BLAST UPGRADE OF BALLISTIC AND NON-BALLISTIC RESISTANCE MASONRY WALLS WITH FRP

SUMMARY

Recent world events have illustrated that sustainability of buildings to blast loads is an ever increasing issue. Many older buildings contain unreinforced masonry (URM) infill walls. Due to their low flexural capacity and their brittle mode of failure, these walls have a low resistance to out-of-plane loads, including a blast load. As a result, an effort was undertaken to examine retrofit methods that are feasible to enhance their out-of-plane resistance. The purpose of this study was to examine the feasibility of coupling ballistic resistance materials with FRP to provide/develop an impact and blast resistant brick façade system with minimal debris scatter. Fig. 1 illustrates the laboratory test set-up for the control wall.

Figure 1. Test Set-Up for Static Load Tests (Control Wall)

"REQUESTED NO-COST TIME EXTENSION TO INDUSTRY SPONSOR"

BACKGROUND

Abroad, numerous attacks have been directed toward embassies, and suicide car bombers have been used to target populated areas. In the cases where complete structural failure is not an issue, the dangers of flying debris have resulted in loss of life or injury to numerous civilians. Of particular concern are unreinforced masonry (URM) infill walls. Structural systems composed of a reinforced concrete (RC) framing system with URM infill walls makes up a significant portion of the building inventory in the United States and around the world. Since there is no reinforcement within these walls, they have little resistance to out-of-plane loads such as a blast load. As a result, an effort was undertaken to examine retrofit methods that are feasible to enhance their out-of-plane resistance. The use of externally bonded and near surface mounted (NSM) Fiber Reinforced Polymers (FRP) laminates and rods have been proven to increase the out-of-plane load capacity.

OBJECTIVE

Previous research studies at UMR investigated the feasibility of developing continuity between the FRP strengthening material and the surrounding reinforced concrete frame system as well as using NSMR and laminate technology. Two strengthening methods were utilized, including the application of glass FRP (GFRP) laminates to the wall's surface and the installation of near surface mounted (NSM) GFRP rods. Both methods, proved beneficial to increase the wall capacity and ductility, but did not significantly address the debris scatter issue. The objectives of this study were to:

1) examine methods to limit debris scatter including the use of FRP grid systems;

2) examine the integration of FRP with ballistic resistance brick façade for new construction;

3) develop a design protocol for these systems and analytically link lab related behavior to field related tests.

EXPERIMENTAL PROGRAM

Retrofit application to strengthen URM walls. This study extends previous work on NSM rods and laminates retrofit schemes to also include grid systems and develop a theoretical model to design this infill wall system with FRP retrofit systems. Analytical work will also be done to couple static load tests to field related blast tests. The feasibility of infill wall systems with FRP for new construction is also under investigation to examine and couple high ballistic resistance brick façade materials. The grid systems are applied using a sprayed polyurea system by Bondo. The test matrix includes examining the effectiveness of ballistic block in combination with FRP grip systems.

Table 1. Experimental Test Matrix

Wall	Retrofit Scheme*	Completed
1	Unstrengthened[2]	v
2	Unstrengthened[3]	v
3	Unstrengthened[4]	
4	Grid with Bondo[2]	
5	Grid with Bondo[1,2]	
6	Grid with Bondo[3]	
7	Grid with Bondo[1,3]	
8	Grid with Bondo[4]	
9	Grid with Bondo[1,4]	

[1] Anchored Boundary Connection
[2] Conventional Masonry
[3] Conventional Brick
[4] Ballistic Enhanced Material

INTERIUM CONCLUSIONS

No conclusions can be drawn on the effectiveness of the ballistic resistance block as these wall systems are yet to be evaluated (see below for explanation). FRP strengthened walls have been shown to improve the blast resistance and limit the debris of scatter.

EXPLANATION FOR NO COST EXTENTION

A no cost extension was requested for the following reasons:

1. Delay in the hiring of a graduate research assistant (GRA). Funding was received in Nov-Dec 2004. The combination of funding receipt and an available pool of graduate students made it impossible to initiate the study as originally planned in August 2004.
2. Delay in the fabrication of the ballistic resistant block by Encore Building Systems located in St. Louis, Missouri. Receipt of the block is expected in June 2005.

CONTACT

John J. Myers, Ph.D., P.E.
Assistant Professor of Civil, Arch. & Envir. Engineering
Dept. of Civil, Architectural and Envir. Engineering
The University of Missouri-Rolla
325 Butler-Carlton Hall
Rolla, Missouri 65409-0030
(V) 573-341-6618 (Fax) 573-341-6215
Email: jmyers@umr.edu