FOAMED GLASS AGGREGATE

Ultra Lightweight Fill

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October 16th, 2018
Atlantic City, NJ
FOAMED GLASS AGGREGATE

• Introduction
• History
• Manufacturing
• Material Properties
• Installation
• Applications
• Brief Case Studies
Introduction

LIGHTWEIGHT FILL ALTERNATIVES

• Geofoam (1-2 pcf)
• Foamed Glass Aggregate (8-25 pcf)
• Foamed Concrete (20-45 pcf)
• Expanded Shale or Clay (45-65 pcf)
History

• Developed in Germany – early 1980s
• Technology taken to Norway – early 1990s
• Thermal barrier for roadways
• Led to Lightweight applications
• Growth through Scandinavia
  • Geotechnical Applications
    (Norway, Sweden, Finland)
• Germany & Switzerland
  • Thermal Insulation
  • Lightweight Concrete
Glass Recovery in the U.S.A.

Total Glass: 11.6 Mton/yr
Containers: 9.4 Mton/yr

... Only ~31%
Made from 100% Post-Consumer Glass

140 million GLASS BOTTLES RECYCLED/year starting in 2018
Manufacturing

10 acre site/ 97,000 sq.ft. building
The Process ...

- Recycled Glass...
  Any Color, Any Size
- Clean Glass Cullet
- Mill into Fine Powder
- Mix w/ Foaming Agent
- Process through Kiln & Conveyor
- Stockpile
The Process ...
Closed vs. Open Cell

Closed Cell
- Wet Process
- Dry Process ✓

Open Cell
### Material Properties - G15

<table>
<thead>
<tr>
<th>Property</th>
<th>Units</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particle Size</td>
<td>in</td>
<td>0.4 – 2.4</td>
</tr>
<tr>
<td>Loose Bulk Density (dry), max</td>
<td>pcf</td>
<td>15</td>
</tr>
<tr>
<td>Compacted Density (moist)</td>
<td>pcf</td>
<td>15-23</td>
</tr>
<tr>
<td>Thermal Conductivity</td>
<td>W/mK</td>
<td>0.11 dry/ 0.15 wet</td>
</tr>
<tr>
<td>Peak Friction Angle</td>
<td>degrees</td>
<td>55</td>
</tr>
</tbody>
</table>

**Compacted Unit Weight Comparison**

- Soil: 120 pcf
- Washed Stone: 100 pcf
- Expanded Shale: 60 pcf
- FGA: 20 pcf
Daily Quality Control

Determine Dry Bulk Density

< 15 pcf (avg ~13.5)

Determine Compressive Strength

@ 20%
> 15,000 psf

Modified version of the European Standard EN 1097-11, "Tests for mechanical and physical properties of aggregates, Part 11: Determination of compressibility and confined compressive strength of lightweight aggregates".
Gradation

Graph showing the % passing vs. Particle size (mm) for samples prior to and post compression testing. The graph indicates that the samples have a smaller % passing at larger particle sizes pre and post compression.

Legend:
- Prior to Compression Testing (Dry Sieve)
- Post Compression Testing to 20% Deformation (Dry Sieve)
Moisture Content and Buoyancy

Moisture Content
- Adsorption of Water to Surface – Closed Cell
- Moist conditions - Typical 6% by volume (additional 3.75 pcf)
- Can be higher if submerged

Buoyancy
- Testing completed – Schnabel Engineering, West Chester
- Using -15 pcf as a typical buoyant unit weight, you would need about 1 foot of “typical” fill (120 pcf) to offset the uplift on 8 feet of submerged FGA (8:1 ratio.....120/15)

Also: Durability Tested
### Gradation Limits
- The backfill material for the embankment shall consist of the following grading:

<table>
<thead>
<tr>
<th>Grain Size (mm)</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse</td>
<td></td>
</tr>
<tr>
<td>2.00</td>
<td>100</td>
</tr>
<tr>
<td>4.00</td>
<td>95</td>
</tr>
<tr>
<td>8.00</td>
<td>65</td>
</tr>
<tr>
<td>16.00</td>
<td>35</td>
</tr>
<tr>
<td>32.00</td>
<td>15</td>
</tr>
<tr>
<td>63.00</td>
<td>5</td>
</tr>
<tr>
<td>90.00</td>
<td></td>
</tr>
</tbody>
</table>

### Direct Shear

### Plasticity

### Magnesium Sulfate Soundness

### Electrochemical Requirements
- **pH**
- **Resistivity**
- **Chlorides**
- **Sulfates**

### Notes on Use
- The material shall meet or exceed the requirements for backfill material as specified in the AASHTO LRFD Bridge Construction Specifications, 2017 Edition. All necessary tests and analyses shall be performed to ensure compliance.

