THE USE OF GEOGRIDS ON MAINLINE AND INTERMODAL FACILITY PROJECTS

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ABSTRACT

The inclusion of geogrid reinforcement within the sub-ballast and ballast layers of roadbed structures has gained widespread acceptance in many parts of the world. Used successfully on projects for more than 20 years, the national rail authorities in several countries have gone so far as to provide formal guidance on the use of these products in their own design codes.

In contrast, widespread use of geogrid technology in North America has been much slower; it would appear however that things are starting to change. Following the recent publication of a new chapter in the AREMA Manual for Railway Engineering (AREMA, 2010) geogrids are now formally recognized in the US and Canadian rail markets. In addition, the use of geogrids has gained significant momentum, particularly during the last five years, as a result of their more frequent use on a larger number of heavy freight and lighter passenger rail projects in the North America.

The paper provides a detailed review of the extensive laboratory and full-scale testing used to quantify the performance benefits associated with the use of geogrids in roadbed structures (ballast life extension, and roadbed thickness reduction). A set of brief case studies is used to highlight how geogrid technology has been put into practice both in North America and further afield. The paper also describes several intermodal yard projects where geogrids have been used to provide similar benefits for the construction of heavy duty pavements.

INTRODUCTION TO MECHANICAL REINFORCEMENT

Koerner (1998) defined a geogrid as “a geosynthetic material consisting of connected parallel sets of tensile ribs with apertures of sufficient size to allow strike-through of surrounding soil, stone or other geotechnical material”. Mechanical reinforcement is a term commonly used to describe the manner by which geogrids interact with the surrounding soil; in rail applications the soil concerned is typically an unbound granular material.
When unbound aggregate is placed on top of a geogrid, the coarser particles partially penetrate through the apertures and lock into position (Figure 1). This effect commonly referred to as “mechanical interlock”, leads to lateral confinement of the unbound aggregate and a general stiffening of the layer. Because of the way a geogrid interacts with surrounding soil, it is often referred to as “the re-bar within an unbound aggregate layer”.

Figure 1: Mechanical interlock resulting from partial penetration of aggregate particles

The same process takes place when a geogrid is used to reinforce an aggregate layer that forms part of rigid and flexible pavement structures typically found within intermodal facilities and other loading/unloading facilities.
GEOGRID TECHNOLOGY IN RAIL APPLICATIONS

Ballast and Sub-ballast Reinforcement

The confining effect of a geogrid is important in roadbed reinforcement applications as lateral movement of granular particles is a major cause of sub-ballast and ballast settlement. However, the layer stiffening effect is also important, particularly when construction takes place on less competent subgrades (stiff clay or worse). Under these circumstances, the stiffer aggregate distributes loads more efficiently onto the underlying soil, thereby reducing both the dynamic movement (vertical track deflection during a single load cycle) and longer-term settlement of the roadbed due to subgrade consolidation.

There are two locations within a roadbed structure where geogrids are typically used. When placed at the bottom of the sub-ballast layer, the principle function of the geogrid is to distribute the imposed dynamic and static loads over a wider area thereby reducing the pressure imposed on the underlying subgrade. In adopting this approach, the designer has two options:

1. Increase the factor of safety for a given roadbed section
2. Maintain the current factor of safety but decrease the required thickness of the ballast and/or sub-ballast layers

To illustrate how these two options can be used in practice, a set of roadbed sections is provided in Figure 2 for a given set of design parameters.
Figure 2: Example roadbed sections to illustrate the benefits of using geogrids within the sub-ballast layer.

Unreinforced:  
Factor of safety = 1.5

Geogrid-Reinforced Option 1:  
Factor of safety = 3.0

Geogrid-Reinforced Option 2:  
Factor of safety = 1.5

Geogrid-Reinforced Option 3:  
Factor of safety = 1.5

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Several of the Class 1 rail companies in the US are regular users of geogrids. Typically these products are used in areas when soft subgrades are encountered and the rail company’s standard roadbed section considered inappropriate for these conditions. The standard section is effectively “beefed up” by placing a geogrid at the bottom of the sub-ballast layer. Although no formal analysis and design is generally undertaken, this procedure is effectively the same as that highlighted in “Geogrid-Reinforced Option 1” above.

