ALERT
Three-Level Strategic Approach

Level 3: Grand Challenges
C1: Ultra-Reliable Screening
C2: 500 meter Stand-Off Discovery and Assessment
C3: Unprecedented Post-Blast & Post-Blowout
C4: Rapid & Thorough Preparedness and Response

Level 2: Enabling Technology Testbeds
F1: Multimodal Explosives Characterization
F2: Explosives Detection Sensors
F3: Explosives Detection Systems
F4: Blast Mitigation

Level 1: Fundamental Science

Test Details
1. The tensile properties of the plain polyurea and composite polymer matrix were determined by conducting coupon testing. In addition, sample ignition loss testing was conducted to determine the fiber reinforcement content. Six various polyureas from two manufacturers were investigated and tested under tension.

<table>
<thead>
<tr>
<th>Material</th>
<th>Tensile Strength (MPa)</th>
<th>Tensile Strength (psi)</th>
<th>Elongation (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polyurea A</td>
<td>17</td>
<td>2466</td>
<td>480</td>
</tr>
<tr>
<td>Polyurea B</td>
<td>14.8</td>
<td>2147</td>
<td>91</td>
</tr>
<tr>
<td>Polyurea C</td>
<td>8.3 - 9.0</td>
<td>1200 - 1300</td>
<td>400 - 440</td>
</tr>
<tr>
<td>Polyurea D</td>
<td>9.0 - 10.3</td>
<td>1300 - 1500</td>
<td>135 - 150</td>
</tr>
<tr>
<td>Polyurea E</td>
<td>13.9</td>
<td>2010</td>
<td>82</td>
</tr>
<tr>
<td>Polyurea F</td>
<td>19.3 - 20.7</td>
<td>2800 - 3000</td>
<td>430 - 445</td>
</tr>
</tbody>
</table>

Coupon specimens were fabricated using each elastomeric polyurea and E-Glass fiber by varying fiber content. Coupon specimen fabrication and testing were conducted according to ACI 440.3R-04.

Comprehensive coupon sample undergoing tension

Important Findings
1. Discrete Fiber-Reinforced Polyurea Specimen Characterization

- Stress-strain behavior of 6 mm (0.25 in) fiber-reinforced polyurea B (left) and polyurea F (right) systems.
- As the fiber content increased for all polyureas, fiber-reinforced systems, material strength and modulus of elasticity increased, but ductility decreased compared to the plain polyurea material.
- In some cases, additional fiber has to be added to some fiber-reinforced systems to achieve a comparable strength level.
- Polyurea B should be further investigated. By increasing the fiber content to 5%, the strength increased significantly and some minor ductility was gained. In addition, polyurea F should be further investigated as well, due to high ductility and strength (see above).

2. Panel Blast Testing

- Reinforced concrete panel with plain polyurea B (left) and reinforced concrete panel with discrete fiber-reinforced polyurea B (right).
- Plain polyurea coatings contained fragmentation during a blast event. Discrete fiber-reinforced polyurea B system exhibited minor bulging compared to the plain coating due to higher polyurea system stiffness.
- Discrete fiber-reinforced polyurea F system exhibited tarring due to higher material elongation capability.
- Steel fiber reinforced concrete exhibited less cracking on the front face compared to plain reinforced concrete.
- Based on preliminary analysis, discrete fiber-reinforced polyurea B system was determined to be the most advantageous for blast mitigation purposes. Further analysis is still pending.

Research to Reality
1. Develop improved manufacturing processes yielding higher volume fractions of fiber with consistent fiber distribution for higher strengthening capabilities.
2. Numerical simulation using explicit finite element program LS-DYNA of plain reinforced concrete and polyurea coated panel behavior under blast loading is currently in progress.

State of the Art
- Investigated a new strengthening technique for multi-hazard mitigation
- Discrete fiber-reinforced polyurea systems under development at Missouri University of Science and Technology (Missouri S&T) in Rolla, Missouri. The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied of the U.S. Department of Homeland Security.