Functionally Optimized Fiber Reinforced Polymer Panels for Seismic Energy Dissipation

Xiaobo Luo[1] and Amjad J. Aref, Ph.D., Advisor

[1]Research Assistant, Department of Civil, Structural and Environmental Engineering
University at Buffalo, State University of New York

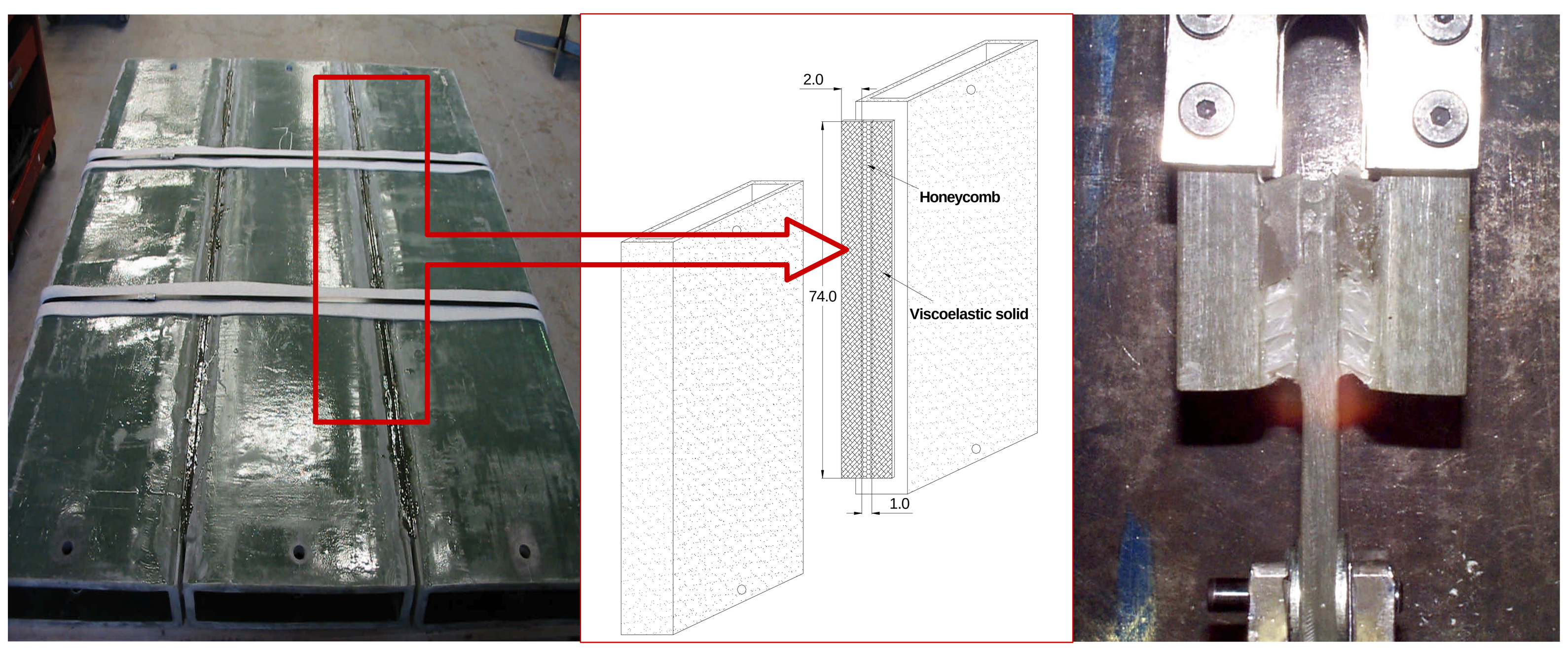
ABSTRACT

This research addresses the analysis and experimental investigation of PMC panels utilized for seismic and vibration mitigation. The concepts rely on introducing considerable shear deformation at strategically located layers. The layers at which the shear deformation to take place, referred to here as the interface layers, are composed of a combination of solid visco-elastic material combined with honeycomb material.

In this research, the conceptual designs of the panels are employed in a benchmark hospital building-namely, the Multidisciplinary Center for Earthquake Engineering Research (MCEER) demonstration hospital structure. Nonlinear 3D finite element analyses were carried out to evaluate the effective damping of added PMC composite panel with viscoelastic interface layers in the retrofitting of the MCEER's demonstration hospital structure. An equivalent Kelvin model consisting of an elastic spring and a linear viscous damper combined in parallel is proposed to represent the FRP composite panel with viscoelastic interface layers. The retrofitted structure was subjected to MCEER west coast ground motions. Significant increase in the system damping was observed with the added PMC composite panels. Both the modal strain energy method and logarithmic decrement method showed the PMC composite panel contributed 8% damping to the hospital structure. Time history analyses results showed that the peak floor displacement and acceleration response were reduced significantly and the vibration damped out very quickly.

