Review report on sealing of shotcrete surfaces

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Outline

- Background & purpose of study
- Arup preliminary report
- FRA’s comments to Arup
- Path toward resolution
Background and Purpose for Shotcrete Surface Study

• Subterranean shotcrete historically is a rough surface that lends to dusting due to the cementitious composition
• DUNE has concerns with excessive dusting and accumulation on detector components (ie racks). LBNF cryogenics has concerns as well with dust in the detector caverns and CUC.
• LBNF has researched different applications and costs to prevent shotcrete dusting (hand troweling, painting, polyurea sprayed coatings, etc.), but all were deemed cost prohibitive.
• Currently there is no science requirement for dust accumulation.
• DUNE requested CF to research low cost options into minimizing the amount of shotcrete dusting in the detector caverns and the CUC.
• FRA tasked Arup to research and provide a Report (docDB 9928) on solutions to mitigate dusting at the 4850L caverns.
High Level Summary of Arup Shotcrete Surface Study

Arup’s report on a high level covered the following:

• Section 2 – Description of Available Products and Application
• Section 3 – Impact of Surface Roughness for Shotcrete Walls
• Section 4 – Sequencing
• Section 5 – Cost Comparison
• Section 6 – Conclusions
• Attachments:
  • Attachment 1: Data Sheet for MasterKure HD 100 WB
  • Attachment 2: Data Sheet for Ashford Formula
  • Attachment 3: Surface Coverage Information
  • Attachment 4: Cost Breakdown
High Level Summary of Arup Shotcrete Surface Study

• The report focused strictly on utilizing a commercially available cementitious penetrating hardener/dustproofer (sodium silicate based) to be applied onto the shotcrete as well as concrete surfaces.

• The two products researched were:
  - BASF - MasterKure HD 100WB
  - Curecrete - Ashford Formula

• The two products researched were also analyzed under two different application scenarios:
  - Applied directly on rough surface of 4” shotcrete
  - Applied directly on smoother 1” fine leveling layer
Proposed Products for Shotcrete Sealing

**MasterKure® HD 100WB & 100C**
Concrete hardener and dustproofer

**FORMERLY SIONSIL® AND SIONSIL CONCENTRATE**

**DESCRIPTION**
MasterKure HD 100WB is a sodium silicate-based concrete hardener and dustproofer that bonds chemically with the concrete to strengthen and harden floors that are porous, ready abrasive, and dry moderately hard.

**PRODUCT HIGHLIGHTS**
- Hardens and densifies concrete floors to reduce absorption and peeling concrete lime
- Non-fly forming, reducing need for cleaning and finishing costs
- Quick drying for fast turn around
- Dust-free even when used with most sealant floor covering adhesives

**APPLICATIONS**
- Interior and exterior
- Floors and walls requiring a harder, easier-to-clean finish
- Docks and ramps

**SUBSTRATES**
- Freshly poured concrete
- Newly cured base concrete
- Aged concrete
- Terrazzo (non-erosion)

**_PACKAGING**
MasterKure HD 100WB
- 5 gallon (190 L) pail
- 40 gallon (150 L) drums

**MasterKure HD 100C**
- 11 gallon (41.5 L) in a 55 gallon (208 L) drum, must be filled with soft water prior to use.

**COLOR**
Clear liquid

**YIELD**
See front on page 3.

**STORAGE**
Store in unopened container in a cool, dry area between 70 and 82°F (21 and 28°C). Keep from freezing.

**SHELF LIFE**
15 months when properly stored.

**WPO CONTENT**
5 % low water and exempt solvents.
Shotcrete Surface Smoothness drives coverage rates and costs (SF/gallon)
Preliminary Arup Cost Analysis

Cost Comparison

A cost estimate was developed for the shotcrete and sealant options considered in this memo and presented in the following Table 2. The costs represent a Level 4 construction cost estimate in line with the accuracy ranges as defined by the AACEi.

Table 2 - Cost Estimate for Options

<table>
<thead>
<tr>
<th>Estimate Items</th>
<th>BASF</th>
<th>Ashford</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Option 1: 4&quot;</td>
<td>Option 2: 3+1</td>
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<tr>
<td>Opt 1: Shotcrete Structural Layer 4&quot;</td>
<td>$2,120,643</td>
<td>$2,120,643</td>
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<tr>
<td>Opt 2: Shotcrete Structural Layer 3&quot;</td>
<td>$1,640,753</td>
<td>$1,640,753</td>
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<tr>
<td>Opt 2: Shotcrete Fine Leveling Layer 1&quot;</td>
<td>$546,918</td>
<td>$546,918</td>
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<tr>
<td>Remove dust from chamber, wash walls</td>
<td>$87,792</td>
<td>$87,792</td>
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<tr>
<td>BASF Walls: Opt 1</td>
<td>$2,226,175</td>
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<tr>
<td>BASF Walls: Opt 2</td>
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<tr>
<td>BASF Floors</td>
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<td>Ashford Walls: Opt 1</td>
<td>$-</td>
<td>$3,324,049</td>
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<tr>
<td>Ashford Walls: Opt 2</td>
<td>$-</td>
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<tr>
<td>Ashford Floors</td>
<td>$242,270</td>
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<tr>
<td>Total Cost</td>
<td>$4,674,058</td>
<td>$3,999,026</td>
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<tr>
<td>Avg $/SF</td>
<td>$21</td>
<td>$18</td>
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</tbody>
</table>

Sealant Only Cost: $11.63/SF, $8.25/SF, $16.56/SF, $11.72/SF
Preliminary Cost Analysis

- Global assessment, 219,481 SF of surface @ $8.25/SF = $1,810,718 in Direct Costs

  CM/GC OHP @ 9.5% $1,720,018
  CM/GC Bond @ 0.5% $9,914
  CM/GC Excise Tax @ 2.041% $40,670

Total Cost in FY 2018 $2,033,320

Escalation 4 years @ 3.5%/year $284,665

Total Preliminary Cost in FY 2022 $2,317,985

That is approximately $10.56/SF, so round up to $11.00/SF based on preliminary information.
FRA main comments on Arup Study

- Confirm any past history projects utilizing concrete hardeners/dustproofers on shotcrete. Contact shotcrete manufacturers and installers as well as sealing manufacturers.
- What are the potential interactions with shotcrete admixtures (eliminating shrinkage reducers, accelerators, etc.)?
- Was hand troweling evaluated at all?
- Was TSL (thin sprayed liners) evaluated at all?
- Arup is in the process of addressing the comments
Path forward to a resolution

- Arup to provide response to FRA review comments
- Discuss the possibility of performing a test on existing shotcrete to verify dust reduction (ie sealing a section of Numi shotcrete)
- Discuss the possibility of performing a test section at SURF
- Receive a more defined science requirement for reducing dust
- Task KAJV with providing a cost estimate for the sodium silicate based penetrating hardener and 1” smoothing layer of shotcrete
- Discuss with stakeholders if $2M+ additional cost is a benefit to the project.