**Pavement Structures within Intermodal and General Loading/Unloading Facilities**

Some of the larger lifting vehicles used within intermodal and general loading/unloading facilities generate axle loads over 200 kips. When these loads are compared with the 18 kip to 20 kip loads typical for conventional highway trucks, there is clearly a substantial difference in load magnitude. Pavement structures built to carry these loads tend therefore to be substantial even when the underlying subgrade is relatively competent. When a geogrid is used to reinforce the granular layer within these heavy pavement structures, a significant reduction in the thickness of the granular layer and/or overlying asphalt/concrete layer(s) can be achieved. When pavement material savings, cost of installation and cost of the geogrid are balanced, total construction savings in excess of 10% can be generated. In the event that a weak subgrade is encountered (CBR < 1.5%), the savings are typically much greater.

Two examples of pavement sections where geogrids were used to reduce material costs are presented in Figures 3 and 4.
Figure 3: Rigid pavement sections with and without geogrid reinforcement

Unreinforced

Roller Compacted Concrete (RCC)

17 in.

6 in.

Aggregate Base

Geogrid-Reinforced

Roller Compacted Concrete (RCC)

14 in.

16 in.

Aggregate Base

Geogrid

Figure 4: Flexible pavement section with and without geogrid reinforcement

Unreinforced

Asphalt Concrete

25 in.

6 in.

Aggregate Base

Geogrid-Reinforced

Asphalt Concrete

18 in.

18 in.

Aggregate Base

Geogrid

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In both examples above, the pavements were constructed on a competent subgrade. When this is not the case, there is often the need to increase the thickness of the aggregate layer or incorporate some sort of subgrade improvement measures – over-excavation and removal of the soft layer, chemical stabilization, etc. Under these circumstances, an additional geogrid-reinforced aggregate layer can be used. In most cases the cost savings associated with the use of a geogrid in this manner can be upwards of 40%.

GEOGRID RESEARCH

The earliest research undertaken to quantify the benefits of using geogrids in roadbed structures was carried out at Queen’s University in Kingston, Ontario by Bathurst and Raymond (1987). An artificial subgrade consisting of a series of rubber bonded cork mats was placed at the bottom of a rigid test box; the remainder of the box was filled with ballast. Cyclic loads generated by a hydraulic actuator were applied to a cross-tie placed on the surface of the ballast.

The results of the testing (Figure 5) illustrated how, for a maximum permanent settlement limit of 25 mm (1 in.), the inclusion of a geogrid within the roadbed structure extended its service life. An almost 5-fold increase was observed for cases where a reasonably competent subgrade (39% CBR) was used and also where a soft subgrade condition existed (1% CBR).

Figure 5: Results of testing undertaken at Queens University, Ontario, Canada
In a further study reported by Matharu (1994), a set of full-scale tests were undertaken at the Network Rail (previously called British Rail) test facility located in Derby, England (Figure 6).

Figure 6: Network Rail full-scale test facility and results for reinforced and unreinforced roadbeds

The main results from the study (also Figure 6) effectively show that when a roadbed structure reinforced with a geogrid is constructed on top of a soft subgrade, its rate of settlement approaches that for the same roadbed structure constructed on bedrock. In addition, on soft subgrade soils and for the same roadbed thickness, the dynamic vertical movement of the track as the wheel of the train passes is reduced by approximately 40% when a geogrid is used to reinforce the roadbed (Figure 7).

Figure 7: Dynamic vertical movement occurring for roadbeds constructed on soft subgrades
A rail corridor constructed between Hochstadt and Probstzella in Germany presented an opportunity to observe the benefits of using geogrids in a full-scale field situation. Plate bearing tests undertaken by the German National Rail Authority (Deutsche Bahn) demonstrated that the stiffness of a geogrid-reinforced 400 mm (16 in.) thick sub-ballast was approximately the same as a 600 mm (24 in.) thick unreinforced layer. Also, the stiffness of both 400 mm (16 in.) and 600 mm (24 in.) unreinforced sections doubled when a geogrid was included (Figure 8).

