Structural Plastics: Polymer Additive Manufacturing in Civil Engineering Research and Education

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Quick Overview

Structural Plastics: Common Materials and Applications

- Wood-Plastic Composites
- GFRP Bars
- CFRP Reinforcement
- Playground
- Military Applications
Quick Overview

Structural Plastics: Extrusion or Injection Molding

Extrusion Manufacturing

Injection-Mold Manufacturing
Quick Overview

Structural Plastics: Extrusion or Injection Molding or Additive Manufacturing

High-Performance Structural Plastic Composites

Hybrid Polymer-Ceramic Structural Composite

Carbon Fiber-Reinforced ABS

Strong & Tough Biomimetics
Quick Overview

High-Performance Composites

IDEA: Apply Pre- and Post-Tensioning of Synthetic and Natural Fiber Reinforcement

3DP in Civil Engineering Education

Leverage 3DP to Create High-Performance Fiber-Reinforced Composites

Post-Tensioned Concrete
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Structural Plastics: Strong in Compression, Weak in Tension

Ducted PLA I-Beam
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Hinchcliffe, Hess, and Srubar. Composites Part B. 2017
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<table>
<thead>
<tr>
<th>Specimen</th>
<th>Property</th>
<th>Flexural Strength, $\sigma$ (MPa)</th>
<th>Flexural Modulus, $E$ (MPa)</th>
<th>$\sigma'_{\tau}$ (MPa/g)</th>
<th>% Increase ($\sigma'_{\tau}$)</th>
<th>$E'_{\tau}$ (MPa/g)</th>
<th>% Increase ($E'_{\tau}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F-I-S1</td>
<td></td>
<td>68.8 ± 3.2</td>
<td>2260 ± 29</td>
<td>1.37 ± 0.06</td>
<td>--</td>
<td>45.1 ± 0.3</td>
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<tr>
<td>F-I-U1</td>
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<td>68.2 ± 9.6</td>
<td>2315 ± 342</td>
<td>1.49 ± 0.09</td>
<td>8%</td>
<td>50.5 ± 3.0</td>
<td>12%</td>
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<tr>
<td>F-I-J1</td>
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<td>78.6 ± 6.9</td>
<td>2612 ± 168</td>
<td>1.68 ± 0.06</td>
<td>22%</td>
<td>55.8 ± 0.7</td>
<td>24%</td>
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<tr>
<td>F-I-F1</td>
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<td>74.0 ± 1.1</td>
<td>2293 ± 81</td>
<td>1.64 ± 0.03</td>
<td>19%</td>
<td>50.7 ± 1.9</td>
<td>12%</td>
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<tr>
<td>F-I-F2</td>
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<td>81.8 ± 4.0</td>
<td>2629 ± 128</td>
<td>1.81 ± 0.05</td>
<td>32%</td>
<td>58.3 ± 2.3</td>
<td>29%</td>
</tr>
</tbody>
</table>

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Next-Generation Structural Plastics

IDEA: Apply Pre- and Post-Tensioning of Synthetic and Natural Fiber Reinforcement

3DP in Civil Engineering Education

IDEA: Modernize the Civil Engineering Design-Build-Test Pedagogy

• Topology Optimization
• 3D Printing
• Innovative Structural Materials

Project Objective: Design a structurally optimized truss bridge using topology optimization software + 3D printing using PLA bioplastic.

3DP Enables On-Demand Manufacture for Enhanced Teaching & Learning
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