Installation of Geogrid to Improve Forest Roads Construction

Rien Visser, Blair Tinnelly and Simon Fairbrother
Associate Professor, Honour Student and Assistant Lecturer
School of Forestry, University of Canterbury, Christchurch, New Zealand
Email: rien.visser@canterbury.ac.nz

Abstract:
Geogrid is a well known product, is readily available and used extensively in civil engineering applications including stabilizing slopes and soil erosion control. In forestry it can be installed over a forest road subgrade to provide additional strength and stability for the overlying aggregate. While it has been used in forest roading applications in various countries and under different conditions, little literature is available to help the forest industry understand the expected performance and potential benefits of geogrid. A trial has been set up in New Zealand on 14 sections of forest road to compare new roads with and without geogrid to understand potential improvement, and by comparing different aggregate thickness layers, provide the opportunity for a cost-benefit evaluation. Although geogrid can come in many shapes and sizes, the TriAx geogrid used in this trial is a thin lattice shaped layer that can be rolled out in 75 meter lengths of 3.8 meter widths. Geogrid is an engineered product and designed with consideration to civil engineering road standards that include well-graded aggregates in multi layer design. Forest roads are invariably single layer design, fit-for-purpose, at the lowest possible cost using locally sourced aggregates. While the full geogrid trial is on-going, this paper presents initial findings related to the actual installation of the geogrid.

1 Introduction

Forest roads in New Zealand, as in many parts of the world, are privately built by forestry companies that are focused on providing fit for purpose roads of lowest possible cost (Fairbrother et al. 2009). Unsealed forest road construction standards typically deviate considerably from published design standards such as ARRB (2009), Austroads (1992), or AASHTO (1993). With aggregate costs being anywhere from 40-80% of total road costs savings are often achieved by using thinner aggregate layers of lower quality, often locally sourced, materials. Inadequate preparation of the subgrade through compaction or soil property modification is also common problem (Fairbrother 2010). Failure to test or understand the strength characteristics of the locally sourced aggregates is another (Fairbrother 2011b).

Forestry roads are also often constructed with very short lead times, being in use within weeks of construction. Other characteristics that differentiate a forest road from a public road include a relatively short duration of intensive use by heavy vehicles. They may also be built with steep grades to minimize road length. Failure, such as excessive rutting, on short sections of road post-construction is also considered acceptable and in most cases readily fixed by simply adding an additional layer aggregate. While forestry companies would prefer a design procedure that guarantees success, most accept that at least some failures provides them with confidence that they are not over-designing their roads.

Geosynthetics, placed between the subgrade and base course, have been used to improve the construction of unpaved roads since the 1970’s (Giroud and Han 2004). A number of studies have been published to show that geogrid can be beneficial and cost effective. Legere and Blond (2002) noted that using geogrid over a bog area in Canada resulted in no significant settlement of the road over a one year period. They also compared it with corduroy, a common forest roading building practice where lower value logs are placed sideways across the road and aggregate placed over top. While the logs have little value, the cost of machinery to prepare and place such logs exceeded the cost of the geogrid. In a more controlled study Sigurdsson (1991) also showed strength improvement using geogrid, but noted that similar results were achieved using thicker aggregates layers. Vischer (2003) reported success when rebuilding failed roads with geogrid on a forest camp ground. Manufactures typically also promote their product using demonstration type case studies (e.g. Maccaferri 2011)

Many forestry companies have used geogrids on an infrequent basis. Most have used it as a product of last resort, often in areas that are very wet and or have very weak soils where simply adding aggregate has not solved the problem. A number of such geogrid applications have not resulted in positive outcomes, but clearly the product has been used outside any reasonable extrapolation of its design limits. Little information is available on actual use, or benefits thereof, of geogrid in forest road construction.

1.1 Geogrid Product Types

Geosynthetics can be differentiated into two main categories; geotextiles and geogrids. Geotextiles typically provide a long-term separation layer to avoid deterioration of the aggregate layer, thereby keeping its strength (Giroud and Noiray 1981).

Geogrids are geosynthetics formed by a regular network of integrally connected elements to allow interlocking with surrounding soil, rock, earth and other surrounding materials to function primarily as reinforcement (Geochemic 2011). The concept is to create a composite soil mass of increased strength (Figure 1). Geogrids are commonly used for retaining walls, stabilizing steepened slope, embankments over soft soils, but also pavement reinforcing. Geogrids are inert to biological degradation and are resistant to naturally encountered chemicals, alkalis and acids.

Figure 1: Geogrid, laid down on a forest road subgrade, being covered with a well graded aggregate.

Currently there are three categories of geogrids (Wikipedia 2011):

1. The original geogrids (called unitized or homogeneous types) are commonly made from polymer materials such as polyester or polystyrene. They may be woven or knitted from yarns, heat-welded from strips of material, or produced by punching a regular pattern of holes in sheets of material, then stretched into a grid.
2. Second is where bundles of polyethylene-coated polyester fibres are used as the reinforcing component, resulting in a product that is more flexible, textile-like geogrids. Polyester yarn geogrids can be made on textile weaving machinery whereby hundreds of continuous fibers are gathered together to form yarns which are woven into longitudinal and transverse ribs with large open spaces between. The cross-overs are joined by knitting or intertwining before the entire unit is protected by a subsequent coating such as PVC. This is the most common type being used for forest roads.
3. The third category of geogrids are made by laser or ultrasonically bonding together polyester or polypropylene rods or straps in a gridlike pattern.

