Economic Loss Assessment for an Existing Tall Building

PEER Internship Program – Summer 2013

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Research Conducted at the University of California, Berkeley

1. Introduction

In this project, the seismic performance of a tall building constructed between the 1960's and 1980's is investigated. Seismic safety concerns exist because these buildings were generally designed for demands less than current design codes. However, a retrofit measure that addresses safety but neglects financial losses due to downtime for structural or nonstructural repairs does not fully mitigate the hazard faced by an owner. The primary motivation of this project is to preemptively reduce post-earthquake disruption and repairs. Projects such as the Tall Building Initiative (TBI) developed guidelines for performance-based seismic design of tall buildings that were intended to be used for new building design and future building design codes. But currently there are no specific guidelines for managing existing tall buildings to improve their reliability and safety. Consequently, the Tall Building Initiative-2 (TBI-2) was developed to address this issue. The overall goal of the TBI-2 is to develop performance based seismic design guidelines to retrofit existing steel tall moment resisting frame (MRF) buildings. As a part of TBI-2, the Pacific Earthquake Engineering Research (PEER) Center is currently working on a project that investigates the economic advantages gained by retrofitting existing steel MRF buildings greater than 20 stories. This investigation uses the Performance-Based Earthquake Engineering (PBEE) methodology to conduct the assessment. The PBEE methodology consists of four stages: hazard analysis, structural analysis, damage analysis, and loss analysis as seen in Figure 1. For the purposed of this project, this report will focus on the loss analysis of a 40 story steel MRF building completed in the early 1970's located in downtown San Francisco.

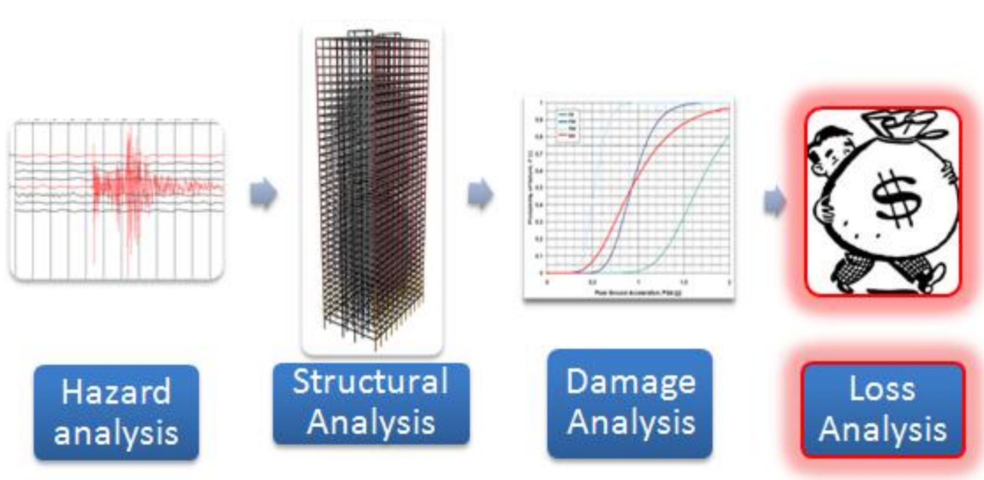


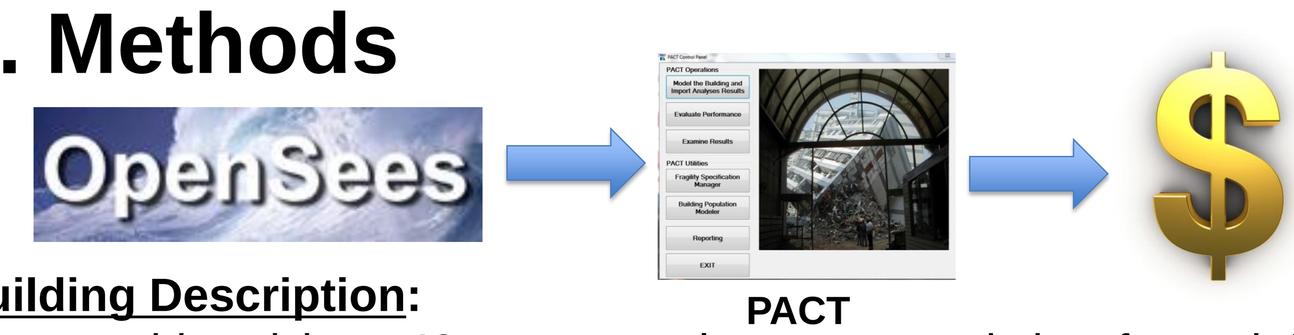
Figure 1 Stages of the PBEE methodology

2. Objectives

•Implement the PBEE methodology for this building to inform owners and insurers on the economic losses associated with this vintage of tall buildings

•Use the seismic response data from OpenSees as an input into PACT to an run an economic loss estimate

