design life equivalence. Such evidence should be submitted at least 3 weeks prior to the required approval date.

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BSI REGISTERED Q05288 BS EN ISO 9001:2000
BSI REGISTERED EMS 86463 BS EN ISO 14001:2004

Installation Guidelines for Tensar SS Geogrids in Areas Underlain by Voids

This installation guideline applies to Tensar SS geogrids supplied by Tensar International or any of its appointed distributors. It provides a basis for Specifiers in the compilation of Specification Clauses particular to their own projects and is applicable to areas underlain by shallow mineworkings, shafts or limestone solution features (swallow holes) where protection is required from voids developing at the surface.

Specific designs, installation details and geogrid specifications are available on request from Tensar International or a local Tensar Distributor.

Subgrade Preparation

The subgrade shall be levelled in accordance with DoT Specification for Highway Works, 2001, Clause 616. It shall be free from stumps, stones or other large protrusions which could cause damage to the grids.

Placing Tensar Geogrids

Tensar SS geogrids shall be placed at the level shown on the drawings or as directed by the Engineer. Where more than one grid layer is to be installed they can be placed one on top of the other or separated by a thickness of granular fill. But grids must be placed at right angles to those in the adjacent layer(s). The grid should extend beyond the anticipated collapse zone by the designed anchorage length.

Overlaps

1. Single Layer of Geogrid

   Braided joints should be used for continuity of tensile strength.

   Adjacent rolls are secured along both the longitudinal and transverse edges by forming 150mm overlaps and braid weaved through every pair of coincident ribs or as directed by the Engineer. The braid shall be securely tied and knotted at 1m intervals. Two lines of braiding shall be provided along each overlap.

   Braid shall be black high density polyethylene three ply twisted monofilament with an index tensile strength 2kN, as supplied by Tensar International.

2. **Two or More Layers of Geogrid**

   Longitudinal and transverse overlaps between adjacent rolls should be 600mm minimum.Overlaps must be maintained during the filling operation. This is generally achieved by placing small heaps of fill locally ahead of the main filling operation.

   The granular fill must be selected so that it is able to fully interlock with the grid to ensure continuity of strength between adjacent rolls.

Fill

Granular fill to be placed on the grid shall be as shown in the drawings or as directed by the Engineer.

Placing Fill

Fill shall be tipped into stockpiles over fill which has been previously compacted. Fill should not be tipped directly onto the grids. The fill stockpiles shall be spread by mechanical plant such as an excavator bucket or a dozer with an opening bucket which causes the fill to cascade onto the grid. The grid should not be allowed to move or fold during the spreading of fill.

Care shall be taken to avoid damage to the grids. No traffic or site plant shall be permitted to travel directly on the grids prior to placing fill.

Compaction

Compaction of unbound materials for sub-bases and road bases shall normally be carried out in accordance with DoT Specification for Highway Works Clause 802. Compaction of other fills shall be carried out in accordance with DoT Specification for Highway Works Clause 612.

