Could Base Isolation be an Effective Structural System for NZ Housing?

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QuakeCoRE Flagship 4 Coordinated Project
QuakeCoRE Annual Meeting 2018

Background

A significant portion of economic loss from the Canterbury Earthquake sequence in 2010-2011 was attributed to losses to residential buildings. These accounted for approximately $12B of a total $40B economic losses (Horspool, 2016). While a significant amount of research effort has since been aimed at research in the commercial sector, little has been done to reduce the vulnerability of the residential building stock.

Figure 1. Vulnerability function for residential buildings. This data can be further broken down into losses due to drift and acceleration sensitive components.

Using loss data from previous New Zealand earthquake events (Figure 1), this QuakeCoRE Flagship 4 Coordinated Project will look to determine if seismic isolation of New Zealand residential houses is a viable method for reducing financial losses. In addition, consideration will be given to other benefits that seismic isolation may bring, including reducing the effects of downtime and negative psychological factors.

Inspiration will be drawn upon from recent work completed in Japan including reducing the effects of downtime and negative psychological factors. Ultimately, the research will look to design an innovative solution for seismic isolation of New Zealand houses which is able to reduce losses in both frequent and rare earthquake events.

Challenges

A BRANZ investigation into two different types of proposed seismic isolation methods for timber houses indicated that the system would prove to be challenges at the forefront of this research area. Although, the effects of wind loading and the challenge of providing isolation at low intensities still prove to be challenges at the front of this research area.

The results of the nonlinear analyses are then used to determine engineering demand parameter (EDP) vs PGA relationships for the isolated system. The median EDP at each intensity is determined and plotted as shown in Figure 7 to derive vulnerability functions for the isolated buildings.

Next, a simplified model incorporating various isolation parameters for lead rubber bearings and friction pendulum devices was created. The isolator hysteretic model was validated using data from Ruaumoko (Project 1) and a Wayne Stewart Pinching Hysteresis model was used for the house. Isolator parameter values are shown in Table 1. The simplified model shown in Figure 5 was then subject to nonlinear time history analyses using ground motions determined from a PSHA for Wellington sites.

The data indicates that approximately two thirds of losses are due to drift sensitive components with the remaining losses due to acceleration sensitive components. Using the data in Figure 1, and by determining the relationships between drift/acceleration and PGA (similar to Figure 7 and 8), the vulnerability curve for the isolated system moves to the right implying lower expected annual losses or scenario based loss when compared to the standard fixed base building.

This preliminary analysis is to be expanded on by incorporating more detailed house models into Ruaumoko and investigating different isolator configurations. Further work is also to be done for modelling scenario based loss in particular using the OpenQuake platform.

References