![Image](image.png)

**Figure 8**: In-situ performance testing of roadbed sections constructed on a main line project in Germany

On a similar project constructed near Cologne, Germany, the inclusion of a geogrid within a roadbed constructed over a soft formation allowed the sub-ballast to be reduced from 1050 mm (42 in.) to 700 mm (28 in.). Despite the thickness reduction, the target modulus of 120 MPa (17,400 psi) was maintained.

On a mainline project in Nagykanizsa, Hungary, the decision was made to include a geogrid within the ballast layer during a rehabilitation operation. Prior to replacement of the existing roadbed, the rail line required monthly re-surfacing. The dynamic deflection of the rail track was measured using a rail car, both prior to and following the inclusion of the geogrid within the roadbed section (Figure 9). The data obtained clearly demonstrates that the inclusion of a geogrid resulted in a dramatic reduction in the dynamic deflection taking place during trafficking. Service disruptions due to the requirement for frequent maintenance have since been eliminated.

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RECOGNITION OF GEOGRID BENEFITS BY PUBLIC AUTHORITIES

The performance benefits highlighted above have been recognized by several public and private authorities. Brief details of the guidance developed by three such authorities are provided in the remainder of this section.

Network Rail, United Kingdom

The National Rail Authority In the United Kingdom (Network Rail, formerly known as British Rail) has used geogrids beneath their mainline tracks since the early 1990’s. In addition, the company has carried out several in-house testing programs, both in the laboratory and along in-service tracks. Based on the results of this testing Network Rail has quantified the performance benefits associated with the use of geogrids in roadbed structures.

Design protocols for roadbed structures are prescribed in Network Rail (2005). The general approach adopted is to attain a pre-determined target stiffness for the roadbed structure itself. As shown in Table 1, the target value varies depending on whether a geogrid is included within the roadbed structure or not – a minimum dynamic sleeper (cross-tie) support stiffness (K) of 60 kN/mm is required for an unreinforced roadbed, whereas only 30 kN/mm is required for the same acceptable level of performance when a geogrid is included within the roadbed section.

Figure 9: Performance testing undertaken on a mainline project in Hungary
<table>
<thead>
<tr>
<th>Track Condition</th>
<th>Minimum Dynamic Sleeper Support Stiffness, K (kN/mm/sleeper end)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absolute Value</td>
<td>30</td>
</tr>
<tr>
<td>Existing Main Lines</td>
<td></td>
</tr>
<tr>
<td>1. With Geogrid Reinforcement</td>
<td>30</td>
</tr>
<tr>
<td>2. Without Geogrid Reinforcement</td>
<td>60</td>
</tr>
<tr>
<td>New Track</td>
<td></td>
</tr>
<tr>
<td>1. Up to 100 mph</td>
<td>60</td>
</tr>
<tr>
<td>2. Above 100 mph</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 1: Required roadbed stiffness based on Network Rail design protocols

For a given set of subgrade conditions and the same type of aggregate, the stiffness of a roadbed section is essentially a function of the combined thickness of the ballast and sub-ballast layers. The design chart shown in Figure 10 illustrates that the use of a geogrid results in a roadbed thickness reduction of around 200 mm. (8 in) relative to a conventional unreinforced section.

Figure 10: Roadbed design chart provided by Network Rail, UK
It should be appreciated that although the Network Rail design protocols refer to geogrids generically (i.e. no specific manufacturer’s products are called out), any geogrid product proposed for use on their rail system requires a current PADS Certificate. This document is obtained from Network Rail and is only issued for products where the performance benefits outlined above have been demonstrated in full-scale laboratory and field tests.

