THE USE OF A SMALL SCALE TRAFFICKING FACILITY TO ASSESS THE PERFORMANCE OF GEOGRIDS AS SUB-BASE REINFORCEMENT

A Walsh[1] & C. G. Jenner[2]

[1] *Tensar International Ltd. (e-mail: awalsh@tensar.co.uk)*
[2] *Tensar International Ltd. (e-mail: cjenner@tensar.co.uk)*

Abstract: The investigation of the performance of geosynthetics in granular layers under trafficking conditions is a complicated issue. The accurate control of all the parameters involved is difficult and reproducible results require the use of expensive full scale trafficking equipment. It is accepted that different geosynthetics perform in different ways and there are no easily determined properties that can be measured to predict that performance. The use of a small scale trafficking facility enables the relatively rapid, reproducible and economic assessment of performance. The paper describes the use of this type of facility in the development of optimum reinforcement characteristics.

Keywords: Geogrid reinforcement, biaxial geogrids, stabilization, subgrade, deformation, laboratory test.

SUMMARY

In order to investigate the effect of geogrid geometry factors on trafficking performance, a series of tests were designed using a small scale trafficking facility which utilised a container into which could be placed a clay subgrade, geogrid and sub-base material. This layered arrangement was then trafficked with a wheel under controlled conditions and the resulting surface deformation measured.

While it is recognised that this test procedure does not attempt to replace independent large scale testing or on site trials, it offers a valuable cost effective initial screening under controlled conditions to gain comparative data on different grid systems to allow further decisions to be made with a greater degree of confidence.

INTRODUCTION

It has been suggested many times in the past that in order to optimise the performance of a geogrid in sub-base reinforcement applications, one of the criteria is that the aperture size and geometry of the geogrid is best chosen to be in union with the particle size distribution of the granular layer and to provide maximum particulate interlock qualities between the geogrid and the fill material thus imparting the maximum degree of strengthening qualities to the reinforced layer.

The traditional method to investigate geogrids for sub-base reinforcement applications has been to carry out relatively large scale trafficking trials using a large wheel load of around 40 kN with a wheel path of approximately 10 m which tests a full size pavement design. This is a very costly and time consuming activity and also has the disadvantage that the size of the geogrid required for the test is such that it usually necessitates production material. The implication of this is that although development laboratory facilities can usually produce a vast variety of non-standard geogrid samples they are not normally of a size compatible with such a full scale test. Some form of smaller scale test based on a similar methodology to the large scale trafficking test is required in order to facilitate the speedy evaluation of different geogrid designs.

Large scale testing of standard biaxial geogrids as described in Table 2 have been performed many times at the UK Transport Research Laboratory (TRL) over the last 20 years and reproducible data is readily available. The graph shown in Figure 1 shows a typical deformation curve over the 10000 wheel passes of the complete test. While it is not intended to concentrate on this data, it is important to note that all aspects of this test are of a significantly larger scale or value than the test procedure described in this paper. These aspects include such elements as subgrade condition, sub-base depth, geogrid size, wheel size, wheel load and wheel path length. Some elements though can be common and these include the use of a clay subgrade, the grading of sub-base aggregate and the maximum number of wheel passes.

The objectives of this work were firstly, to design the test to be similar to the conventional large scale test in that there is a clay subgrade onto which the geogrid is placed before being covered with a sub-base layer which is then compacted before being repeatedly loaded with a rolling wheel in order to produce a measurable and comparable surface deformation. Secondly, having proved that the test is suitable, to obtain deformation data for a control test (with no geogrid) and then for a standard production biaxial geogrid with the ultimate aim of trying to align the deformation values from the small scale testing with those of the full scale test. This then creates a baseline from which it should be possible to compare new geogrid designs in a cost effective environment in order to identify the critical elements of the geogrid that contribute to sub-base reinforcement performance before proceeding to the large scale test.

