Foundry Sands in Embankments Fills & Bases

Foundries are crucial to transportation systems

- Foundries produce critical parts
  - Automotive
  - Construction
  - Aerospace
  - Rail
  - Defense
- DOD and DOE have industry partnerships

What is Foundry Sand?

- Engineered sand
- Byproduct of metal casting process
- Uniform grain size per source
- Most amended with bentonite
- High structural integrity

What is Foundry Sand?

- Sustainable & recycled material choice
- Local source of high quality fine aggregate
- Superior or comparable performance
- May provide cost savings
Foundry Sands in Embankments Fills & Bases

**Engineering Properties**

- **Physical properties of foundry sand and natural sand**
  
  - Foundry Sand, 45X Mag
  - Natural Ohio Fine Grained Sand, 45X Mag

**Two types, different “fits”**

- **“Green sands”**
  - Bentonite clay bonds
  - 80% of volume
  - Large scale external molds
  - Intensively studied
  - Best “fit” where clay is an advantage

- **“Resin sands”**
  - Chemical resin bonds
  - 20% of volume
  - Used for cores and some sand molds
  - Fewer fines
  - Best “fit” where fine aggregate is required

**Engineering Properties**

<table>
<thead>
<tr>
<th>Property</th>
<th>ASTM Standard</th>
<th>FG1</th>
<th>FG2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulk density</td>
<td>C29</td>
<td>60-70 pcf</td>
<td>80-90 pcf</td>
</tr>
<tr>
<td>Moisture content</td>
<td>D2216</td>
<td>3-5%</td>
<td>0.5-2%</td>
</tr>
<tr>
<td>Specific gravity</td>
<td>D854</td>
<td>2.5-2.7</td>
<td>2.6-2.8</td>
</tr>
<tr>
<td>Dry density</td>
<td>D698 Standard Proctor</td>
<td>110-115 pcf</td>
<td>100-110 pcf</td>
</tr>
<tr>
<td>Optimum moisture content</td>
<td>D69</td>
<td>8-12%</td>
<td>8-10%</td>
</tr>
<tr>
<td>Permeability coefficient</td>
<td>D2434</td>
<td>$10^{-3} - 10^{-1}$ cm/s</td>
<td>$10^{-5} - 10^{-9}$ cm/s</td>
</tr>
</tbody>
</table>

*Table 1. Typical physical properties of foundry sand*

**Constructability**

- Consultants in the geosciences, materials and the environment

John E. Dingeldein, P.E - 2014 FHWA Sustainable Materials Webinar - IndustrialResourcesCouncil.org
Foundry Sands in Embankments Fills & Bases

Conventional Equipment

Engineered Uses for Foundry Sand
- Embankment and structural fill
- Retaining wall backfill
- Roadway structural systems (Working Platform/Subbase)
- Blended granular bases
- Flowable fill
- Asphalt mix
- Concrete mix
- Manufactured soils/bioswales

Structural Fills & Embankments

Ohio Turnpike Project 439901
- Embankment required 58,000 tons of material
- Reinforced pavement supporting embankment
- Used MSE Retention System
Ohio Turnpike Project 779901
- Embankment required 54,000 tons of granular backfill
- Third lane extension
- Reinforced Using a Pre-Cast Concrete Modular System
- Contractor: The Great Lakes Construction Co.

IR 271 Slide Repair
- 10,000 tons of Spent Foundry Sand
- Excellent Drainage
- Excellent Compaction
- Layered Composite

Wisconsin Hwy. 10 Embankment

Road Bases
- Flexible Pavement Base
- Subbase
- Subgrade
- Rigid Pavement Base or Subbase
- Subgrade
Foundry Sands in Embankments Fills & Bases

State Highway Project

Performance Advantages in Sub Base or Embankment
- Not Susceptible to Freeze/Thaw
- Excellent compaction values
- Easy to use, handling not an issue
- Extremely uniform material, in contrast to conventional granular materials
- Relatively abundant and low cost
- Not moisture sensitive

Blended Granular Bases
- Foundry sand is being used in a variety of blended bases, inc.
  - Cement treated aggregate
  - Blends with Recycled Concrete Aggregate