**National Rail Authority (SZDC), Czech Republic**

The use of geogrids within roadbed sections gathered significant momentum in Eastern Europe during the period locally known as “The Velvet Revolution”; this term describes the overthrow of the old communist government within what was then called Czechoslovakia. One of the immediate needs during this period was to bring Czech railways up to the same standards as the rail structures used in Western Europe. The need to minimize costs was however a main concern. This prompted the Czech Rail Authority (SZDC) to consider adopting some of the latest construction techniques available.

The use of geogrids within the roadbed structure was considered at this time to be innovative technology. However, their use in recent years has become commonplace and was marked by a recent publication (SZDC, 2010). This document was developed following several years of discussion and performance testing undertaken at the Technical University of Prague. The guidance in this document essentially provides the rail designer with protocols for the incorporation of a set of specific geogrid products.

**American Railroad Engineering and Maintenance of Way Association (AREMA), USA**

The premier reference document for the design of rail structures in the US is provided by AREMA (2010). Within Chapter 1, Section 11 of this document guidance is provided on the use of geogrids within a roadbed structure. Section 11 was developed following a thorough review of the performance testing described above along with numerous projects constructed using these techniques over the last 25 years.
In addition to providing general guidance on the benefits of using geogrids within ballast and sub-ballast layers, the AREMA design manual also presents a specification for a particular set of geogrid properties (Table 2). Alternative geogrids can be approved at the discretion of the design engineer, but AREMA provides some stringent recommendations on the level of proof required for “non-specified” products.

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Units</th>
<th>Minimum Value (Sub-ballast reinforcement)</th>
<th>Minimum Value (Ballast reinforcement)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aperture size* (machine x cross machine direction)</td>
<td>Direct measurement</td>
<td>Inches (mm)</td>
<td>0.70-0.80 x 1.50-1.60 (17.8-20.3 x 38.1-40.6)</td>
<td>1.70-1.80 x 2.40-2.50 (43.45.5 x 61.0-63.5)</td>
</tr>
<tr>
<td>Open area</td>
<td>Direct measurement</td>
<td>%</td>
<td>70</td>
<td>75</td>
</tr>
<tr>
<td>Rib thickness</td>
<td>ASTM D1777</td>
<td>Inches (mm)</td>
<td>0.05 (1.27)</td>
<td>0.05 (1.27)</td>
</tr>
<tr>
<td>Junction thickness</td>
<td>ASTM D1777</td>
<td>Inches (mm)</td>
<td>0.16 (4.0)</td>
<td>0.17 (4.4)</td>
</tr>
<tr>
<td>Aperture stability modulus @ 20cm-kg</td>
<td>US Army Corps of Engineers 62</td>
<td>lb-ft/deg (kg-cm/deg)</td>
<td>0.470 (6.5)</td>
<td>0.419 (5.8)</td>
</tr>
<tr>
<td>Flexural rigidity (Machine direction)</td>
<td>ASTM D1388</td>
<td>(lb-ft) (mg-cm)</td>
<td>0.0542 (750,000)</td>
<td>0.0325 (450,000)</td>
</tr>
<tr>
<td>Tensile modulus @ 2% strain (machine x cross machine direction)</td>
<td>ASTM D6637-01</td>
<td>lb/ft (kN/m)</td>
<td>18,500 x 30,000 (270 x 437)</td>
<td>19,000 x 32,500 (277 x 474)</td>
</tr>
<tr>
<td>Junction strength</td>
<td>GRI GG2-87</td>
<td>lb/ft</td>
<td>1080 (15.7)</td>
<td>956 (13.9)</td>
</tr>
<tr>
<td>Junction efficiency</td>
<td>GRI GG2-87</td>
<td>%</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>Carbon black</td>
<td>ASTM 4218</td>
<td>%</td>
<td>0.5</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Table 2: AREMA geogrid specification

CASE STUDIES – MAINLINE PROJECTS

There are more than 100 projects where stiff biaxial geogrids have been used to reinforce the sub-ballast or ballast layers within a roadbed structure. All the US Class 1 rail companies have used geogrids within their roadbed structures at one time or another and several light/passenger rail companies also have experience in the use of these products. The following sub-sections provide brief details on a selection of these projects.
Utah Transit Authority (UTA) Light Rail Project, Salt Lake City, Utah (2005-2008)

The UTA’s FrontRunner commuter rail line runs 44 miles from the city of Ogden in Weber County south to Salt Lake City. The line is located in an existing right-of-way that runs parallel with the Wasatch Mountains. The area is part of a natural drainage basin, characterized by poor quality soils and shallow groundwater. The subgrade beneath the roadbed typically consists of low to medium strength cohesive soils and loose to dense sand.

