FOAMED GLASS AGGREGATE:
A “New” and Unique Lightweight Fill

Mid-Atlantic QAW
February 14, 2018
Outline

• Introduction
• History of Development
• Material Properties
• Applications and Installation
• Research and Testing
• Case Studies
History
US EPA - Insulation
1977
History of Foamed Glass Aggregates - Europe

• Developed in Germany in early 1980s
• Technology taken to Norway in 1990s
• Thermal barrier for roadways
• Led to lightweight applications
• Growth throughout Scandinavia
  • Geotechnical Applications
• Germany and Switzerland
  • Thermal insulation
  • Additive for lightweight concrete
Glass Containers: 9.38 M tons/year  
Recovery ~34%  

Total Glass: 11.57 M tons/year  
Recovery ~28%  

US EPA
Glass Processing
MRF-Cleaning-Milling

- Cleaning of glass cullet
- Uses all colors and any size
- Milled into powder
- Mixed with foaming agent
Process transforms the cullet into a new material
1500 Chester Pike, Eddystone, PA

Baldwin Locomotive Plant

10 acre site

97,000 sq.ft. building
### UL-FGA
ULTRA-LIGHTWEIGHT FOAMED GLASS AGGREGATES

<table>
<thead>
<tr>
<th>Property</th>
<th>Units</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particle Size</td>
<td>mm (in)</td>
<td>10 – 60 (0.4 – 2.4)</td>
</tr>
<tr>
<td>Loose Bulk Density (dry), max</td>
<td>kg/m³ (pcf)</td>
<td>240 (15)</td>
</tr>
<tr>
<td>Compacted Density (dry)</td>
<td>kg/m³ (pcf)</td>
<td>265-310 (16.5-19.5)</td>
</tr>
<tr>
<td>Thermal Conductivity</td>
<td>W/mK</td>
<td>0.11 dry</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.15 wet</td>
</tr>
<tr>
<td>Peak Friction Angle</td>
<td>degrees</td>
<td>55.7</td>
</tr>
</tbody>
</table>

#### Compacted Unit Weight Comparison

- **SOIL**: 120pcf
- **WASHED STONE**: 100pcf
- **EXPANDED SHALE**: 60pcf
- **FGA**: 20pcf
Applications

• Many uses for lightweight aggregates
  • Embankment fill over soft soils
  • Retaining walls
  • Bridge abutments
  • Reduced lateral load of backfill
  • Lightweight fill over culverts and utilities
  • Under foundation slab insulation and drainage
  • Insulation layer
    • Horizontal or vertical
  • Greenroofs
Transportation

Highway Embankments and Landslide Repairs

Norwegian Public Road Authority
Transportation
Highway Embankments and Landslide Repairs

Hasapor Sweden
Approach Fill for Bridge Abutments

- Reduces lateral earth pressure
- Reduces settlement at interface
Lightweight Backfill for Retaining Walls

Glasopor, Norway
Lightweight Backfill against Foundations

Uusioaines Oy, Finland
Cut and Cover Tunnels
Insulation for Permafrost

Drainage and Capillary Break

Norwegian Public Road Authority
Insulation and Lightweight Backfill - Utilities
Sound Walls

- Absorbs noise
- Lightweight – reduced foundation
- Porous
- UV Stable
Rockfall Protection

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

Geobrugg AG ROCKFALL-X™ G
Green Roofs
Under Slab

- Insulation
- Bearing capacity
- Drainage
- Capillary Break
Under Foundations
Meets European Energy Efficiency Requirements
Lightweight Additive for Concrete

Misapor
Installation and Compaction

- 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 and Compaction

Easily graded

Plate Compactor Lifts 12” Max.
Side Slopes @ 45°

- Geotextile Separator (Recommended 6 oz./SY minimum)
- Cover soil
Shipping

- Up to 100 CY/trailer
- Reduced carbon footprint
  - 1 trailer of Foamed Glass
  - 7 tri-axial loads of stone

Delivery in Super Sacks
3CY  1,200 lbs. vs. 8,000 lbs.
Research and Testing
Quality Control Program

- Modified versions 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”.
  - Density (Dry, bulk density < 15 pcf)
  - Compression (Stress @ 20% Deformation > 15,000 psf)

Determination of dry bulk density
Compressive Strength Testing
GSD Pre- and Post-Compression Testing

Source: AeroAggregates
DREXEL UNIVERSITY - CIVIL, ARCHITECTURAL AND ENVIRONMENTAL ENGINEERING
DIRECT SHEAR TESTING (ASTM D 3080 MODIFIED)

Test Series No. 1: Lightweight aggregate (LWA-1G) lightly compacted under dry conditions

![Graph showing shear stress vs. displacement]

<table>
<thead>
<tr>
<th>Test No.</th>
<th>Shear Box Size (in x in)</th>
<th>Normal Stress (psf)</th>
<th>Shear Rate (in/min)</th>
<th>Soaking</th>
<th>Consolidation Step 1 (psf)</th>
<th>Consolidation Step 2 (psf)</th>
<th>Consolidation Step 3 (psf)</th>
<th>Soil Compaction (g/t)</th>
<th>Shear Strength (psi)</th>
<th>Failure Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A</td>
<td>12 x 12</td>
<td>500</td>
<td>0.04</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>15.5</td>
<td>444</td>
<td>(1)</td>
</tr>
<tr>
<td>1B</td>
<td>12 x 12</td>
<td>750</td>
<td>0.04</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1255</td>
<td>1116</td>
<td>(1)</td>
</tr>
<tr>
<td>1C</td>
<td>12 x 12</td>
<td>1200</td>
<td>0.04</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1784</td>
<td>1684</td>
<td>(1)</td>
</tr>
</tbody>
</table>

NOTES:
1. Shear failure was forced to occur internally through the soil specimen at the predetermined plane between the upper and lower shear box during each test.
2. The reported residual shear strengths of failure mode and cohesion were determined from a best-fit line drawn through the test data. Care should be exercised in using these strengths parameters for applications involving normal stresses outside the range of the stresses covered by the test series. The residual shear strength was calculated using the shear force measured at the end of the test.

