“LIGHTWEIGHT GEOSYNTHETIC FILL FOR EMBANKMENTS AND BRIDGE ABUTMENTS”

Dave Woods - Principal Engineer - Jablite Civils
Outline

• Overview of Geosynthetics
• Introduction to Geofoam
• Geofoam Properties
• Geofoam Applications
• Irlam Bridge #193
• Cow Lane Reading
• Conclusion
Definition: Geo-Synthetics

- Geo: from Greek *geo*, meaning "earth"

- Synthetics: from Greek *synthetikos* – etymology: "skilled in putting together" – commonly accepted definition: man-made, artificial products

- Geosynthetics: “(artificial) products/components that are skilfully added to earth”

- Typically we think of textiles, grids, mats, membranes, composites and strips manufactured from a range of polymers
Functions of Geosynthetics

- Separation / Filtration
- Reinforcement
- Drainage
- Mechanical Stabilisation
- Barrier
- Others

Source: International Geosynthetics Society (IGS) & Loughborough University
The missing function: Load Reduction

Extremely lightweight synthetic fills with a high compressive strength can be used in embankment fill over poor ground to reduce the risk of settlement or as fill behind retaining structures and bridge abutments to prevent lateral thrust and reduce the loading behind structures.
What are lightweight fills?

- Pulverised Fuel Ash (PFA) – byproduct of fuel industry (75% of the density of site won fills or aggregates)
- LECA - Light Expanded Clay Aggregate (400-800kg/m$^3$)
- LYTAG – sintered PFA aggregate (400-800kg/m$^3$)
- GLALPOR – foamed glass aggregate (130-150kg/m$^3$)
Expanded Polystyrene / Geofoam

- When we think of expanded polystyrene we generally think of the beans in a bean bag, packing chips for fragile goods and Styrofoam cups and food packaging.

- It is also the first plastic we think of when we mention the problems of pollution.
Expanded Polystyrene / Geofoam

- In engineering terms we prefer to use the term Geofoam
- Compressive strengths up to 500kPa
- Density from 15-55kg/m³
Environmental Sustainability

• EPS has a rating of A and A+ in the BRE Green Guide for reducing CO2 and SO2 emissions by reducing the needs for heating and cooling as an insulation material
  • Inert, Non Toxic, Non Biodegradable

• 100% recyclable in spite of UK labels to the contrary

• Manufactured using steam, no chemicals, no CFCs

• In Civil Engineering EPS can eliminate removal and disposal of unsuitable soils, or importation of granular fill reducing vehicle movements by up to 90%. 
THIRD PARTY PRODUCT – LIGHTWEIGHT GEOSYNTHETIC FILL FOR EMBANKMENTS AND BRIDGE ABUTMENTS
EPS Material Properties

Stress Strain Curves for Jablite EPS to 10% Strain

Compressive Strength (kN/m²) vs. Compression (%)
## EPS Material Properties

<table>
<thead>
<tr>
<th>GEOFOAM GRADE</th>
<th>20</th>
<th>45</th>
<th>70</th>
<th>90</th>
<th>100</th>
<th>120</th>
<th>140</th>
<th>170</th>
<th>190</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal Density (kg/m³)</td>
<td>15</td>
<td>20</td>
<td>25</td>
<td>31</td>
<td>34</td>
<td>38</td>
<td>43</td>
<td>48</td>
<td>55</td>
</tr>
<tr>
<td>Compressive Strength at 1% nominal compression (kN/m²)</td>
<td>21</td>
<td>45</td>
<td>70</td>
<td>90</td>
<td>100</td>
<td>120</td>
<td>140</td>
<td>170</td>
<td>190</td>
</tr>
<tr>
<td>Compressive Strength at 10% nominal compression (kN/m²)</td>
<td>70</td>
<td>100</td>
<td>150</td>
<td>200</td>
<td>250</td>
<td>300</td>
<td>350</td>
<td>400</td>
<td>500</td>
</tr>
<tr>
<td>Shear Strength (kN/m²)</td>
<td>55</td>
<td>75</td>
<td>100</td>
<td>125</td>
<td>170</td>
<td>225</td>
<td>260</td>
<td>300</td>
<td>375</td>
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<tr>
<td>Shear Modulus (kN/m²)</td>
<td>2100</td>
<td>2800</td>
<td>3400</td>
<td>4100</td>
<td>4800</td>
<td>5400</td>
<td>6100</td>
<td>6800</td>
<td>7400</td>
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<tr>
<td>Youngs Modulus (kN/m²)</td>
<td>2100</td>
<td>4500</td>
<td>7000</td>
<td>9500</td>
<td>-</td>
<td>-</td>
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</tr>
<tr>
<td>Bending Strength (kN/m²)</td>
<td>115</td>
<td>150</td>
<td>200</td>
<td>250</td>
<td>350</td>
<td>450</td>
<td>525</td>
<td>600</td>
<td>750</td>
</tr>
</tbody>
</table>