TEST SECTIONS

John E. Dingeldein, P.E - 2014 FHWA Sustainable Materials Webinar - IndustrialResourcesCouncil.org
Foundry Sands in Embankments Fills & Bases

**Project Location – Village of Cuyahoga Heights, OH**

<table>
<thead>
<tr>
<th>SAMPLE</th>
<th>DESCRIPTION</th>
<th>CBR</th>
<th>P200</th>
<th>MAX DRY DENSITY, PCF</th>
<th>OPTIMUM MOISTURE CONTENT, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>8521</td>
<td>Subgrade Fill: Cinders, gravel, brick &amp; slag</td>
<td>2</td>
<td>23</td>
<td>101</td>
<td>18</td>
</tr>
<tr>
<td>8524</td>
<td>Recycled Concrete</td>
<td>---</td>
<td>4.4</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>8528</td>
<td>Foundry Sand</td>
<td>18</td>
<td>9.5</td>
<td>114</td>
<td>15</td>
</tr>
<tr>
<td>8525</td>
<td>304 RCA/FS Blend</td>
<td>34</td>
<td>7.9</td>
<td>113</td>
<td>13</td>
</tr>
<tr>
<td>8522</td>
<td>304 Crushed Limestone</td>
<td>55</td>
<td>11</td>
<td>141</td>
<td>6</td>
</tr>
</tbody>
</table>

**BASE COMPACTION**

**FLOWABLE FILL (CLSM)**

John E. Dingeldein, P.E - 2014 FHWA Sustainable Materials Webinar - IndustrialResourcesCouncil.org
Typical Mix Design

As recommended in ACI 229R:

<table>
<thead>
<tr>
<th>Component</th>
<th>Typical Mix Design (lb/yd³)</th>
<th>Range (lb/yd³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fine Agg/RFS</td>
<td>2850</td>
<td>1850 - 2910</td>
</tr>
<tr>
<td>Cement</td>
<td>100</td>
<td>50 - 200</td>
</tr>
<tr>
<td>Fly Ash</td>
<td>250</td>
<td>0 - 300</td>
</tr>
<tr>
<td>Water</td>
<td>500</td>
<td>325 - 580</td>
</tr>
</tbody>
</table>

Advantages in CLSM

- Reduced cost with better properties
- Less bleed water than concrete sand or other materials
- Less consolidation/settlement
- Excellent workability – no segregation

Foundry Sand Role in CLSM

- Replace virgin fine aggregate in flowable fill with foundry sand
- Reduce the need for adding fines (fly ash)
- Additional water may be required when flowable fills contain foundry sand for hydration of bentonite
- Reduces need for more expensive cementitious fly ash
- EPA’s CPG requires use of RFS and/or Fly Ash in Federally-financed projects

Experience in HMA

- Commercial applications successful
- FHWA has done research
- Meets Superpave guidelines
- PennDOT fine aggregate spec
- National Asphalt Pavement Association (NAPA) has endorsed use
- Guidelines under development
- Will recommend 7-10% mixture
- Some mixes use up to 30%
Foundry Sands in Embankments Fills & Bases

**Asphalt Paving**

- Hummer test track – South Bend
- ~1500 tons of core sand in the asphalt mix.

**Concrete**

- Non-conforming with specifications for concrete sand
  - Lower strength for same cement content due to finer material
  - Air void system is consistent with industry standards
  - Good workability
  - Can be combined with other materials that are recycled

**Concrete Production**

- Performance characteristics often meet or exceed those of conventional materials
- Cost are often reduced in the production of materials
- Foundry Sand can often be used in the production of non-typical materials such as concrete and bioswales
- Foundry Sand has been used successfully in deep fill applications where dynamic compaction is used.

**Summary**

- Foundry Sand has many beneficial uses in every day construction of roads and embankments and is environmentally friendly
- Performance characteristics often meet or exceed those of conventional materials
- Cost are often reduced in the production of materials
- Foundry Sand can often be used in the production of non-typical materials such as concrete and bioswales
- Foundry Sand has been used successfully in deep fill applications where dynamic compaction is used.