A conventional roadbed design which incorporated a thicker sub-ballast layer, proved cost prohibitive due to the extremely high cost associated with the sourcing of local aggregate. Calculations determined that the required sub-ballast thickness could be reduced conservatively from 12 in. to 8 in. by including a layer of geogrid at the interface between the sub-ballast and the underlying subgrade. Reducing the sub-ballast depth provided significant cost savings and expedited the construction process – less aggregate could be placed in less time. In addition, this approach eliminated contact with the shallow groundwater and for a 900 ft length of track, eliminated the need to relocate an existing set of buried utilities.

Dallas Area Rapid Transit Authority (DART), NW1A Rail Section, Dallas, Texas (2003-2008)

DART has been a regular user of geogrids within their roadbed structures since 2003. Traditionally, prior to constructing their standard section, the underlying cohesive soils would be mixed with lime to a depth of 6 in. Although it provided good short-term support for the roadbed, this approach resulted in some logistical problems.

Installation of the lime stabilization was not well suited for the project due to the generation of extensive dust clouds in what was an urban location. Additionally, installation process for lime stabilization requires dry, mild conditions; when the local weather does not comply, construction work on the project is temporarily suspended. Finally, protruding utility pipes were present at the time the roadbed was constructed. As large vehicles are required to install the lime, this would have made things very difficult for the contractor and slowed down the construction process significantly.
In order to provide an alternate solution to the lime stabilization, a structural analysis was undertaken to demonstrate that installation of the 6 in. thick layer of lime could be avoided by including a layer of geogrid at the bottom of the standard roadbed section. Installation adopting this “mechanical stabilization” technique was both simple and fast, requiring only minor slitting of the geogrid in the areas where the protruding utilities were located.


During 2008 and early 2009, KCS undertook the reconstruction of a 91 mile section of disused track in south Texas. Where weaker subgrades were encountered or the original sub-ballast had been removed or washed out, normal construction methods required placement of up to 12 in. of new sub-ballast. Instead, a geogrid was placed at the bottom of the new sub-ballast in order to reduce the required thickness to only 6 in.

In the absence of any local suppliers, aggregate was transported in from quarries in Hatton, AR and Mexico resulting in a particularly high cost for the sub-ballast layer. On this project, reducing the required sub-ballast thickness resulted in significant construction cost savings. In total, approximately 237,000 SY of geogrid was installed.

CASE STUDIES – INTERMODAL YARDS


Close to 700 semi-tractor trailers with a maximum weight of 80,000 lbs (350 kN) roll in and out of this facility each day. In addition, the pavements in the northern area of the facility are required to withstand the pressures imposed by straddle cranes that weigh 180,000 lbs (800 kN) and have a loading capacity of 100,000 lbs (445 kN). The facility is open for business 24/7 throughout the year and the pavements are thus subjected to Chicago’s blistering summer days and bitter winters.
A number of options were considered for increasing the bearing capacity of the site’s underlying soils; in the end, a geogrid solution was selected. Ultimately two layers of geogrid were used to reinforce the unbound aggregate layer. In using a geogrid system, CSX were able to save almost 30% on the cost of their flexible pavement when compared with a rigid pavement solution.