BACKGROUND

Earthquake-resistant design and retrofitting of structures using various energy absorption devices such as viscoelastic (VE) dampers, viscous fluid dampers, friction dampers, and added damping and stiffness devices have received considerable attention in recent years. Similar to partial rehabilitation techniques using composite material such as column wrapping, the use of prefabricated polymer matrix composite (PMC) infill panel systems is a very efficient way to achieve seismic retrofitting of existing facilities because of the efficiency of the material and its ease of use in construction.

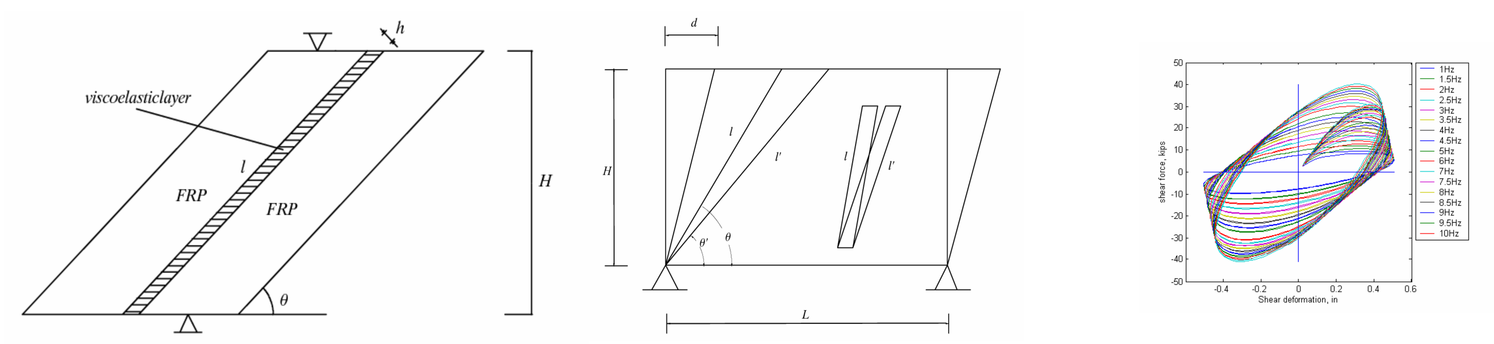


OBJECTIVES

1.Study the effective use of Fiber Reinforced Polymer (FRP) Infill panels for passive seismic energy dissipation
2.Introduce energy dissipation effects produced by novel combined interface damping layers along with the investigation of several design parameters
3.Characterize the properties of advanced composite panels and their impact on modifying the response of hospital structures.
4.Find optimal layout of the FRP interface layer and the geometry shape of the infill panel system

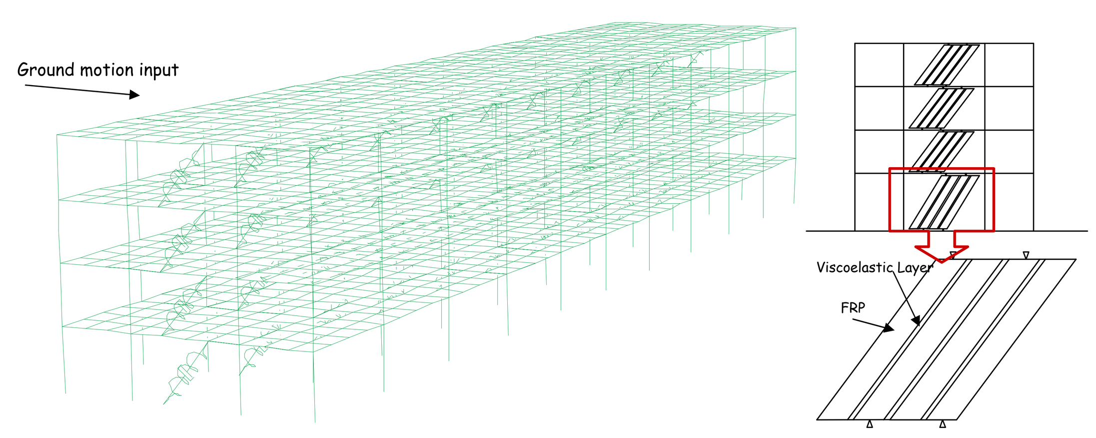
METHODS

Based on viscoelastic theory and passive energy dissipation method, a simplified shear deformation model was proposed and analytical solution was found for the FRP infill panel system. An optimal FRP panel installation angle was investigated based on the simplified model. The analytical solution was compared with numerical results and a damping modification coefficient was proposed. The properties of the damping modification coefficient were investigated. Using the damping modification coefficient, the FRP infill panel system's damping coefficient was calculated easily and an equivalent Kelvin model was used in ABAQUS in stand of the complicated FRP infill panel system. The MCEER demonstration hospital building WC70 with added FRP infill panel system was analyzed under MCEER west coast ground motion.