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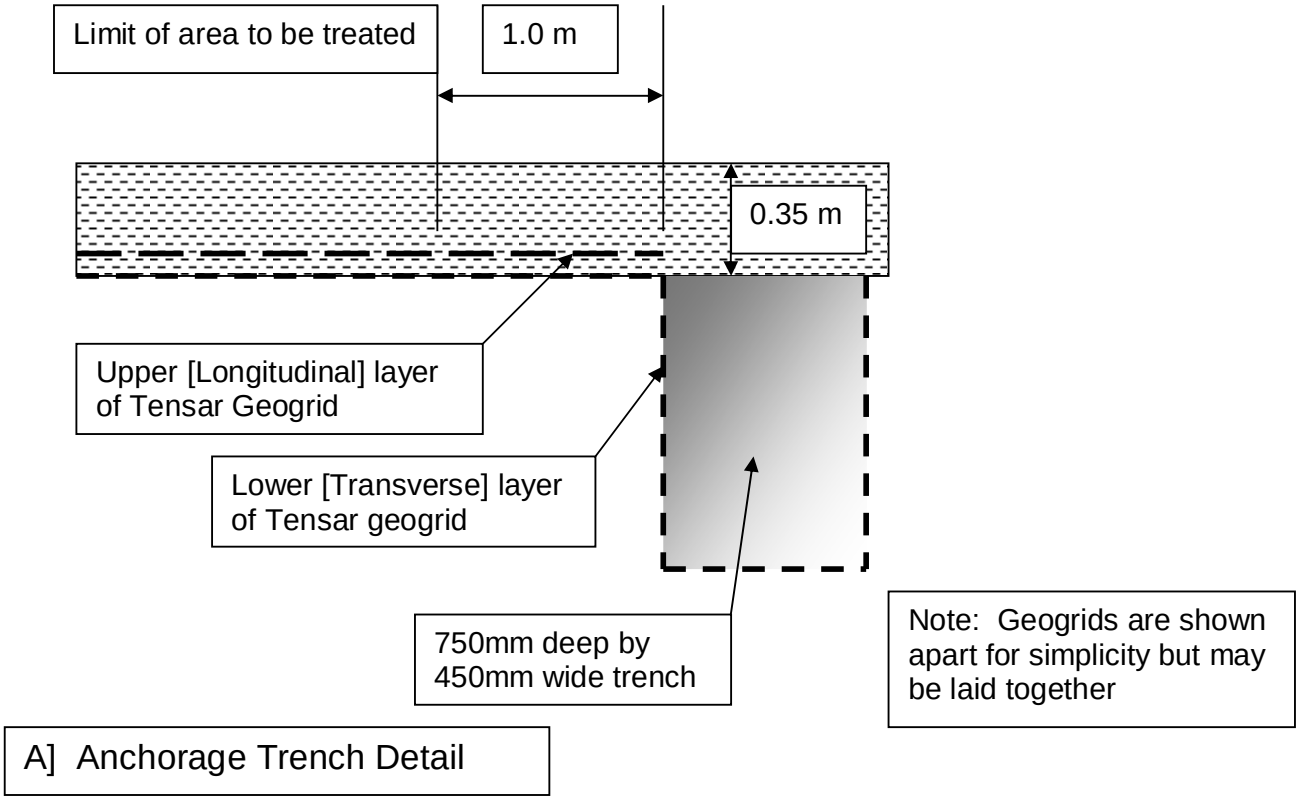
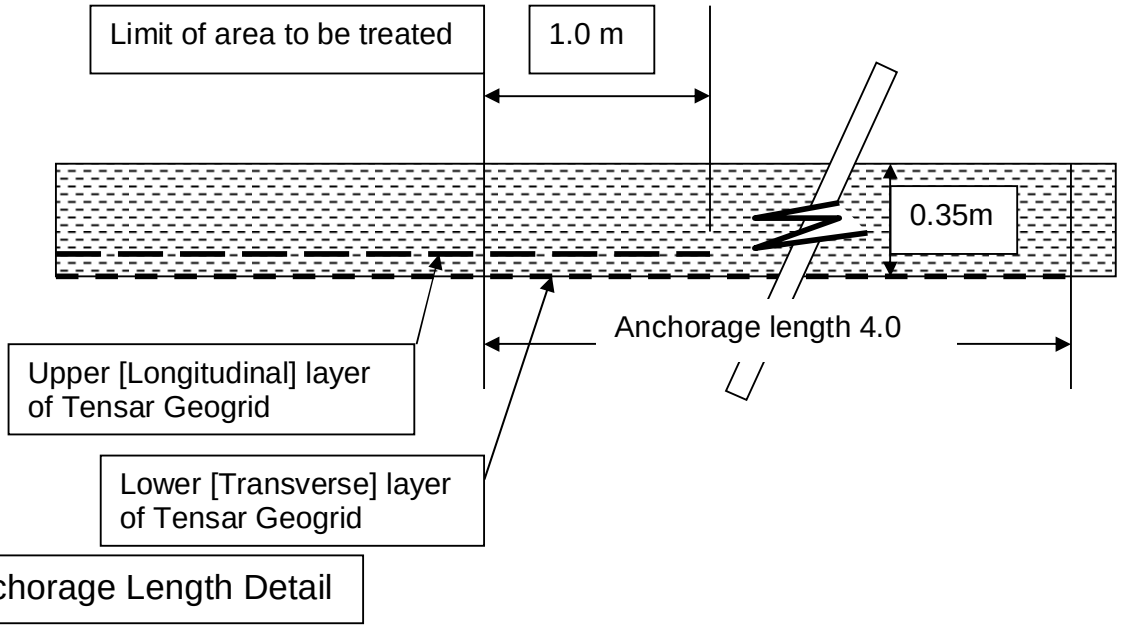
Anchorage Details.

There are two methods of anchoring the geogrid at the perimeter of the treated area.



A] Anchorage Trench Detail

or



B] Anchorage Length Detail

Examples of Similar projects

Sports facility at Stepford Road, Glasgow using Tensar SS grids in areas underlain by shallow mineworkings.
Client: Glasgow City Council.
Contractor: Lanrec Limited Completed : 1998.

Note: There was a void migration during November 2002. The geogrid performed as expected