Geofoam Applications for Transportation Infrastructure

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What is EPS Geofoam?

- Expanded Polystyrene
- Light-weight cellar plastic material
- Molded in blocks
- Used for construction, architectural and landscaping purposes
EPS Block Manufacturing

1. **Pre-Expansion**
   - Expandable Polystyrene Beads
   - Steam

2. **Drying**
   - Expanded Polystyrene Puff
   - Air

3. **Maturation**
   - (Optional)

4. **Molding**
   - Steam
   - Molded EPS Part
Density

EPS block density is controlled by the amount of styrene beads used to make the block. More beads produce higher density.

raw styrene beads  steam expanded (1st steam heating) called pre-puff

block molding (2nd steam heating)  block placement of geofoam block
Block Molding of EPS

Courtesy of Tri State Foam
Beginnings of Geofoam in Roadways

Flom Bridge – 1972 - Norway
## EPS Properties

### ASTM D6817 Physical Property Requirements of EPS Geofoam

<table>
<thead>
<tr>
<th>Type</th>
<th>EPS12</th>
<th>EPS15</th>
<th>EPS19</th>
<th>EPS22</th>
<th>EPS29</th>
<th>EPS39</th>
<th>EPS46</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density, min., kg/m³ (lb/ft³)</td>
<td>11.2 (0.70)</td>
<td>14.4 (0.90)</td>
<td>18.4 (1.15)</td>
<td>21.6 (1.35)</td>
<td>28.8 (1.80)</td>
<td>38.4 (2.40)</td>
<td>45.7 (2.85)</td>
</tr>
<tr>
<td>Compressive Resistance, min., kPa (psi) at 1 %</td>
<td>15 (2.2)</td>
<td>25 (3.6)</td>
<td>40 (5.8)</td>
<td>50 (7.3)</td>
<td>75 (10.9)</td>
<td>103 (15.0)</td>
<td>128 (18.6)</td>
</tr>
<tr>
<td>Compressive Resistance, min., kPa (psi) at 5 %</td>
<td>35 (5.1)</td>
<td>55 (8.0)</td>
<td>90 (13.1)</td>
<td>115 (16.7)</td>
<td>170 (24.7)</td>
<td>241 (35.0)</td>
<td>300 (43.5)</td>
</tr>
<tr>
<td>Compressive Resistance, min., kPa (psi) at 10 % A</td>
<td>40 (5.8)</td>
<td>70 (10.2)</td>
<td>110 (16.0)</td>
<td>135 (19.6)</td>
<td>200 (29.0)</td>
<td>276 (40.0)</td>
<td>345 (50.0)</td>
</tr>
<tr>
<td>Flexural Strength, min., kPa (psi)</td>
<td>69 (10.0)</td>
<td>172 (25.0)</td>
<td>207 (30.0)</td>
<td>240 (35.0)</td>
<td>345 (50.0)</td>
<td>414 (60.0)</td>
<td>517 (75.0)</td>
</tr>
<tr>
<td>Oxygen index, min., volume %</td>
<td>24.0</td>
<td>24.0</td>
<td>24.0</td>
<td>24.0</td>
<td>24.0</td>
<td>24.0</td>
<td>24.0</td>
</tr>
</tbody>
</table>

**Courtesy EPS Alliance**

**EPS 19 or 22 is most commonly used in roadway projects**
Common Geotechnical Uses of EPS Geofoam

• Reduce foundation soil settlement to protect bridges, buried utilities and adjacent structures on soft ground

• Improve stability and bearing capacity of embankments

• Improve stability landslides and cut slopes

• Rapid construction in time critical areas
Geotechnical Conditions
Settlement Record for Primary Consolidation
When Things Go Wrong

Settlement at S. University Ave.
Provo, Utah

Settlement of Approach Slab
2002 Host City of Winter Olympics – Salt Lake City

SALT LAKE 2002

TM © 1992 SLOC. 380 USC 380
Settlement Reduction and Buried Utilities

- Buried Pipeline
- NEW FILL
- Buried Pipeline
- Ruptured Pipeline
Settlement Reduction and Buried Utilities

Buried Utilities

Geofoam Embankment from State St. to 200 W. Interstate I-80, Salt Lake City, Utah
I-15 Reconstruction Project – Typical Geofoam Fill

I-15 Reconstruction Project
Salt Lake City, Utah
EPS Roadway Embankment

SR 519 Project – Seattle, Washington
Light Rail Embankments

UTA – Light Rail – Salt Lake City, Utah
Lokkeberg Bridge, Norway, Norwegian Public Roads Administration
Temporary Bypass Bridge
Slope Stabilization – 2nd Mesa, Arizona

- **EPS geofoam blocks**
- **Landscaping/soil**
- **Geomembrane/separation layer (if required)**
- **Sand-leveling course**
- **Drainpipe**
Common EPS Pipeline Protection Strategies

- **a)**: Pavement, EPS Blocks, Backfill, Pipe or Culvert
- **b)**: Pavement, EPS Block, Backfill, Pipe or Culvert
- **c)**: Pavement, EPS Blocks, Concrete Slab, Sand Infill, Slot Trench, Ductile Steel Pipe, Backfill
- **d)**: Pavement, Concrete Slab, Void, Pipe with Hanger, Backfill
Commuter Rail Embankment Construction

Front Runner – UTA – Corner Canyon – Draper Utah – Photos from ACH Foam
Wasatch Fault at Little Cottonwood Canyon

Little Cottonwood Canyon, Sandy, Utah
Slot Trench Cover System for Fault Crossing

Crossing of Wasatch Fault Zone in with High-Pressure Gas Line
Salt Lake City, Utah, Questar Gas Corp.
Design Considerations

