INFILL WALLS AS A SPINE TO ENHANCE THE SEISMIC PERFORMANCE OF NON-DUCTILE REINFORCED CONCRETE FRAMES

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Reinforced concrete (RC) frames containing unreinforced masonry infill (URM) walls are a commonly used structural system in much of the world. As a result, there are many existing buildings of this type. Buildings with weak, non-ductile RC frames and URM infill walls are especially prevalent in areas with rapidly expanding urban populations such as South Asia, and can be major sources of earthquake risk. Infill walls may have beneficial or detrimental effects on the behavior of the overall structure. The beneficial effects derive from the fact that the infill walls add, up to a certain level of ground motion, to the lateral force resisting capacity and damping of the structure. However, the URM wall is brittle and prone to early failure due to in-plane loads, and interacts with the surrounding frame in such a way that column shear failure is made more likely. Also, the infill wall failure may lead to the formation of a soft story and consequent column failure, as shown in Figure 1. Out-of-plane failure of the URM infill walls leads to life-safety hazard from falling debris. There is also an interaction effect between the in-plane strength of the wall and its out-of-plane strength, with load in one direction reducing the strength in the other.

Because the detrimental effects of infill walls on weak non-ductile RC frames are a major source of earthquake vulnerability, researchers from the United States and Pakistan are searching for low-cost retrofit solutions as part of a collaborative capacity building project. The partners of this project include NED University of Engineering and Technology in Karachi, Pakistan, GeoHazards International of Palo Alto, California, University of California, Berkeley, Tipping Mar + Associates, Stanford University, and Computers and Structures, Inc.

This paper reports the results of an investigation on the efficacy of using rocking spines of strengthened infill walls as a retrofit measure. The study examines the effects of spines of strengthened URM infill walls, Figure 2, on the behavior of the RC frame, with particular emphasis on whether spines could reduce the tendency to form a soft story. For this purpose, a five story, three bay frame is selected to represent complex multi-story behavior, where the collapse of stiff infill walls may lead to the formation of a soft story mechanism. The frame behavior using different infill arrangements is investigated under a variety of ground motions with different characteristics. For the analyses, a progressive collapse algorithm, previously developed and implemented into a structural analysis platform is utilized and the interaction between the in-plane strength of the wall and its out-of-plane strength is taken into consideration. Analyses show that infill retrofit with rocking spines provides significant improvement in drift capacity and strength. Figure 3 shows a comparison of some analysis results. The infill spines work with the existing brittle frame, eliminating the story mechanism. A rocking spine retrofit solution can be implemented without foundation work, at low cost, and with simple construction methods.

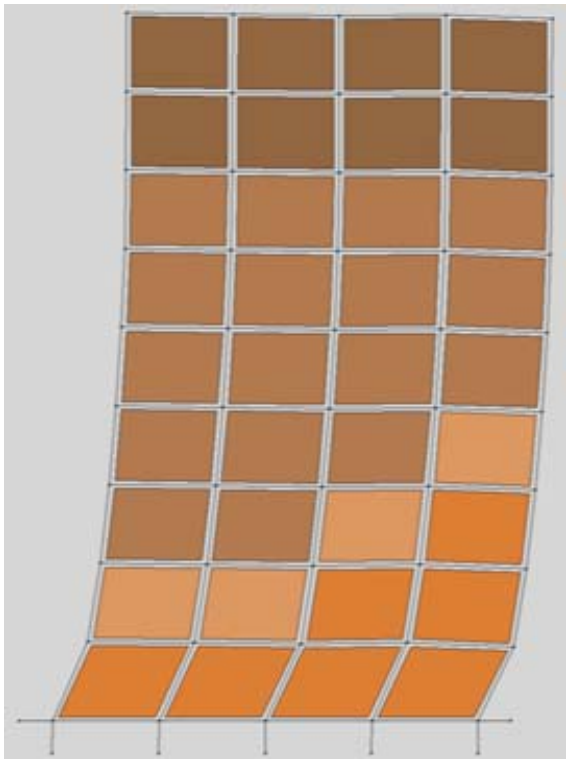

Figure 1. Deformed shape of the unretrofitted RC frame with URM infill showing formation of story mechanism as a result of pushover analysis