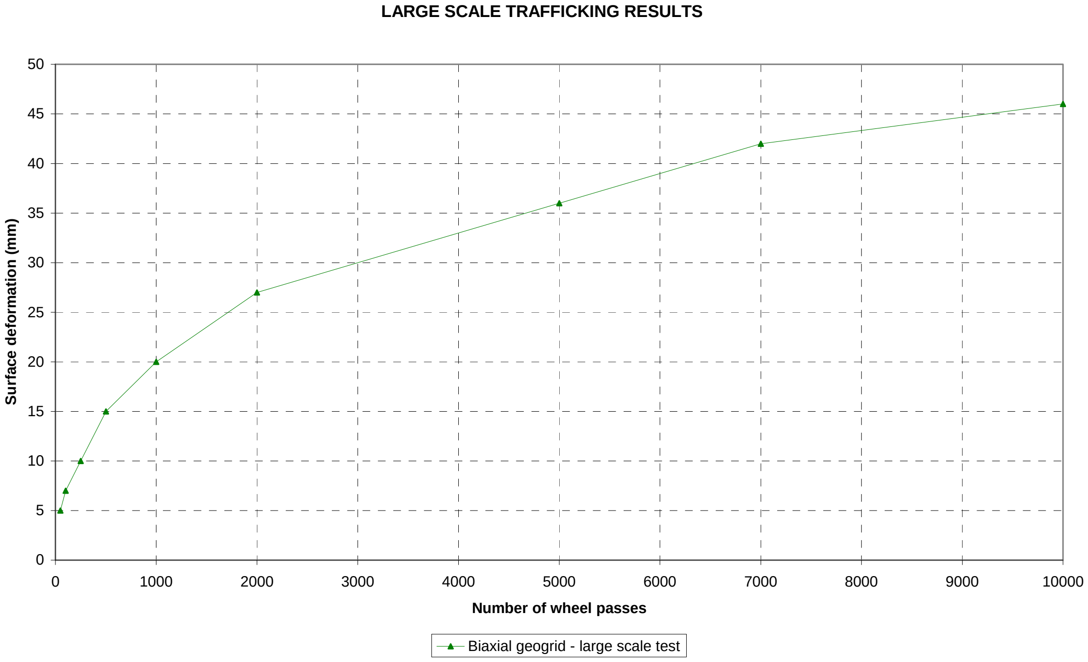

Figure 1. Results from large scale trafficking testing of the standard biaxial geogrid.

PROCEDURE

The basic procedure for the test was relatively simple. A container was used to hold all the different elements of the test i.e. the clay subgrade, the geogrid and the sub-base aggregate. After a controlled compaction of the aggregate the wheel was used to traffic the layered construction with a known load for a given number of passes. At chosen intervals the surface deformation caused by this trafficking was measured.

In arriving at an appropriate procedure for this test a number of different preliminary trials were carried out to determine such factors as the most suitable clay moisture content, clay depth, aggregate moisture content, aggregate depth, wheel load and wheel speed. While it is not intended to discuss these previous tests in detail, it is important to realise that many of the parameters for the test have been derived form previous work and not just chosen at random. It was also found from these previous tests that it was desirable to use a new batch of sub-base aggregate for each test. Another critical factor was found to be the moisture content of the clay as a value too high led to increased deformation at a reduced number of wheel passes and a value too low resulted in a decreased deformation which made it more difficult to separate geogrids with subtle design changes. The preferred parameters for the test are given in Table 1 below.

Table 1. Preferred test parameters.

Property	Value	Accuracy
Clay subgrade moisture content [1]	23 %	+/- 1 %
Clay subgrade depth	70 mm	+/- 1 mm
Sub-base moisture content [1]	3 %	+/- 2 %
Sub-base depth	150 mm (2 x 75 mm)	+/- 5 mm
Sub-base size grading [2]	UK Type 1	Within the specified grading curve
Wheel tyre pressure	45 psi	+/- 1 psi
Wheel tyre width	110 mm	Fixed
Wheel tyre diameter	470 mm	Fixed
Wheel speed	20 passes / min.	+/- 1 pass / min
Wheel load	2 kN	+/- 0.1 kN
Deformation	Measured in mm	+/- 0.5 mm
Box length	1000 mm	Fixed
Box width	600 mm	Fixed
Geogrid length	700 mm	+/- 5 mm
Geogrid width	600 mm	+0/- 5 mm

[1] Calculation based on (wet weight - dry weight) x 100 / dry weight.
[2] Sieve analysis

Every effort was made to adhere to these values as close as possible but some degree of variation is inevitable in all experimental work particularly when using natural materials and the accuracies shown are those which were found to be realistically achievable. In particular it was found that the moisture content of the clay was very important as this could produce significant variations in the deformation.

