DISCRETE FIBER REINFORCED POLYUREA SYSTEMS FOR INFRASTRUCTURE REPAIR AND BLAST MITIGATION

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Abstract

The first part of this research investigated the development and characterization of different discrete fiber-reinforced polyurea systems for infrastructure applications. The behavior of various systems consisting of several polyureas with different fiber configurations was evaluated by conducting coupon tensile testing. The purpose of further testing was an effort to develop a polyurea system for blast mitigation, multi-hazard, and/or repair-retrofit applications. The addition of fiber to a polymer coating provides improved stiffness and strength to the composite system while the polyurea base material provides ductility. The second part of this study examined the behavior of plain and steel fiber reinforced concrete panels coated with various discrete fiber-reinforced polyurea systems under blast loading. In addition to the polyurea a high-volume fly ash-wood fiber (FA-WF) material is being investigated as an added layer to the panels. Results from this study will be used to evaluate alternative construction methods and coating systems to protect at-risk structures and their inhabitants.

Relevance

The focus of this research is on the applicability of an elastomeric polyurea coating for blast mitigation, seismic, and general repair-retrofit. The coating possesses several advantageous characteristics, including elasticity, ductility, and energy absorption. Additionally, polyurea is capable of containing spalling and reducing fragmentation during a blast event (Carey and Myers 2009). The development of strengthened polyurea coating systems could yield a multi-hazard retrofit material suitable for at-risk aging infrastructure. The unique aspect of the polyurea is it can be applied to existing structures in a short amount of time with instantaneous results.

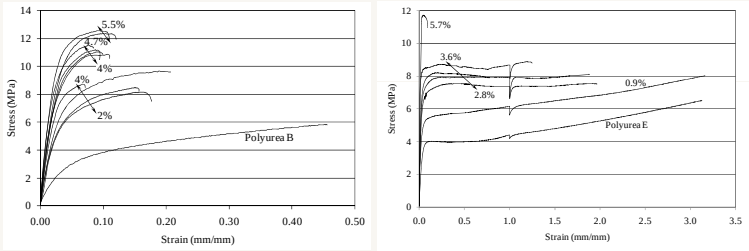
Technical Approach

DISCRETE FIBER-REINFORCED POLYUREA SYSTEMS CHARACTERIZATION

TEST DETAILS

Five (5) polyureas (Systems A-E) from two manufacturers were investigated. Coupon tests were used to determine tensile properties and sample ignition loss tests were used to determine fiber content. Each polyurea was investigated with 6-mm (0.25-in.) glass fiber incorporated in various contents (0-6%).

IMPORTANT FINDINGS



Stress-strain behavior of representative discrete fiber-reinforced polyurea system B (left) and polyurea system E (right).

As can be seen in the above figure adding the glass fibers significantly increased strength, but decreased ductility. Two polyureas, namely Systems B and E, shown in the above figure were selected for further investigation. Polyurea B was chosen because of it's overall strength and polyurea E was selected for its unique combination of ductility and strength.

BLAST TESTING OF FOUR TYPES OF PANELS WITH EXTERNAL STRENGTHENING SYSTEMS

TEST DETAILS

Eighteen panels, each 1180 x 1180 mm (46.5 x 46.5-in.) with a 0.5 percent reinforcement ratio in each direction were fabricated. Four panel types were investigated including plain concrete, steel fiber concrete, steel fiber concrete with a FA-WF layer, and steel fiber concrete with a FA-WF and an air-gap. The first two types of panels have already been tested at Missouri S&T experimental mine using the charge weight of 1.36 kg (3 lb) of C4 and 305-mm (12-in.) standoff distance. The FA-WF panels will be tested this Spring. Polyurea systems were applied on the tension side of each specimen except the controls.

IMPORTANT FINDINGS

- Polyurea B without discrete fibers contained fragmentation, the discrete fiber polyurea B panel exhibited minor bulging, and the polyurea E exhibited tearing.
- Less cracks were evident in the steel fiber panels versus the plain concrete.
- Of the panels tested the steel fiber panel with the discrete fiber polyurea B was determined the most advantageous for blast mitigation.

Reinforced concrete panel with plain polyurea B (left) and reinforced concrete panel with discrete fiber-reinforced polyurea B (right).

Accomplishments Through Current Year

All the panels were fabricated and half of the panels have been tested. All material and blast properties were gathered and modeling is in process for finite element modeling (FEM).

Future Work

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.
3. Blast testing on the panels with steel fiber and FA-WF.

Opportunities for Transition to Customer

The project team has collaboratively worked with **LINE-X Protective Coatings Corp.** located in Columbia, MO in the discrete polyurea formulation/development and characterization studies. This effort is in a direct alignment to transition the technological development to the field and satisfy DHS's mission for a unified national effort to secure the country and preserve our freedoms.

Patent Submissions

The Center for Technology Transfer and Economic Development at Missouri S&T is exploring the patentability of the discrete fiber polyurea. http://ecodevo.mst.edu/

Publications Acknowledging DHS Support

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Other References

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Crawford, John E. and Shengrui Lan. "Blast Barrier Design and Testing." 2006. Karagozian and Case. 28 February 2011 <http://www.kcse.com/pdfs/P-06-1_add.pdf>.

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