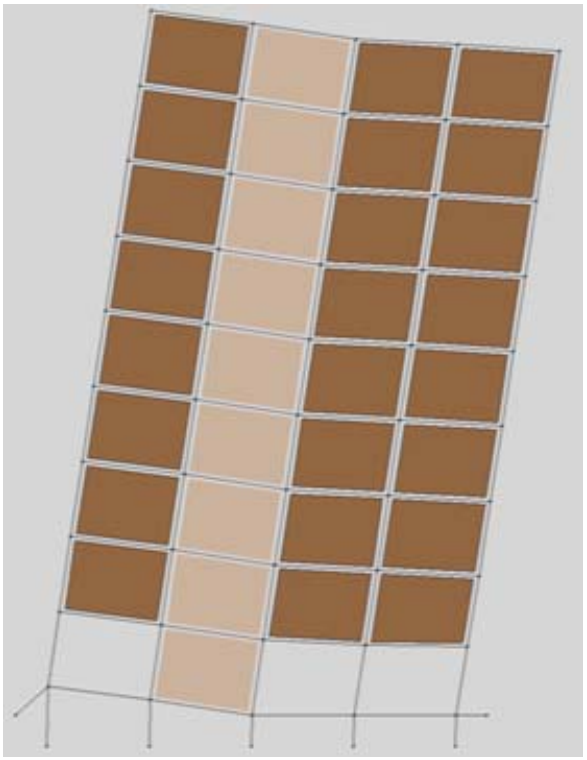

Figure 2. Deformed shape of the RC frame with URM infill retrofitted with rocking spine as a result of pushover analysis

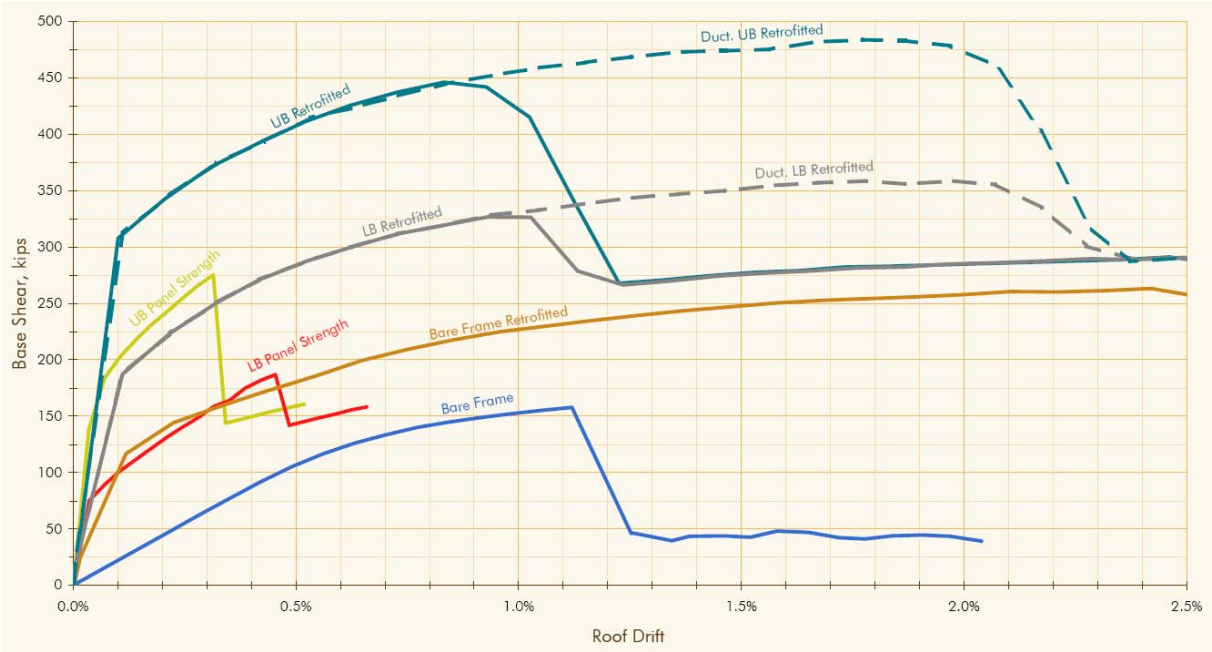

Figure 3. Pushover curves showing effects of spine retrofit and panel strength