The direction of the trafficking was in the machine direction (MD) of the geogrid and it can be seen that the length of the geogrid sample, at 700 mm, is clearly less than the total length of the box (Figure 2). This is due to dimensional limitations of geogrid samples made in the development laboratory. The geogrid sample was placed in the centre of the box approximately 150 mm from each end.

Once all the constituent materials were accepted, each test was assembled in the same way. Firstly the clay was placed in the box and compacted to remove any voids and worked into a homogeneous layer of constant thickness, particularly in the central region where the wheel would pass.

Once the clay subgrade was acceptable, the geogrid was placed on its surface and sufficient sub-base was placed on top to form the first of the two 75 mm compacted layers. This sub-base was then compacted with a hand held vibrating plate for a period of three minutes. This was then repeated with more sub-base for the next 75 mm layer and once again compacted for three minutes. Figure 2 shows a sequence of photographs that show the building of the various elements of the test with the clay, placement of the geogrid, addition of the sub-base aggregate and wheel loading. Figure 3 shows a fully assembled test awaiting the start of the trafficking. More information on the test equipment can be found in Sumyaty (2007).

Figure 2. Photographs of test sequence. From left to right - clay subgrade, geogrid placement, sub-base addition, sub-base compaction and trafficking.

Figure 3. Assembled trafficking test

With the sub-base sufficiently compacted to the correct depth, the whole assembly was positioned on four load cells under the wheel and the average reading from the load cells adjusted to read zero, thereby allowing any further load due to the wheel to be directly recorded. At this point the base line for the measurement of the deformation was recorded by placing a rigid beam over the central region of the box where the wheel would pass. The distance from the beam down to the top of the sub-base was recorded. Any further increase in this value would then be due to the formation of a rut.

When trafficking commenced, the wheel load, speed and path length were set and the equipment required no further intervention until the chosen number of passes were reached when the wheel was manually stopped. During trafficking the wheel was always kept within the box and changed direction approximately 150 mm from each end of the box. The load on the wheel was applied by the use of a hydraulic piston at one end of a cantilevered beam supporting the wheel while being pivoted at the other end. The four load cells under the box indicated the average load applied by the wheel and a feed back to the hydraulic system maintained the chosen load. When a deformation reading was required, the wheel was stopped and the rigid beam placed back on the box above the wheel path and the distance from the beam to the bottom of the sub-base rut recorded.

The testing programme was designed in two phases. The first phase looked at a control containing no geogrid and the second phase tested a standard production biaxial geogrid known to provide improved trafficking performance from numerous independently conducted large scale trafficking tests, real application testing and its use over many years. Table 2 gives a brief description of the main characteristics of the standard biaxial geogrid used in this work. This biaxial geogrid was produced from a uniplanar sheet of extruded polymeric material by a 'punch and stretch' production method.

Table 2. Biaxial geogrid characteristics.

Grid type	**Weight (g/m^2)**	**Tensile strength (kN/m)**	**Aperture size (mm)**	**Aperture area (mm^2)**	**Junction centres (mm)**
Biaxial	335	30	37 x 37	1369	39

RESULTS

Numerical results

The numerical results are disclosed in Tables 3 and 4 below. In each case the type of test is indicated, the number of wheel passes, the depth measured from the rigid beam to the aggregate surface and the deformation in the wheel path in the centre position of the box which is calculated by subtracting the depth reading at zero wheel passes from the depth reading at the given number of wheel passes.