DATE REPORTED: 4/28/2016
FIGURE NO: C-1
PROJECT NO: SGI13023
DOCUMENT NO: 
FILE NO:

- Evaluation of Interface Shear Strength
- Geogrid/FG interface shear strength

![Graph 1](image1)

![Graph 2](image2)
Moisture Content and Buoyancy

**Moisture Content**
- Adsorption of Water to Surface – for 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)
Retaining Walls

• T-Wall – The Neel Company
• RECO – FGA meets the backfill requirements for steel straps
• Pullout Testing completed for PET and HDPE Geogrids
• Pullout Testing completed on steel and Poly straps
European Case Studies
New Metro Line
From Jar to Kolsås

- Constructed over marsh area
- Owner wanted to reduce excavation
- From top-bottom:
  - Tracks
  - Ballast
  - Subbase
  - GT
  - FGA
  - GT
  - Subbase
  - GT
Halden Rail Yard

- Expansion of Rail yard
- 6 new tracks
- Very soft soil near river
- Required lightweight option to reduce surcharge
- 15,000 m³ used to build up area
New E18 Motorway - Retvet- Knapstad

- 61,000 m³ FGA is part of the new E18 Winton - Vinterbro.
- The six-kilometer long stretch to be built 20 meters wide
- Motorway with four lanes and central reserve.
- The stretch will have a speed limit of 100 km / h.
Norwegian Public Roads Administration
Sørenga Bridge Approach

- Reconstruction of Bridge approaches due to settlement
- Total of 4,000 m$^3$
Hämeenlinna, Highway E12
Hämeenlinna, Highway E12
Hämeenlinna, Highway E12
Current DOT status

- Approved by MD SHA
- Approved VDOT
- 2 Projects with PADOT
- 1st Project with NJDOT
- NYSDOT
- MassDOT
  - READi (Review, Evaluate, Accelerate, Deploy, innovation) Committee
- ConnDOT
- NHDOT
- PA Turnpike – Innovation Council in October 2017
PA DEP Press Release 11/27

“First North American Use”

“Its reuse right here in the city”

Secretary Patrick McDonnell

http://www.ahs.dep.pa.gov/NewsRoomPublic/articleviewer.aspx?id=21344&typeid=1
I-95 - CP2 - Ramp F -- PADOT

The Lightest Aggregate Available – The Benefit of being Ultra-Lightweight
Route 7 / Hackensack -- NJDOT

RT 7 Hackensack River Wittppenn Bridge Contract 4

- Ground Improvements: Lightweight Aggregate (LWA)

  - ~28,000cy LWA
  - Use Geotextile at base of LWA
  - Over-excavation required prior to placing LWA
  - Dewatering required during earthwork

- Ground Improvements: Geofoam

  - ~24,000cy Geofoam
  - Wrapped in Geomembrane
  - Covered with 4” concrete slab
  - Staged Construction Required along FHR Sta 130 to 133+50 to maintain traffic

  - First 450 CY Installed October 2017
Route 7 / Hackensack -- NJDOT

- Paved, Trafficked & Monitored, Shows No Movement
SEPTA – Media Line

EXISTING RETAINING WALL ELEVATION

1. EXISTING FENCE (TO BE REMOVED)
2. EXISTING CONCRETE SIDEWALK (TO BE REMOVED)
3. EXISTING GROUND

EXISTING SECTION

PROPOSED SECTION

1. EXISTING RETAINING WALL ELEVATION

6. PROTECTIVE FENCE
7. 1" MIN. GROUT LEVELING PAD
8. 1/2" PREMOLDED EXPANSION FILLER WITH JOINT SEALING MATERIAL BETWEEN WALL & SIDEWALK
9. 4" CONCRETE SIDEWALK
10. 6" SUBBASE
11. LIGHTWEIGHT FILL
12. GEOTEXTILE, CLASS 1
13. WRAP LIGHTWEIGHT FILL WITH GEOTEXTILE, CLASS 1
14. CONTINUOUS 2"x2" OF NO. 57 COARSE AGGREGATE ENCASED IN GEOTEXTILE, CLASS 1
15. 4" STRUCTURE FOUNDATION GRAN

EC951 DOWELS Ø 1/2" MAX SPACING (SEE NOTE 3)
EC951 DOWELS Ø 1/2" MAX SPACING (SEE NOTE 3)
CLEAN EXISTING CONCRETE AND COAT ALL MORTAR SURFACES WITH EPOXY BONDING AGENT

SCALE: 1/4" = 1'-0"

(EC952 BARS NOT SHOWN FOR CLARITY)
Engineered Material

Ultra Lightweight Material
High Strength to Density Ratio
High Friction Angle
Freeze-Thaw Tested
MSE Wall Tested
Chemically Inert, UV Stable, Volume Stability
Efficient Installation, Not Weather Sensitive
Thank You