CASE STUDIES IN RAILWAY CONSTRUCTION

GEOGRID-REINFORCED GRANULAR MATERIALS

LABORATORY TESTS
NEWER MEASUREMENTS

SZÉCHENYI ISTVÁN UNIVERSITY
Dr. Szabolcs FISCHER assistant professor
• Overview of the presentation
  – Laboratory tests with multi-level shear box
  – Measurement results
  – Evaluation of the results
  – Conclusions
  – References
• Laboratory tests with multi-level shear box – investigated materials
  – **31.5/63 E** type railway ballast material (Colas Északkő Ltd., Szob):
    • without geosynthetic,
    • **GG1**: Biaxial geogrids which is produced from stiff, preloaded, extruded PP strips, in both direction with the same strength, average aperture size: ~44×40 mm,
    • **GC1**: GG1 geogrid with 160 g/m² mass PP nonwoven geotextile,
    • **GR2**: Biaxial woven geogrid which is produced from high tenacity PET yarns with PVC coating, with small aperture size (~35×35 mm),
    • **GC2**: GR2 geogrid with nonwoven geotextile,
    • **GG3**: Biaxial extruded geogrid manufactured by stretching the punched sheet of PP in two orthogonal direction, with an average aperture size (~39×39 mm),
  – **FZKA 0/56** type granular road protection layer (Colas Északkő Ltd., Szob):
    • Without geosynthetic.
    • **GG1**,
    • **GC1**,
    • **GC2**,
    • **GG3**.
## GEOGRID-REINFORCED GRANULAR MATERIALS – LABORATORY TESTS, NEWER MEASUREMENTS

<table>
<thead>
<tr>
<th></th>
<th>GG1 and GC1</th>
<th>GG2</th>
<th>GC2</th>
<th>GG3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw material</td>
<td>PP</td>
<td>PET+PVC</td>
<td>PET</td>
<td>PP</td>
</tr>
<tr>
<td>Production method</td>
<td>Welded</td>
<td>Woven</td>
<td>Woven</td>
<td>Extruded</td>
</tr>
<tr>
<td>Tensile strength at 1.0% elongation</td>
<td>7 kN/m</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>Tensile strength at 2.0% elongation</td>
<td>12 kN/m</td>
<td>7,5 / 8 kN/m</td>
<td>7,5 / 8 kN/m</td>
<td>10,5 kN/m</td>
</tr>
<tr>
<td>Aperture size</td>
<td>44×40 mm</td>
<td>35×35 mm</td>
<td>35×35 mm</td>
<td>39×39 mm</td>
</tr>
</tbody>
</table>
GEOGRID-REINFORCED GRANULAR MATERIALS – LABORATORY TESTS, NEWER MEASUREMENTS

31.5/63 E type railway ballast

Lower border line
Upper border line

Undersize in mass (%) vs. Size of mesh (mm)

MSZ EN 13450:2003
FZKA 0/56

Construction steps 1.

Note: Photos were not taken during this measurements.
Construction steps 2.

Note: Photos were not taken during this measurements.
Compaction of the ballast layer

Compaction:
- at 20 cm and 40 cm depth.

Platform vibrator:
- type: L-2/C,
- mass: 68 kg,
- power output: 1.1 kW,
- nominal vibrating frequency: 3000/min,
- platform: 500x500 mm.

Note: Photo was not taken during this measurements.

It was important to ensure identical vibrating work in each trials.
Pushing force

Counter force

Displacement

Note: Photo was not taken during this measurements.
Displacement of the particles on the upper level

Note: Photo was not taken during this measurements.
Displacement of the particles on the upper level

On side of the counter force

On side of the pushing force

Particles’ jam

Particles’ lack

Note: Photo was not taken during this measurements.
• Measurement results
Determination of qualifying parameters – the „inner shear resistance”

1. Deriving from the horizontal size of the shear box, the investigated zone is between the 10...20 mm values according to 1.0 m base. Widening this interval the 5...40 mm zone is chosen for the analysis. Tangent of the linear regression function = inner shear resistance

2. Tangent ratio.
Tangent of the linear regression function related to the measured data between 5…40 mm frame displacement in case of 31.5/63 E type railway ballast material – without geosynthetic reinforcement and with different geosynthetic types.

![Graph showing tangent values for different geosynthetic materials.](image-url)
Tangent ratio related to shearing graphs’ linear regression functions in the geosynthetic plane in case of 31.5/63 E type railway ballast material – without geosynthetic reinforcement and with different geosynthetic types.
Tangent of the linear regression function related to the measured data between 5…40 mm frame displacement in case of FZKA 0/56 granular protection layer – without geosynthetic reinforcement and with different geosynthetic types.
Tangent ratio related to shearing graphs’ linear regression functions in the geosynthetic plane in case of FZKA 0/56 granular protection layer – without geosynthetic reinforcement and with different geosynthetic types
• Evaluation of the results 1.
  – In this presentation polynomial regression functions aren’t determined, measured data (points) are linked by continuously polylines, they picture the functional connection.
  – According to the laboratory test results it can unequivocally be stated that multi-level shear box is adequate for determining inner shear resistance (defined points of the function) of granular aggregates, e.g. crushed stone railway ballast (31.5/63 E) and granular protection layers (FZKA 0/56).
Evaluation of the results

– From the +0.20 m height the effect of geosynthetic can be neglected.

– It can be stated according to these measurement that the optimal geogrid aperture size in case of railway ballast (1.4×dmax=≈88mm), in case of FZKA 0/56 (3.5×d50=≈35…55 mm) (according to Brown, et al, and Koerner) confirm the uneffectiveness of GG2 and GC2 geosynthetics (35×35 mm aperture size), and GC1 (44×40 aperture size combined with geotextile) in 31.5/63 E type railway ballast, but the welded and extruded geogrids (GG1 and GC3) can provide positive effect. In case of FZKA 0/56 granular protection layer all the four investigated geosynthetics ensured reinforcement – in case of geosynthetics without geotextiles were applied the effect was almost the same –, the maximum reinforcement can be observed with woven geogrid (GG2).
• Conclusions
  – Summarisely it can be stated according to the test results that in case of geosynthetic reinforcement their performance (effectiveness) aren’t determined by the manufacturing technology or junction form, but the following significant parameters have to be considered regarding to the built-in conditions:
    • adequate aperture size (mesh),
    • required tensile strength in the zone related to 1-2 % (or 0.5…4%) deformation interval.
• References


TENSAR INTERNATIONAL LTD.: Railways. Mechanical Stabilisation Track Ballast and Sub-ballast, marketing issue, 2013, Blackburn, 11 p. (www.tensar.co.uk/downloads)

Fischer Szabolcs: A vasúti zúzottkő ágyazat alá beépített georácsok vágánygeometriát stabilizáló hatásának vizsgálata, PhD értekezés, SZE MMTDI, 2012, DOI: 10.15477/SZE.MMTDI.2012.005


Fischer Szabolcs: Út- és vasútépítési szemcsés rétegek erősítése geoműanyagokkal, XVII. Közlekedésfejlesztési és beruházási konferencia, Bükkfürdő, Magyarország, 2016.04.20-2016.04.22., Szombathely, KTE, 2016, pp. 36-38


Koerner R. M.:, Designing with Geosynthetics, Xlibris Press, USA, 2012