Table 3. Results for the control test i.e. no geogrid.

Number of passes	**Depth reading (mm)**	**Deformation (mm)**
0	72	0
20	85	13
50	88	16
100	91	19
200	96	24
300	99	27
500	105	33
1000	114	42

It should be noted that the control test was stopped at the 1000 wheel passes as the 42 mm of deformation was close to exceeding maximum for the equipment.

Table 4. Results for the biaxial geogrid test.

Number of passes	**Depth reading (mm)**	**Deformation (mm)**
0	87	0
20	91	4
50	93	6
100	95	8
200	99	12
300	101	14
500	104	17
1000	109	22
2000	114	27
3000	119	32
4000	122	35
5000	124	37
6000	125	38
7000	126	39
8000	128	41
9000	129	42
10000	129	42

Graphical results

Figures 4 and 5 show the numerical results in graphical form. Figure 4 shows the small scale trafficking surface deformation results for the control test and the standard biaxial geogrid. The control data has been included to give some indication of the general performance difference between an unreinforced system and one reinforced with a geogrid of the type described in Table 2. Figure 5 compares the large scale and small scale surface deformation results for the same biaxial geogrid.

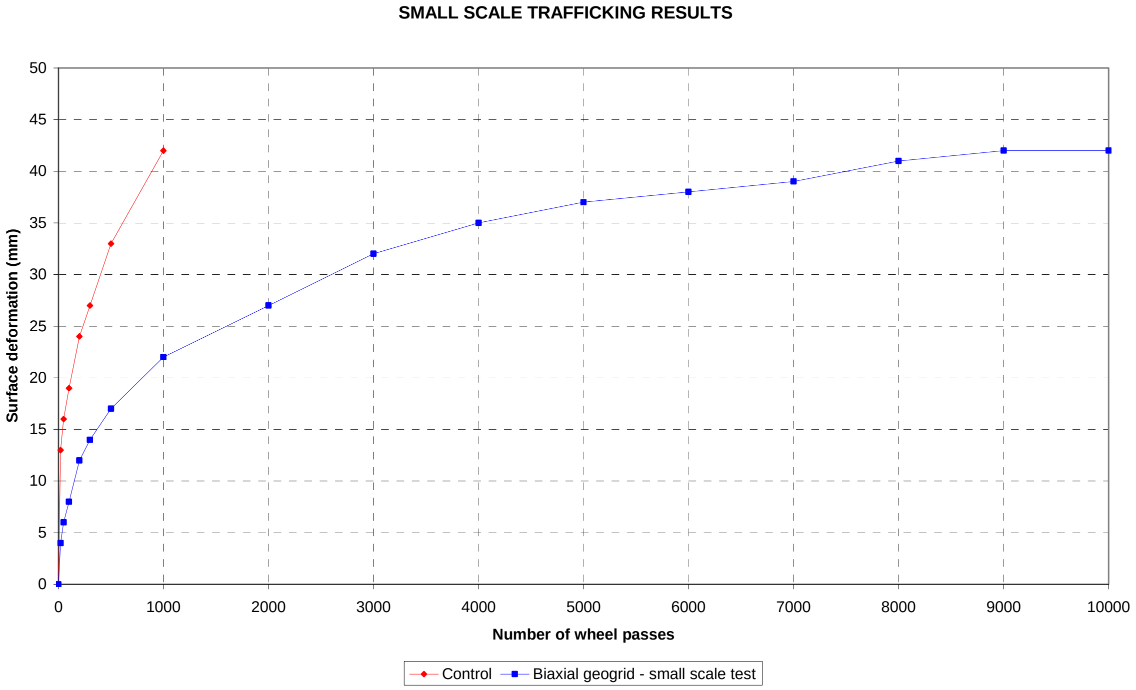

Figure 4. Small scale trafficking results.