**Canadian Pacific Rail (CPR) Project – Detroit, Michigan (1987)**

This project was designed by CPR Engineers at their head office in Calgary, Alberta. The site was underlain by soft soils which resulted in the requirement for a thick pavement section. The client was interested in using mechanical reinforcement to reduce the thickness of the base course layer thus leading to cost savings and a reduction in the time required for construction activities. A single layer of geogrid was used to reinforce the base aggregate within the main pavement section, thus reducing the required thickness of this layer. The actual pavement section constructed to carry the heavy axle loads characteristic for this facility is illustrated in Figure 11.

![Figure 11: Pavement section at Canadian Pacific Rail Intermodal Facility, Detroit, Michigan](image-url)
ACKNOWLEDGEMENT

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Reference Document 013/2010 Geomat
Správa železniční dopravní cesty
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Table 2: AREMA geogrid specification

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Figure 10: Roadbed design chart provided by Network Rail, UK

Figure 11: Pavement section at Canadian Pacific Rail Intermodal Facility, Detroit, Michigan
The Use of Geogrids on Mainline and Intermodal Facility Projects

Jim Penman
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Contents

- Introduction to mechanical reinforcement
- Ballast and sub-ballast reinforcement
- Heavy duty pavement structures
- Geogrid research
- Case studies
Mechanical Reinforcement
Mechanical Reinforcement

- Supplied in rolls; 9 ft, 13 ft, 15 ft wide
- Aggregate compacted on geogrid
- Minimum aggregate thickness 6 in.
Ballast and Sub-ballast Reinforcement
Ballast/Sub-ballast Reinforcement

Geogrid placed at bottom of sub-ballast – improved bearing capacity solution

Geogrid placed at bottom of ballast – maintenance reduction solution
Sub-ballast Reinforcement
Sub-ballast Reinforcement

Main objectives in reinforcing sub-ballast

- Increase factor of safety for existing section
- Maintain existing factor of safety and optimize roadbed thickness
Sub-ballast Reinforcement

Unreinforced: FoS = 1.5

Reinforced: FoS = 1.5

Reinforced: FoS = 3.0
Ballast Reinforcement
Ballast Reinforcement

Predominantly used to increase the period between maintenance events
Heavy Duty Pavement Structures
Subgrade Improvement

- Critical Mechanism – subgrade failure or deformation
- Principle benefits:
  - Cost savings (50%)
  - Faster construction
Base Reinforcement

- Critical Failure Mechanism – lateral movement of aggregate particles

- Principle benefits:
  - Initial cost savings – generally 10% to 20%
  - Extended design life – 3 to 6 times
Cost analysis data:
- Area - ¼ mile x ¼ mile
- Asphalt cost - $75/ton (installed)
- Aggregate cost - $15/ton (installed)
- Undercut cost - $5/CY
Port of Long Beach, CA

7” AC

17” Crushed Aggregate

Cost: $44.27/SY

6” AC

14” Crushed Aggregate

Cost: $41.88/SY

Total saving: $462,000
Keystone Avenue - Carmel, IN

13” AC

Cost: $51.18/SY

9” AC

8” Crushed Aggregate

Tensar TX170 Geogrid

Cost: $47.79/SY

Total saving: $655,000
Geogrid Research

Network Rail Facility
Derby, UK
R&D Work – 
Quantifying Performance Benefit

Network Rail Test Facility 
Derby, UK
R&D Work – Quantifying Performance Benefit

Deflection Influence Lines

- Test 1 – Soft subgrade and no geogrid
- Test 3 – Soft subgrade and geogrid 100 mm above bottom of sub-ballast

Network Rail Test Facility, Derby, UK
Geogrid Research

Composite Element Test (CET)
University of Nottingham
Nottingham, UK
R&D Work –
University of Nottingham

Composite Element Test (CET)
R&D Work – University of Nottingham

Number of cycles

Settlement (mm)

Control
Geogrid Section
R&D Work – University of Nottingham
R&D Work –
University of Nottingham
R&D Work —
University of Nottingham
R&D Work –
University of Nottingham
R&D Work – University of Nottingham