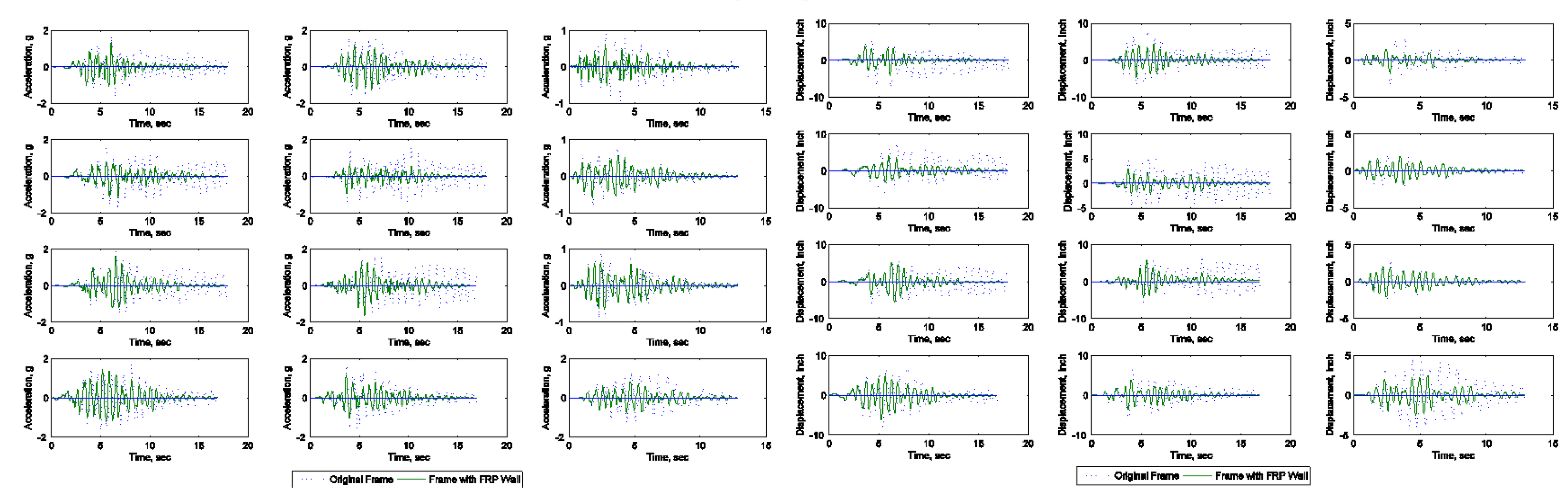


RESULTS

•Optimal FRP panels installation angle was found to be 45 degree.
•Equivalent Kelvin model of the FRP box panel was used in the nonlinear analysis.



Earthquake No.	Floor No.	Bare Frame (g)	Retrofitted Frame (g)	Reduction Ratio %
1	1	1.02	0.67	35
1	2	1.03	0.85	17
1	3	1.17	0.86	26
1	4	1.62	1.31	19
2	1	0.92	0.76	17
2	2	1.00	0.70	30
2	3	1.51	1.02	33
2	4	1.70	1.27	25
3	1	0.72	0.46	36
3	2	0.81	0.41	50
3	3	0.78	0.49	37
3	4	0.98	0.63	35
4	1	0.94	0.79	16
4	2	1.14	0.84	26
4	3	1.26	1.02	19
4	4	1.50	1.18	21



CONCLUSIONS

•The FRP infill panel system can dissipate most of the energy inputted to the structure system and increase the structure's damping significantly.
•Both floor acceleration and displacement responses are reduced significantly.
•Significantly increase in the damping of the demonstration hospital structure is obtained.
•Optimal installation and configuration of FRP box panels might give better performance.

ACKNOWLEDGEMENTS

Faculty Advisor: Amjad J Aref, Ph.D.
This work was supported primarily by the Earthquake Engineering Research Centers.