3. Methods



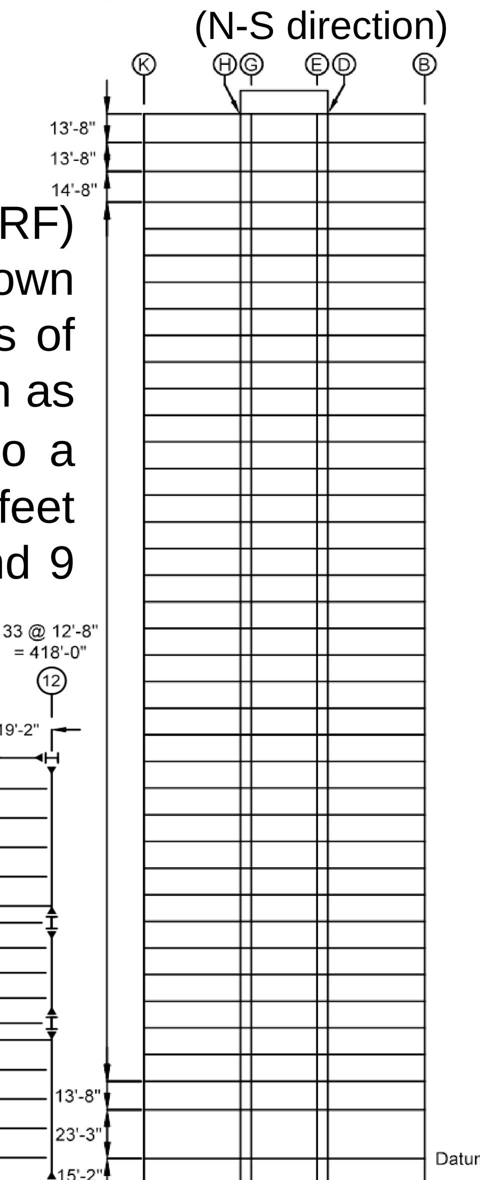


Figure 3 Elevation View (N-S direction)

Building Description:

The considered is a 40 story, steel moment resisting framed (MRF) building used in this assessment was completed in 1973 in downtown San Francisco. The basic building plan is regular with dimensions of 128 ft 4 in. by 198 ft 4 in. with varying bay spacing in each direction as seen in Figure 3. The total height is 496 ft 11 in. There is also a penthouse on top of the roof that consists of two systems, 80 feet apart, between girder lines H and D and column lines 4 and 5 and 9 and 10 as seen in Figure 4.

Data from OpenSees Model:

- 2 Hazard Levels
  - •Service level
  - •Design Level
  - ❖20 Ground Motions
- Loma Prieta Case Study
  - •3 Ground Motions
- 2 Earthquake Directions:
  - •Fault Normal and Parallel

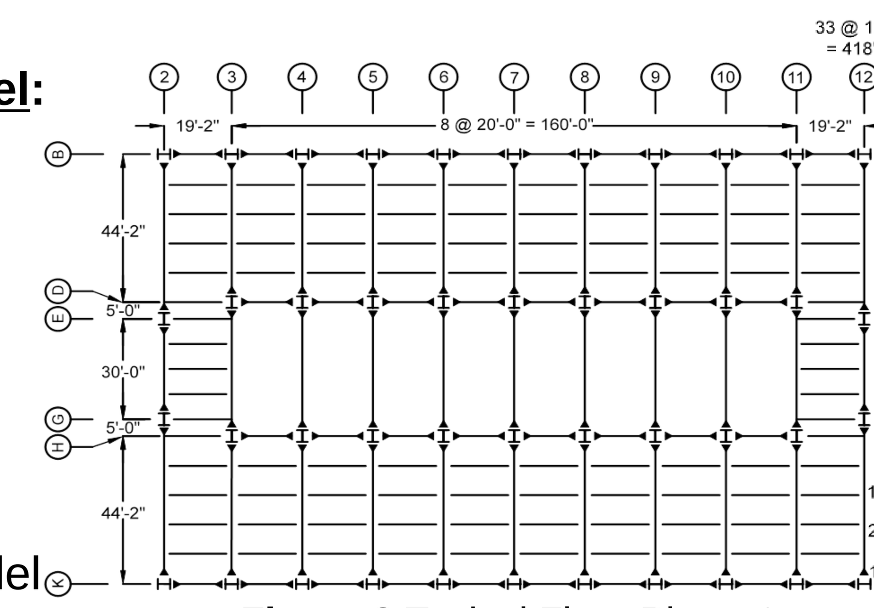


Figure 2 Typical Floor Plan

- Peak demand parameter values for all the ground motions in the hazard levels and the Loma Prieta case study were extracted from the structural analysis:
  - •Story drift Ratio
  - •Floor Velocity
  - •Floor Acceleration
  - •Residual Drift Ratio

PACT Model:

A PACT non-linear, intensity-based assessment was performed on the 40 story SMRF building. In order to simplify the model, the following assumptions were made:

