Geocells Development on the UK Railways

Dr. Mohamed Wehbi
BSc MSc PhD, CEng, MPWI
Senior Design Engineer
Network Rail Design Delivery

EurIng Levente Nogy
BSc, MSc, CEng, MICE, FPWI
Senior Design Engineer
Network Rail Design Delivery
Outline

- Background
- Research aim
- Laboratory testing
- Numerical modelling & case study
- Installation guidance
- Future / moving forward
- Conclusion
Background

• Developed by the US Army Engineers Corps
• Just like a Geogrid, but extruded in the vertical direction!
• Can reduce trackbed depth of construction by up to 40 – 50%
• Low material cost typically (£6 per sq m)
• Typical overall trackbed cost reduction is ~20%
Background

- Geocells reinforcing mechanism:
  - Vertical confinement
  - Lateral confinement
  - Tension membrane effect

![Diagram of geocells reinforcing mechanism](image)
Aim

• In the UK, the use of Geocells is still limited to a number of bespoke sites, due to:
  – Absence of universally agreed design approach (Designers reluctance)
  – Limited installation experience (Contractors reluctance)

• Therefore the aim, is to develop a comprehensive guide that provides design recommendations and best practices for Geocells installation.

• A collaboration is Required!
Lab testing

- TU Clausthal University was commissioned to carry a number of lab testing to quantify the reinforcing properties of Geocells.
Lab testing

- Effect on Subgrade stress at 250kPa applied stress
Lab testing

150mm sub-ballast

subgrade modulus $E_I = 4 - 5 \text{ MN/m}^2$

- unreinforced sand, $h = 15 \text{ cm}$
- Geoweb, $h = 15 \text{ cm}$

200mm sub-ballast

subgrade modulus $E_I = 4 - 5 \text{ MN/m}^2$

- unreinforced sand, $h = 20 \text{ cm}$
- Geoweb, $h = 20 \text{ cm}$

300mm sub-ballast

subgrade modulus $E_I = 4 - 5 \text{ MN/m}^2$

- unreinforced sand, $h = 30 \text{ cm}$
- Geoweb, $h = 30 \text{ cm}$
Modelling

- Using a 3D dynamic finite element model of a moving train on a track
Modelling

- Three designs
- One standard design and two alternatives with Geocells
- Clay soil with $E = 20$ MPa
- Line speed = 100 mph
- Traffic = 30EMGTP
- Analysis period = 10 years
- Assuming NO maintenance interventions
Modelling

- The model has inherent track irregularities / geometry
Modelling – results

<table>
<thead>
<tr>
<th>Design</th>
<th>Max settlement (mm)</th>
<th>Average settlement (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard 250mm fill (unreinforced)</td>
<td>15.9</td>
<td>12.6</td>
</tr>
<tr>
<td>250mm Geocells</td>
<td>12.6</td>
<td>10.0</td>
</tr>
<tr>
<td>150mm Geocells</td>
<td>15.5</td>
<td>12.4</td>
</tr>
</tbody>
</table>
Case study – Northern Programmes

(a) Conventional standard design

(b) Alternative Geocells design
Case study – Northern Programmes

Over 20% Reduction in cost

<table>
<thead>
<tr>
<th></th>
<th>After major renewal in 2002</th>
<th>After Geocells installation in 2017</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Top 35m</td>
<td>Top 70m</td>
</tr>
<tr>
<td>Track quality (SD)</td>
<td>2mm</td>
<td>3.2mm</td>
</tr>
<tr>
<td>Track deterioration (RD)</td>
<td>0.7mm/year</td>
<td>0.9mm/year</td>
</tr>
</tbody>
</table>
Installation Guidance

1. Prepare subgrade. Remove debris, rocks.
2. Compact subgrade.
3. Install geotextile (if required).
4. Partially expand GEOWEB® sections.
5. Connect GEOWEB® sections with XTRA® keys. Connect side to side (A) and end to end (B).
Installation Guidance (cont.)

(Courtesy of Presto)

6. Hold sections open. Use Options A, B, C or D.
   - A: T-Bars
   - B: ATRA® anchors
   - C: Wood Stakes
   - D: Infill Select Cells

7. Infill GEOWEB® cells.

8. Spread infill.

9. Compact infill.

E Steel Rods
Subgrade preparation
Extending the GC panels
Connecting the cells
Unloading the granular fill
Unloading the granular fill (cont.)

SINGLE LINE WORKING

DOUBLE LINE WORKING

MULTIPLE LINE WORKING
Unloading the granular fill (cont.)
Levelling and Compaction
Levelling and Compaction (cont.)
Connecting panels installed in different shifts

Approx. 1-2m

1m
Moving forward
Conclusion

• The use of Geocells offers a great opportunity to design and build more sustainable railway tracks.

• Understanding the mechanism of Geocells reinforcement is key to develop optimum designs.

• The use of Geocells in trackbed design should be always accompanied by cost-benefit analysis.

• If best practices are followed, the installation of Geocells can be very efficient.