Geogrid Encapsulation of Railway Formation

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ABSTRACT: In South Australia, high strength polymer geogrids, together with non-woven geotextiles have been used to reinforce railway ballast.

A case study is presented from a project across soft soil conditions and very high ground water table. In this case the adopted solution involved encapsulating the railway sub-ballast in high strength bi-axial oriented polymer geogrid, to form a stiff 'raft'. The method involved excavating to sub-grade level, laying non-woven geotextile directly followed by geogrid. Ballast material was then placed to a specified depth and a second layer of geogrid was placed to effectively 'encapsulate' this sub-ballast layer.

On this raft, or platform, further ballast was then placed to form the normal railway ballast formation.

Performance after one year is given. Details are given of other options that were considered, such as permanent de-watering of the sub-grade by pumping.

1 INTRODUCTION

Geotextiles have been used for many years in railway applications for separation, filtration and drainage functions, however the use of geogrids in railway ballast reinforcement is relatively new (see reference 3,4,5). In this project, geogrids in combination with geotextiles were used to encapsulate a railway sub-ballast formation to allow construction through an area with a very high water table.

2 BACKGROUND

The Australian National (AN) authority in Adelaide, South Australia, was faced with the problem of having to lower a 700m section of railway track one metre to achieve greater headroom under a bridge due to increased container traffic heights.

This section of track, located at Cavan near Adelaide, is in an area of very high water table, and posed problems regarding suitable construction methods for the track base and drainage systems.

3 INVESTIGATIONS

Four boreholes and three Electric Cone Penetration (ECP) tests were placed along the length of the track. Standpipe piezometers were installed to allow long-term assessment of the water table level.

4 RESULTS OF THE INVESTIGATIONS

The natural soils revealed by the boreholes consisted of a succession of sandy and silty clays. The consistency of the soil ranged from firm to stiff. In one area immediately below the overpass only fill material was found, a sandy gravel, and probable related to past construction activity.

Analysis of the electronic cone tests showed that the soil at the proposed formation level could be expected to have an undrained shear strength (Su) of approximately 100kPa. Slightly weaker soils were found close to the surface with higher strength material occurring approximately 0.5m below proposed formation level. Pocket penetrometer testing of the soil recovered from the bores tended to confirm the strength estimates.

The ground water was measured on the day following drilling to allow for the effects of disturbance to dissipate. The measurements showed that the ground water level in each of the bores was E.L. 2.7, above design formation level. Past experience showed that the new formation and track was likely to be flooded.

5. DISCUSSION

The topography of the area is flat, making the use of any passive drainage systems highly problematic. If the formation was to be drained to the point where the ground water would have no practical effect on the track construction a substantial and long-term lowering of the ground water table was required. This could only be achieved if a substantial investment were made in some form of pumping system, with the concomitant expenditure in maintenance of this system. The construction period could also be expected to increase.

No mechanical system is totally reliable so that failure could be anticipated, firstly of the drainage and subsequently of parts of the track. Pumping of the ground water was therefore not considered the best solution. The soils at and below formation level were considered to have sufficient strength (bearing capacity) to withstand the applied loads, see calculation and Figure 1. below:

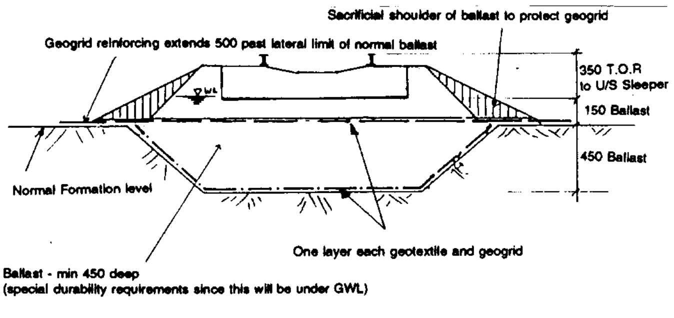


Fig 1. Design Cross Section

5.1 Stress Calculations

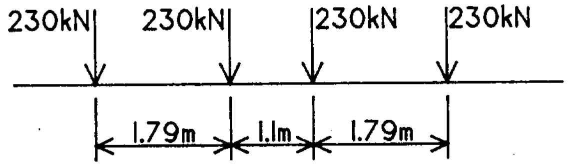
At 500mm below Top of Rail (TOR):

Live load including impact = 230kPa (Based on AN close-coupled well wagons with 230kN axles)
Cooper M250 (current bridge design standard) gives approx 180kPa.