- Type of Polystyrene
- Dimensions of Block
- Density of Blok
- Compressive Strength
- Allowable Load & Creep
- Interface Friction
- Stability of Internal Slope
- Concentrated Loads
- Degradation
- Durability

- **Bedding Material & Compaction**
  - Chemical Attack
  - Moisture Absorption
  - Buoyancy
  - Thermal Resistance
  - Ultra Violet Exposure
  - Differential Icing
  - Flammability
  - Insect Infestation

This presentation focuses on the items in red and the role geomembranes have in geofoam systems.
• Placement of non-woven geotextile fabric as separation layer between bedding sand and subgrade – Alabama DOT
• Note also use of alternating block placement for EPS internal stability (red arrows)
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Design Considerations
(Prevention of Chemical Attack)

• Solvents that Dissolve Geofoam
  • Gasoline
  • Diesel
  • Other Petroleum Based Fuels
  • Organic Fluids

• Protection Against Accidental Spills
  • Concrete Incapsulation
  • Geomembranes
  • Fascia Panel Walls (etc.)
Petroleum Contaminated Soil

- **Soil contaminated** with virgin *petroleum* products is a *hazardous waste* if it exhibits a characteristic of a *hazardous waste*, namely, ignitability, corrosivity, reactivity, and toxicity.

- Generally, contaminated soil is to be excavated in a timely manner and containerized.

- Temporary storage while tested.

- If found non-hazardous, then usually landfilled.

- Otherwise, treatment will be necessary.

- If EPS blocks or the their protective system(s) have been damaged by petroleum or other activities then it should be replaced at this time.
From: Silas.Nichols@dot.gov [mailto:Silas.Nichols@dot.gov]
Sent: Wednesday, March 25, 2009 5:39 PM
To: 40 Nico Sutmoller
Subject: RE: Geomembrane Question

Hi Nico,

There is no FHWA “position” on the topic of using geomembranes with load distribution slabs. I will say that I recommend that states go with one or the other.

--silas
Silas Nichols, P.E.
Senior Bridge Engineer - Geotechnical
Federal Highway Administration
Office of Bridge Technology
1200 New Jersey Avenue, SE
Primary Methods of Protection against Liquid Petroleum Hydrocarbons

Concrete Protection (Urban Construction)

Photos: Sutmoller

Geomembrane Protection (Rural Construction)
Geomembranes compatible with EPS:

• polypropylene
• polyethylene
• chlorosulphonated polyethylene (CSPE)
• ethylene interpolymer alloys (EIAs)

These materials offer various degrees of protection against petroleum intrusion. (See producer’s testing results.)
• Primary protection of EPS embankment from potential petroleum spill damage is the concrete pavement and its surface drainage system.
  • 14-inch concrete is relatively impermeable
  • Pavement sloped for drainage
  • Storm drain system for collection of fluids
  • Drain pipe incapsulated in low strength concrete (CLSM)
• Secondary protective layer that acts as a barrier for petroleum spill is the 6-in reinforced concrete load distribution slab
• Sides of vertical EPS fills were constructed with vertical faces covered with a concrete tilt-up panel wall to protect the EPS face from UV degradation, impact damage and potential petroleum spills
• For cases where EPS embankment is tied to existing earthen embankment (i.e., roadway widening), a geomembrane was required at the edge of the LDS to prevent any possible intrusion of petroleum at this interface. However, a capping geomembrane that covers the entire top of the EPS embankment is not required.

- Concrete Pavement (35 cm)
- Load Distribution Slab (15 cm - Reinforced)
- Geomembrane Petroleum Resistant (3 component) for exposed side slope only
Chemical Attack - Protective Barriers

- Tripolymer Geomembrane
  - Polyvinyl Chloride (PVC)
  - Ethylene Interpolymer Alloy
  - Polyurethane

- 9 mm thickness minimum (total)
Low strength concrete (CLSM) placed around storm-drain system and catch-basins within EPS embankment (I-15 Reconstruction Project, Salt Lake City, Utah).
This presentation focuses on the items in red and the role geomembranes have in geofoam systems.
Lightweight Terrain and Terracing

Geomembrane placed atop the geofoam

Geomembrane

Geomembrane placed underneath geofoam

Stormwater collection pipe (French drain) may be required for some cases depending on design storm.

Hydrocarbon resistance membrane is generally not required.
Summer 2006, engineers needed a lightweight void fill material to reduce the weight of the plaza on a below-grade parking structure. EPS Geofoam helped to reduce 3 million pounds of weight on the parking structure and provided a flat, level surface for the plaza’s landscaping. Below the landscaping, 12 feet of EPS Geofoam was used in the Moran Eye Center project.
Two to three layers of EPS 19 Geofoam was installed on the drainage matt. Above the Geofoam a fabric filter was applied to prevent soil from slipping between the cracks of the Geofoam blocks. Two feet of landscaped soil covers the Geofoam. EPS 29 Geofoam was installed under areas where an adjacent roadway passes the capital, which required a higher compressive strength material. Geofoam was also used to create elevation changes for landscaping.
Green Roof – Salt Lake Conference Center

Conference Center, Salt Lake City, Utah
Coefficients of friction between geofoam and geomembrane are low. This may cause internal sliding during large seismic events.
Geofoam Handbook

http://www.civil.utah.edu/~bartlett/Geofoam/

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The North American Chapter of the International Geosynthetics Society (IGS-NA)
www.igs-na.org
Geosynthetics for Coal Combustion Residual Applications

Tuesday, June 25, 2019 at Noon CDT
Free to Industry Professionals
1.0 PDH

Presenter: Jason D. Ross, PE (S&ME)
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