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Pullout Testing of Geogrids and Straps for MSE

Images courtesy of SGI Lab, Atlanta, GA
Creep and Modulus

**Creep**
- 0.6% Strain from Day 1 to 50 years
- For normal Stress up to ~5,000 psf

**Elastic Modulus**
- 522-730 tsf (50-70 MPa)
- For normal Stress ~1,000-2,000 psf

**Resilient Modulus**
- 775-1,550 tsf (75-150 Mpa)
- AASHTO T 307
- Varies based on confining stress
Installation

- Maximum lift thicknesses of 24 inches (0.6 m)
- Compaction is performed with a tracked excavator or dozer 600 - 1,000 psf (30 - 50 kPa)
- 2 to 4 passes over the UL-FGA layer
Installation

- Easily graded
- Side Slopes @45°
- Geotextile Separator (6 oz/sq yd)

Images showing construction equipment and installation process.
Shipping

• 100 CY Walking Trailer
  • (1) Load UL-FGA  --VS--
  • (3) Loads other ‘LW’ Agg
  • (7.5) Loads Washed Stone
• Simplify Logistics in the Field
• Improve Efficiency in the Field
• AND Reduce Carbon Emissions

• Also, Delivers in Super Sacks
  • (3 CY) UL FGA = 1,200 Lbs  --VS--
  • (3 CY) Stone  = 8,500 Lbs
Applications ...

- Embankment over Soft Soils
- Bridge Approaches
- Cover over Tunnels, Culverts, Aging Utilities
- Retaining Walls, Building Foundations, MSE Walls

Green Roofs, Under Foundation Slabs, Pipe Insulation, ...
Applications ...

ROCKFALL PROTECTION

Images courtesy of Geobrugg AG ROCKFALL-X™ G

Gravel ballast
Horizontal layer of TECCO® mesh
ROCKFALL-X™ G damping system

Casutt Wyrsch Zwicky AG
www.cwz.ch
Applications ...

EMAS

Images courtesy of Runway Safe
Soil Balancing

Existing

Proposed

10’ Fill

No Net Surcharge!!

20 pcf
Foamed Glass Aggregate

Utility or other sensitive structure

120pcf

Utility or other sensitive structure

120pcf

Utility or other sensitive structure

2’Cut
Reduced Carbon Footprint

- 50% Less CO2 than Other Lightweight Materials
- 50% Less Energy Consumed than Other Lightweight Options

http://www.epd-norge.no/?lang=en_GB

An EPD® (Environmental Product Declaration) is an independently verified and registered document that communicates transparent and comparable information about the life-cycle environmental impact of products. Both the underlying LCA (Life-Cycle Assessment) and the EPD are always based upon international standards.

Regional Greenhouse Gas Initiative
an initiative of the Northeast and Mid-Atlantic States of the U.S.

PARIS CLIMATE CHANGE ACCORD
Case Studies

• Pennsylvania
  • Langley Avenue Navy Yard Access, Philadelphia
  • I-95 South, Philadelphia
  • JFK Blvd, Philadelphia

• New Jersey
  • RCA Pier, Camden
  • Wittppenn Bridge (Route 7), Kearny
Langley Avenue, Philadelphia
Langley Avenue, Philadelphia

Ultra Lightweight Foamed Glass Aggregate Use Area
Langley Avenue, Philadelphia
Langley Avenue, Philadelphia
I-95 South, Philadelphia
JFK Blvd, Philadelphia
RCA Pier, Camden
Wittpenn Bridge, Kearny

RT 7 Hackensack River Wittpenn Bridge Contract 4

Ground Improvements: Lightweight Aggregate (LWA)

- 38,500 cy LWA
- Use Geotextile at base of LWA
- Over-excavation required prior to placing LWA
- Dewatering required during earthwork

RT 7 Hackensack River Wittpenn Bridge Contract 4

Ground Improvements: Geofoam

- Over 26,500 cy Geofoam
- Wrapped in Geomembrane
- Covered with 4” concrete slab
- Staged Construction Required along FHR Sta 130 to 133+50 to maintain traffic
Wittpenn Bridge, Kearny
Foamed Glass Aggregate

- Ultra Lightweight Engineered Material
- High Strength to Density Ratio
- High Friction Angle, MSE Wall Tested
- Durable
- Chemically, UV, Volume Stable
- Efficient Installation, Not Weather Sensitive
- Sustainable and Environmentally Responsible
QUESTIONS?

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