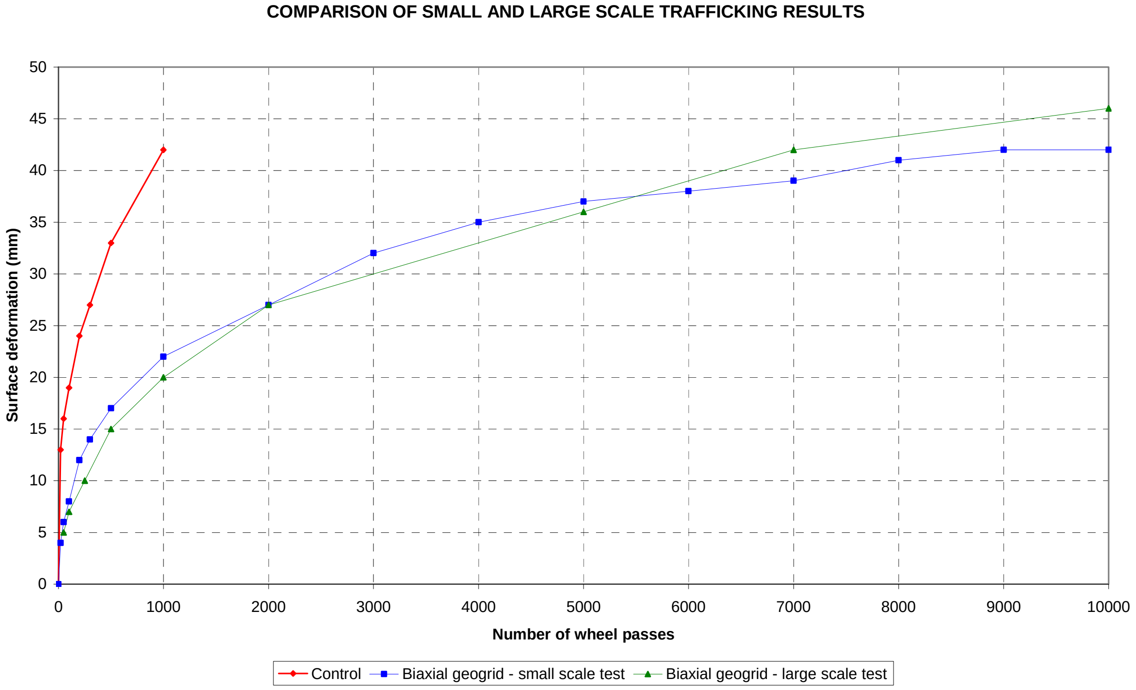

Figure 5. Comparison of small scale and large scale trafficking results.

DISCUSSIONS AND CONCLUSIONS

One of the initial concerns of this work was the ability to keep the test under control as each test involved the use of large amounts of natural materials which, by its very nature, has a high degree of variability. Such factors as the type, moisture content and depth of the subgrade layer were identified as potential sources for error and every effort was made to keep these values as constant as possible. It was hoped to design the small scale trafficking test such that the actual numerical surface deformation values were similar to the large scale trafficking test. This was finally achieved, as can be seen from Figure 5, after using a number of different subgrade moisture contents, subgrade depths, sub-base depths and wheel loads. Although this short paper only has space to describe a few individual tests that are representative of the overall ability of the small scale trafficking test to correlate with the large scale trafficking test there have been many repeated tests that have shown the consistent nature of the two test methods. This has given a reasonable degree of confidence that the test procedure is under control and that some indication of the large scale trafficking performance can be deduced. This has provided a relatively quick and cost effective method to enable the performance of different geogrid designs to be evaluated before a commitment is made to the much more expensive and time consuming large scale trafficking test.

Acknowledgements: The work presented in this paper was completed with the assistance of the University Of Nottingham and the Transport Research Laboratory.

Corresponding author: Mr Chris Jenner, Tensar International Ltd, Cunningham Court, Shadsworth Business Park, Blackburn, BB1 2QX, United Kingdom. Tel: +441254266806. Email: cjenner@tensar.co.uk.

REFERENCES

Sumyaty, J. 2007. Experimental Validation of the Shakedown Concept for Pavement Analysis and Design. PhD thesis. University of Nottingham, chapter 4, 80-85.