FLEXURAL AND SHEAR REINFORCEMENT OF REINFORCED CONCRETE BEAMS USING FIBER REINFORCED POLYUREA COATINGS

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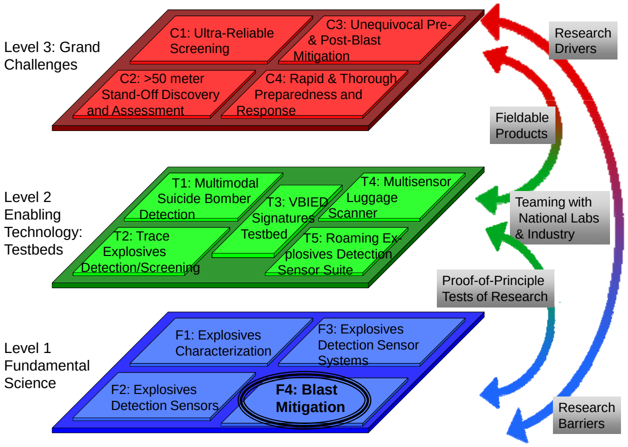
ALERT
Three-Level Strategic Approach



Accomplishments

▪Cylinder/Column Confinement Testing Complete
▪General Strengthening for Flexural and Shear Reinforcement Complete (Details Shown)

Abstract

Increased security risks in the US over recent years demand that engineers develop effective solutions for protecting structures and their inhabitants from blast and impact damage. In addition, the aging infrastructure of the country is constantly being subjected to higher loading conditions and more stringent structural code requirements. The coupling of these two situations suggests a need for strengthening systems which can be used in repair and retrofit applications but that will also provide multi-hazard benefits, allowing for better seismic performance and blast and impact damage mitigation, while also providing general strengthening. Recent research conducted at Missouri S&T has shown that spray-applied polyurea coatings provide exceptional containment of fragmentation and debris scatter during blast and impact loading, and also that the elastic polyurea material can be strengthened with the addition of discrete, randomly-oriented chopped glass fibers. This poster presents testing of the flexural and shear strengthening capabilities of glass fiber reinforced polyurea when applied to reinforced concrete beams. Test parameters included beam design, type of polyurea, and fiber volume fraction, and extensive data was collected during testing, including ultimate load and deflection of the beams. The results presented suggest that measurable strength gain can be attained utilizing the composite system, and thus, may prove beneficial for several infrastructural applications throughout the US.

Objectives of Study

1. Determine strengthening abilities of polyurea and glass fiber reinforced polyurea.
2. Consider flexural and shear failure.
3. Develop and validate model to predict future results.

Challenges and Significance

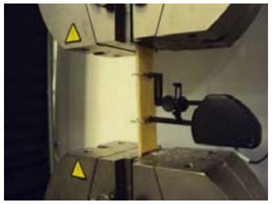
The use of polyurea coatings as a blast damage mitigation barrier has been well-researched and supported, and the addition of chopped fibers has been shown to increase the coating strength (Carey and Myers, 2010), however, the application of strengthened polyurea systems to structures has not been documented. The development of strengthened polyurea coating systems could yield a multi-hazard retrofit material suitable for at-risk aging structures.

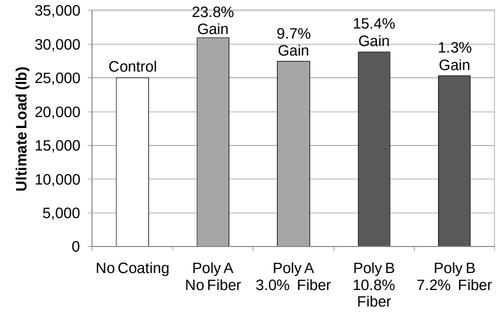
Test Details

1. Reinforced concrete beams were considered for flexural and shear type failures. Selected beams were coated on the bottom and sides (U-shape) with polyurea and fiber-reinforced polyurea and compared to non-coated control specimens. One beam was tested for each coating scheme shown.

Coating Description	*Code*	V_f	*Strength(psi)*
Flexural Beam Testing			
Control – No Coating	F-C	N/A	N/A
Polyurea A, No Fiber	F-P-A-0	0%	2147
Polyurea A, Lower Fiber Ratio	F-P-A-L	3.0%	1004
Polyurea B, Lower Fiber Ratio	F-P-B-L	7.2%	1403
Polyurea B, Higher Fiber Ratio	F-P-B-H	10.8%	1859
Shear Beam Testing			
Control – No Coating	S-C	N/A	N/A
Polyurea A, Lower Fiber Ratio	F-P-A-L	3.0%	1004
Polyurea B, Higher Fiber Ratio	F-P-B-H	10.8%	1859

2. Flexural beams were tested in 4-point loading during which deflection and strain values in concrete and coating were monitored. Shear beams were tested in a similar setup utilizing different load spans in order to obtain two tests from each region and determine coating contribution to shear capacity.





Beam Coating Description
Unit Conversion: 1 lb = 4.45 N; 1 in = 25.4 mm

Important Findings

1. The polyurea coating systems provided additional flexural reinforcement that resulted in ultimate capacities as much as 24% greater than the control case (non-coated beam).
2. The deflection of polyurea-coated beams as opposed to non-coated beams was up to 94% greater.
3. The ductility of the coated beams was substantially greater than that of the non-coated beams. Polyurea B with 7% fiber volume fraction developed an increase in ductility of 30% and overall ductility was increased by as high as 160% with various polyurea coating systems.
4. The shear capacity of the coating system was measured to be 2.3 k (10.2 kN) in the case of Polyurea A with low fiber volume fraction, and greater than 6.2 k (27.6 kN) in the case of Polyurea B with high fiber and larger coating thickness.

Research to Reality

1. Develop improved manufacturing processes yielding higher volume fractions of fiber with consistent fiber distribution for higher strengthening capabilities
2. Complete advanced blast testing and blast modeling, in addition to advanced modeling of flexural and shear reinforcement behaviors
   ➢Yield multi-hazard repair/retrofit technique

State of the Art

▪Investigated a new strengthening technique for multi-hazard mitigation

References

▪Carey, N.L., and Myers, J.J. (2010), “Elastomeric Systems with Discrete Fiber for Infrastructure Repair and Rehabilitation”, Structural Faults & Repair – 2010, Edinburgh, UK.

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