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Enabling Smart Retrofit to Enhance Seismic Resiliency: Japan and NZ Case Studies

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1. Introduction

This project endeavours to not only show the effectiveness and underline the benefits of accounting for retrofit/rehabilitation in seismic loss but also develop a simplified way to incorporate cost-benefit analysis in practice. By following the performance based earthquake engineering framework suggested by the Pacific Earthquake Engineering Research (henceforth denoted as PEER-PBEE [1]), seismic loss is quantified for both New Zealand and Japan typical commercial buildings.

2. New Zealand Case Study

In New Zealand, a 22-storey steel building with eccentrically based frames (EBF) located in downtown Christchurch was assessed. Two retrofit options were considered; improving the dry-wall partitions and re-detailing the exterior cladding connections. The findings show that improving the dry-wall partitions, is more effective than re-detailing the exterior claddings, as illustrated in Fig.1. Re-detailing the exterior cladding could even worsen overall building performance due to the un-even trade-off between increased losses due to increased drifts and the reduced losses due to less cladding damage. In general, this study shows that to be cost-effective, retrofit should focus on addressing the most critical component, which for this building was the non-structural partition walls.

3. Japan Case Study

In Japan, the repair cost of a 14-story steel building with buckling restrained braces (BRB) was investigated in-line with PEER-PBEE framework [1]. Due to lack of data on Japanese Hazard, the uniform

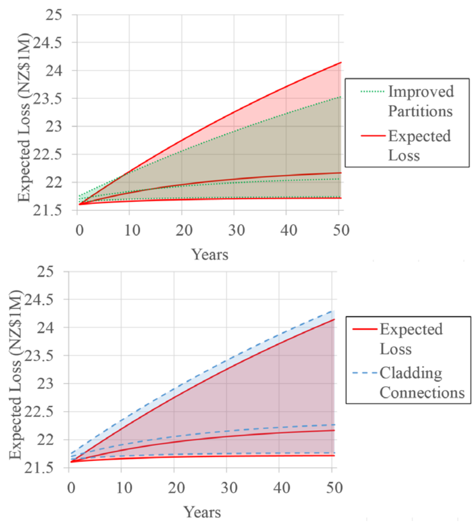

Fig.1 Cost-benefit analyses of retrofit options [2]

hazard spectra corresponding to each hazard level in Osaka were developed based on documents by the Architectural Institute of Japan (AIJ) and suggestions from FEMA P.58 [3]. The findings show that during small intensity earthquakes, the repair cost of non-structural partition walls dominated the loss. To reduce the total repair cost, several seismic retrofitting options were considered. Increasing the number of BRB does reduce the structural demand. However, owing to the increase of implementation and repair costs of the BRBs, it was found that this was not cost-effective.

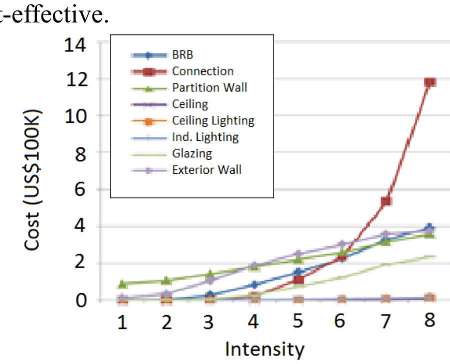

Fig.2 Item loss for each intensity measure [4]

4. Plasterboard Partition Walls

From the findings, it can be summarized that in terms of expected annual losses, plasterboard partition walls currently contribute towards losses significantly. This is supported by previous studies in the literature (e.g. [5]). As such, it is recommended that the performance of these elements be improved. To quantify the seismic behaviour of possible improvements, experimental testing of the seismic performance of partition walls has been conducted.

Partitions are sensitive even to small intensity earthquakes, owing to the onset of damage in typical partitions initiating at inter-storey drifts as low as 0.2% [3]. In response to this, a number of proposals have been made in the literature for “low-damage” partition walls. However, the experimental work on these novel solutions, such as [5], has not included a number of important configurations common in buildings. Therefore, more experimental tests are required to rigorously assess the impact of these variables on the overall seismic performance of the system of low-damage partition walls.

In this work, an experimental testing campaign was initiated into the seismic performance of several low damage partition systems possessing angled return walls and constructed using New Zealand materials and construction practices. Full-scale tests, shown in Fig. 3, are conducted to compare each system and develop experimental fragility functions. The expected results of this investigation will be valuable quantitative data for the seismic behaviour of low damage systems of non-structural partition walls that will enable reliable prediction of damage and losses in these systems to motivate cost-effective retrofit initiatives.

5. Summary and Conclusions

In summary, it was found that non-structural components, particularly partition walls, contribute significantly towards loss. As such, it is recommended to improve the element to help reduce the total losses.

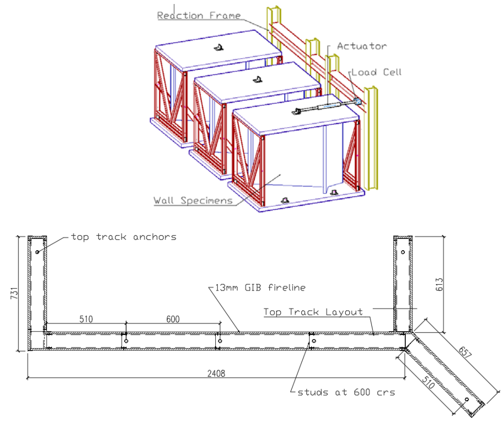

Fig. 3 Experimental test setup plan (Left: perspective; right: partition plan)

Future work of this research will include the simplified methods of incorporating losses, a more refined retrofit analysis and the results of the experimental tests for non-structural plasterboard partition walls.

6. Acknowledgements

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