Geosynthetics currently cost about NZ$14 per linear meter (3.8 meter width), with geogrid products approximately twice the price of geotextiles. To make its use positive in terms of cost-benefit, its application must be able to carry more traffic, increase the life span, reduced the depth of aggregate and or reduce the quality (and cost) of the subgrade preparation. There are a number of companies actively developing geogrid products and they also provide technical information to aid the design engineer. For roading design applications this includes software that helps calculate the required aggregate depth with and without (Tensar 2011; Maccaferri 2011).

1.2 Geogrid Implementation

For our trial the TriAx product comes standard as 75 meter rolls that are 3.8 meters wide (Figure 2). They weigh about 75 kgs and as such are easily man-handled by two people. For straight sections of road they are simply rolled out along the sub-grade, with the starting end held down by some rocks. The geogrid can easily be moved as long as it is uncovered. Som advantage is gained by tensioning the geogrid so that it will developed strength faster when loaded, and this can be achieved by using pegs to hold the edges in place.

Figure 2: Placing a 25 meter section of geogrid into position

Road Curves

Curves can be put into the geogrid by either folding a triangular segment into one side, or cutting approximately three-quaterters of the way across and then overlapping to form a triangular section (Figure 3). Folding is both awkward to achieve and caused problems when putting aggregate on top. Geogrid is very springy and has a tendency to pop up and stand proud of the surface. Geogrid is easily cut using scissors or a sharp knife and makes it easier to create the curve, but the longitudinal strength is lost. Manufacturer recommendation is a 1-2 meter overlap of product to ensure continuity of strength, but this can quickly add to cost.

Figure 3: Geogrid is used in a curve on a forest road.

Width - 3.8 metre

While 3.8 meters readily accommodates the technical legal truck width in New Zealand of 2.4 meters, it does not cover the typical road design width of 5.5 meters. Once covered by aggregate the exact placement of the goegrid is no longer visible (Figure 4) and it is very probably that trucks will effectively drive over road sections without the benefit of geogrid. This problem is exacerbated in corners where off-tracking from trailers almost guarantees that the rear wheels of the trailer will not be on the geogrid. A logical solution is to simply increase the width of the geogrid using two sections side by side, but clearly this doubles the cost per linear meter.

Figure 4: Once aggregate is applied over the geogrid the exact location is no longer visible.

Subgrade strength.

Geogrid will best perform on soils with a relatively low CBR rating where the subgrade will deform and allow the geogrid to develop lateral and longitudinal strength (Giroud et al. 1985). Subgrade strength measurements collected by Tinelly et al. (2011) for this trial using a Clegg Hammer and converted using a formula developed by McGregor (2009) indicated that this measure varied extensively both across the road as well as along the road in the relatively short sections (Figure 5). Soil samples analysed in the lab also indicated significant changes over short sections, making a uniform design based on these parameters for a road almost impossible.

Figure 5: While the subgrade may look uniform, geotechnical testing, such as CBR measurements and or soil plasticity tests often indicate that forest road subgrades vary significantly over relatively short stretches, making exact design difficult.

Very soft soil

On very soft soil not only the aggregate, but also the geogrid, is pressed into the subgrade. This occurred in two cases and then the presence of geogrid can hinder the repair of the road. With the ruts deep enough, the geogrid can catch on the trucks differential and be pulled up. Once a section of geogrid is badly deformed in placement it must be either cut away or be pulled out completely to allow road repairs to be carried out.

Aggregate size

Fairbrother (2011a) noted that aggregated used on New Zealand forestry roads are on average very coarse. Larger rock is also common as locally quarried material is rarely screened. The TriAx is designed for an AP 40 material, that is, where the maximum aggregate size is 40mm. This provides an optimum lock between the aggregate and the geogrid. Larger rock pieces don’t lock as well and can also damage and or cut the geogrid (Figure 6).

Figure 6: Spreading base course onto geogrid using an excavator. The maximum rock size in this aggregate is clearly too large and can easily cut the geogrid.

Subgrade smoothness

A smooth prepared subgrade devoid of rock material is best for rolling out geogrid. Any rock material greater than about 5cm standing proud would provide considerable localised tension in the geogrid with the risk of it being cut with the application of the subsequent aggregate layer.

Aggregate application

Ideally, aggregate is placed over the geogrid using an excavator, with the machine and subsequent trucks only travelling over the road once the designed aggregate depth is achieved. Excavators are rarely used to place aggregate when constructing forest roads. Normally dump trucks will spread the aggregate, or simply dump and allow a grader to spread. Dumping backwards, if done correctly, will at least provide a protective layer over the geogrid (Figure 7).

Figure 7: Covering Geogrid using a dump truck.

Using a grader to spread can and did cause problems when the blade came in contact with the geogrid (Figure 8). It immediately rips the product and can easily pull the geogrid up over larger sections.