Poisson’s Ratio 0.12 – 0.17

Equivalent per 1m³
- Concrete 2340 Kg
- Granular Fill (Type 1) 2100 Kg
- Soil 1800 Kg
EPS Embankment Design

Wheel Load
100kN over 0.09m² (1080 kPa)

Wearing course over 450mm Granular Fill
Load Spread at 2:1 (0.56m²)
Self Weight = 9 kPa

Load at the top of EPS is 186 kPa
Grade 500 EPS (190 kPa @ 1% Strain)
1000mm x 1000m x 1000mm Block
Load spread at 2:1
Depth of 2m Self Weight = 1 kPa

Load at the base of the EPS is 48 kPa

Soft Silts and Clays have a bearing capacity of approximately 50 kPa
Civil Engineering Applications

➢ Roads and road widening
  ➢ Rail Embankments
  ➢ Bridge Abutments
  ➢ Retaining Walls
  ➢ Structure Infill
➢ Culvert and Pipe Protection
➢ Ground Heave Protection
➢ Temporary Works and Access
  ➢ Void Formers
  ➢ Landscaping
  ➢ Landslip Repairs
➢ Others including Floor Raising and Pontoons
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Irlam Bridge #193 Replacement

merit award 1999

for an outstanding example of civil engineering work completed in 1998 (constructed in the north west area)

under bridge no 193 infilling and removal

client: railtrack plc
supervisor: n w ashurst consultants ltd
designer: mott macdonald ltd
contractor: birse construction ltd
supplier of efp: venvet resin

the institution of civil engineers
north western local association

igss / ice nwgg 27th march 2019 – lightweight geosynthetic fill for embankments and bridge abutments
Irlam Bridge #193 Replacement

- Original 1892 bridge on the Manchester to Liverpool line over the former alignment of the river Irwell which was diverted into the Manchester Ship Canal in 1900.
- The bridge had reached the end of its service life and train speeds had been downgraded to 25mph so replacement was needed.
- The old river bed was infilled with up to 8m of very soft clays and silts and was contaminated with arsenic, hydrocarbons and methane so removal was too difficult.
- Headroom restrictions made piling impossible.
Irlam Bridge #193 Replacement

- Solution to place 4m of preload to consolidate the soft soils prior to placement of capping, gas blanket and geogrid reinforced mattress
- A 10m EPS embankment with 1:1 earth sides was then built up to soffit level of the bridge prior to possession
Irlam Bridge #193 Replacement

- Under a short possession the deck was removed in 6 pieces, piers trimmed and embankment completed to trackbed level
- RC trough placed and ballast and track relaid prior to reopening

1. Remove bridge deck
2. Trim pier
3. Final EPS and granular fill layers
4. Place r.c. trough
5. Ballast and track
Irlam Bridge #193 Replacement

• 20 years on and the only sign of where the embankment is is the slightly less mature vegetation on the south facing embankment slope
Cow Lane Reading

- Very low brick arch bridge on busy commuter route with a history of congestion problems needed replacement.
Cow Lane Reading

- Simple integral concrete bridge solution proposed but construction was restricted to a 1 week line closure over Christmas in 2011.
Cow Lane Reading
In conclusion

+ EPS is a lightweight material with a high strength to weight ratio, reduces dead loads by more than 90%

+ Light weight means 1 EPS delivery can replace 10 standard fill deliveries reducing road traffic and all associated problems

+ Can be used as a replacement for traditional materials in embankments, roads and structures

+ Dimensional stability removes the risk of ratcheting under thermal expansion and contraction of integral bridge structures

+ Can be cut to shape to fit any project requirements and is light enough to be placed without plant

+ Does not require compaction or compliance testing significantly decreasing construction time and enabling construction in all weathers

+ Sustainable for full life cycle of the project and recyclable even after use

- Often considered only when all other solutions are proved to be unworkable
Thankyou

Any Questions?

Next IGS UK Event:
30th April 2019 Leeds with Yorkshie Geotechnical Group
Sealing Systems for Containment – Chris Quirk