No. passes:
Unreinforced = 300,000
Reinforced = 750,000
2.5 fold increase

No. passes:
Unreinforced = 350,000
Reinforced = 1,000,000
Almost 3 fold increase

Control
SSLA30
7.5 mm settlement

Settlement (mm)

Number of cycles

0 200,000 400,000 600,000 800,000 1,000,000
R&D Work – University of Nottingham

- After 1 million cycles the geogrid was exhumed
- QC strength measured
- No significant damage due to loading
Geogrid Research

Network Rail Study
Coppul Moor, UK
R&D Work – Network Rail: Coppull Moor, UK

- Reconstruction on UK main line
- Investigation of deformation before and after installation of reinforcement
R&D Work – Network Rail: Coppull Moor, UK

Increase in ballast life: 
= 0.9 / 0.25 = 3.6

Geogrid installed

Ch 10 miles 220 yds to 440 yds

Year


Year

0 1 2 3 4 5 6 7 8 9 10

SD over 35m (mm)

Deformation
0.9 mm/yr
0.25 mm/yr

Ch 10 miles 220 yds to 440 yds

Geogrid installed

Increase in ballast life: 
= 0.9 / 0.25 = 3.6
R&D Work – Network Rail: Coppull Moor, UK

Year


SD over 35m (mm)

0

1

2

3

4

5

6

7

8

9

10

Deformation

1.43 mm/yr

0.4 mm/yr

Ch 10 miles 440 yds to 660 yds

Increase in ballast life:

= 1.43/0.4 = 3.6

Geogrid installed
Ballast Life Extension Cost Analysis
Cost Analysis

Approximate costs for:
- Track surfacing: $18,000/mile
- Geogrid cost: $27,000/mile (installed)

Need to extend existing ballasting period by factor of 1.5 for economy

Results from research studies:
- Queens University study: Factor = 4.8
- Nottingham University study: Factor = 3.0
- Coppull Moor in service study: Factor = 3.6
Pavement Structures R&D
Full Scale Test Facility
Test Results

![Diagram showing test results for different sections and AC types.](image-url)
Case Study

Utah Transit Authority
Frontrunner Passenger Rail Project
UTA Frontrunner Rail Project

- Design/build contractor interested in faster, cheaper construction
- Soft to medium subgrade
- Importing good quality stone expensive
UTA Frontrunner Rail Project

- Geogrid used to reduce sub-ballast thickness from 12” to 8”
- Filter fabric placed beneath the geogrid for additional separation
Case Study

Dallas Area Rapid Transport (DART)
NW1 Rail Line, Dallas, TX
DART Project, Dallas, TX

- Geogrid/geotextile solution opted for in lieu of lime stabilization
- Principle benefit – expedited construction
- Many utility access points along the right-of-way
Case Study

Kansas City Southern (KCS) Project
Victoria to Roseburg, TX
KCS Project Victoria – Rosenberg, TX

- Reconstruct 91 mile section of disused track
- Aggregate sourced from Mexico and AR
- Sub-ballast thickness reduced from 12 in. to 6 in.
Case Studies

Heavy Duty Pavement Structures
Port of Los Angeles, CA

- Pier 300 container yard
- 75 acre development
- Dredged material
- Geogrid used in lieu of lime
  - Less construction time
  - Saved $500,000
Port of Corpus Christi, TX

- Cargo Dock 8
- Very soft soil discovered during construction
- Geogrid solution
  - No undercut required
  - Used local oyster shell + sand fill (no import of fill)
Port Projects in Florida

Port of Fernadina, Nassau Terminal
*Reduce aggregate thickness below pavers*

Port Everglades, Southport Terminal
*Guard against differential settlement of AC*

Port of Tampa, Berth 208
*Reduce differential settlement beneath pavers*
Closure
Summary

On mainline rail projects, geogrids can be used to:
- Reduce roadbed thickness (6 to 8 inches)
- Reduce ballast settlement rate (3 to 5 times)

For intermodal projects, geogrids can:
- Reduce subgrade improvement layer (50%)
- Reduce required thickness of AC and ABC

Technology is proven and reliable
Questions?