Figure 8: Spreading using a grader over geogrid.

2 Conclusions

Geogrid is a well know product that has found consistent use in geotechnical applications. Despite theoretical potential to help design and build cost-effective forest roads, its use in the forest industry is limited. To improve our understanding a set of test sections have been installed in New Zealand. This paper presents information on the actual installation of the geogrid product, as well as some of the common difficulties that are unique to forest roads. Considering this information should overcome many of the typical problems that can result in failure.

3 Aknowledgements

We would like to thank Maccaferri Ltd, (www.maccaferri.co.nz) for providing both technical knowledge as well as supplying Geogrid for the trial. Mike van den Arend, Sales Engineering (Christchurch), Robert Frisk (Napier) and Gordon Stevens (Technical Marketing Manager, Auckland). We also thank the following comapines and people for helping with the installation: Hikurangi Farm Forestry (Dan Fraser / Wayne Trafford); Rayonier (Brendan Slui / David Byrne / Alistair Hayward /Fraser Field); Blakely Pacific, (Barry Wells); City Forests (Guy Bonner / Joseph Graham) and Panpac (Bruce Evans).

4 References

American Association of State Highway and Transportation Officials (AASHTO). 1993. Guide for design of pavement structures, Washington,D.C.

Arnold, G., Werkmeister, S. and Alabaster, D. (2007). The effect of grading on the performance of basecourse aggregate. Land Transport New Zealand Research Report 325. Wellington.

ARRB (1998). A Guide to the Design of Pavements for Light Traffic. APRG Report 21. Australian Road Research Board, Victoria, Australia.

AUSTROADS, 1992. Pavement Design: A guide to the structural design of road pavements. AUTSTROADS, Sydney, Australia.

Fairbrother, S., Visser, R. and McGregor, R. 2009. Forest Road Pavement Design in New Zealand. Kins Beach, CA, USA: 32nd Annual Meeting of the Council on Forest Engineering (COFE 09), 15-18 Jun 2009. 8pp.

Fairbrother, S. 2011a. Aggregate Gradation – Getting the Road Surface Right. New Zealand Journal of Forestry, Vol. 55, Issue 4, pp. 11-12. NZ Institute of Forestry, Wellington.

Fairbrother, S. 2011b. Estimating Forest Road Aggregate Strength by Measuring Fundamental Aggregate Properties in proceedings Council for Forest Engineering, Quebec City, June 6-9.

Fannin, R. J., and Sigurdsson, O. 1996. Field observations on stabilization of unpaved roads with geosynthetics. J. Geotech. Eng.,122(7), 544–553.

Geocheminc. www.geocheminc.com/geogrids.htm, accessed 2011

Giroud, J. P., Ah-Line, C., and Bonaparte, R. 1985. Design of unpaved roads and trafficked areas with geogrids. Polymer grid reinforcement, Thomas Telford Limited, London, 116–127.

Giroud, J. P., and Han, J. 2004. Design method for geogrid-reinforced unpaved roads. II: Calibration and applications. J. Geotech. Geoenviron.Eng., 130~8!, 787–797.

Giroud, J. P., and Noiray, L. 1981. Geotextile-reinforced unpaved road design. J. Geotech. Eng., 107(9), 1233–1254.

Giummarra, G. 2009. Unsealed roads manual: guidelines to good practice. ARRB Group Ltd, Victoria, Australia.

Maccaferri. www.maccaferri.co.nz/wawcs013197/Software.html, accessed 2011

Perkins, S. W. 1999. Geosynthetic reinforcement of flexible pavements: Laboratory based pavement test sections. Final Rep., FHWA/MT-99-001/8138, 140 pp.

Sigurdsson, O. 1991. Geosynthetic stabilization of unpaved roads on soft ground: A field evaluation. MS thesis, Univ. of British Columbia, 149 pp.

Standards NZ, 1991. NZS 4407:1991, Methods of sampling and testing road aggregates. Standards New Zealand, Wellington.

Tensar Corporation. 1996. Design guideline for flexible pavement with tensar geogrid reinforced base courses. Tensar Technical Note (TTN:BR96), 77 pp.

Tingle, J. S., and Webster, S. L. 2003. 'Review of corps of engineers design of geosynthetic reinforced unpaved roads. Presentation and CD-Rom Publication at the TRB 82nd Annual Meeting, Washington, D.C., 24 pp.

Tinnelly, B, R. Visser and S. Fairbrother. 2011. Geo-grid Forest Road Trials: Interim Update Report February, 2011. Unpublished Report, School of Forestry, Canterbury University, Christchurch, New Zealand.

Transit NZ (2006). TNZ M/4: 2006. Specification for basecourse aggregate. New Zealand Transport Agency, Wellington. Downloaded from www.nzta.govt.nz/resources/basecourse-aggregate.

Vischer, W. 2003. Low-Volume Road Flexible Pavement Design with Geogrid-Reinforced Base. Transportation Research Record: Journal of the Transportation Research Board, Vol 1819A:247-254.

Wikipedia/Geogrid. www.en.wikipedia.org/wiki/Geogrid, accessed 2011