At 950mm below T.O.R.:

Live load including impact = 160kPa (Based on AN close-coupled well wagons with 230kN axles)
Cooper M250 gives approx 90kPa.

For information: AN close-coupled well wagon axle loads are:



All soil pressures above are based on Boussinesq (using Newmark charts and distributing axle loads through the track structure to the underside of sleeper), see reference 1. With no drainage system, there would be ground-water at or near the formation level for substantial periods during the life of the track. The presence of ground-water would result in squeezing or "pumping" of the soil under the effect of the dynamic train wheel loads. This phenomenon results from the local rise in the pore water pressure which, when repeated a sufficient number of times, causes migration of the soil fines.

Standard earthen sub-ballast construction would soon lose strength under these conditions.

6 DESIGN

To counter these water problems it was proposed to encapsulate a lower ballast layer in combined geotextile and geogrid. The geogrid would provide reinforcement and hold the formation together whilst the geotextile would provide separation, filtration and drainage functions. The standard ballast formation would then be built on this base. See Figure 1 and Figure 2.

Such a design is slightly more difficult to construct than the standard track. The benefits for this location are that there is no need to construct a complicated drainage system, that the long term stability of the track is improved and that maintenance can be expected to be reduced over the longer term. To reduce construction time and rail track down time, compaction of the ballast may be reduced to a nominal value during construction, although track settlement would be expected under normal loading, and increased short term maintenance expected.

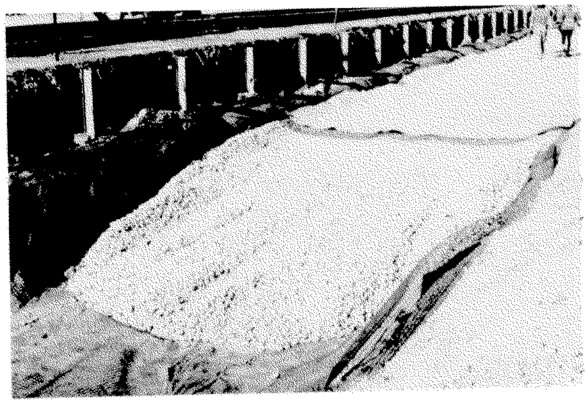


Figure. 2. Sub-ballast during construction

The geogrid used was Tensar SS35 which is high strength polypropylene grid with a quality control strength of 42kN/m in the transverse direction and 34.0kN/m in the longitudinal direction. The grid has an aperture size of 32mm transverse by 29mm longitudinal. The geotextile used was Bidim A44, a non-woven needle-punched continuous filament polyester geotextile, mass 310g/m².

6.1 Reinforcing Function

The use of geogrids to reinforce the ballast reduces the effective stress on the subgrade by up to 40%, see Reference 2. The geogrids high tensile modulus (rigidity) provides resistance to stretching under load and reduces aggregate movement.

7 CONSTRUCTION

The project was carried out by AN in March 1993, during dry conditions. The railway line was closed for a total of nine days for construction. Excavation was carried out to formation level then the geotextile and geogrid were laid transversely across the excavation. The grid was overlapped approx-imately 100mm. The sub-base layer of 42mm ballast was laid to a minimum thickness of 450mm. It was anticipated to place the ballast in 150mm lifts, however, difficulty was experienced with movement of the geogrid over the soft foundations. The ballust was finally placed in one lift of 450mm. This was then graded and rolled to achieve some minimal compaction. Then the capping layers of geogrid followed by geotextile were placed. 150mm of ballast were placed on this followed by placement of the rail track. Refer Figure 3.

Fig 3. Placement of rail track

8 PERFORMANCE

Construction was completed successfully in March 1993. Since then the water level has often reached track level. On one occasion the line was closed due to floods. Tamping of the ballast layer has been carried out, however, no noticeable movement or settlement of the track has occurred.

9 ACKNOWLEDGMENTS

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