- • The basement and penthouse were not included in the model
- •The floor velocity for the first floor was assumed to be the same as the second floor
- •The non-structural quantities in the building were generated using the Normative Quantity Excel Worksheet (ATC 2012c)) and were assumed to be consistent throughout all the floors except for the first floor

4. Results

Table 1 Hazard Levels PACT Results

	Repair Cost	Downtime	
		Parallel	Serial
Service Level (SL)	$5,260,000	7 days	147 days
Design Level (DL)	$352,287,749	1822 days	1822 days

Table 2 Loma Prieta Case Study PACT Results

	Repair Cost	Downtime	
		Parallel	Serial
Loma Prieta (LP)	$1,481,578	2 days	42 days

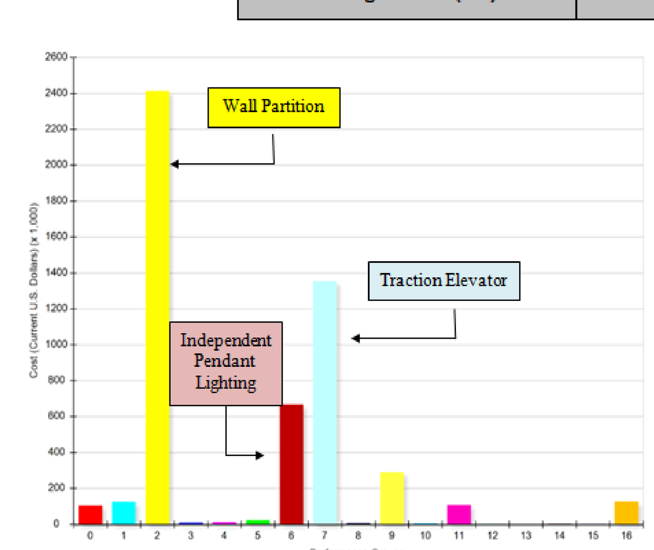


Figure 4 SL Repair Cost Contributors

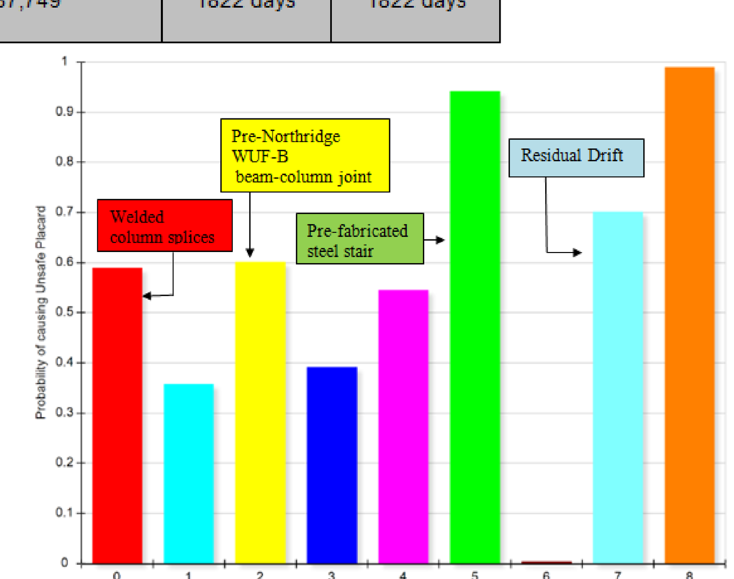


Figure 5 DL Unsafe Placarding Contributors

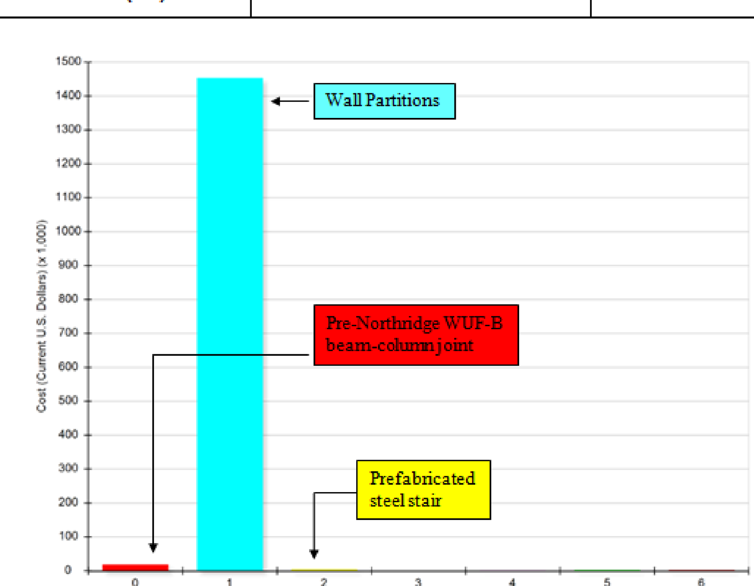
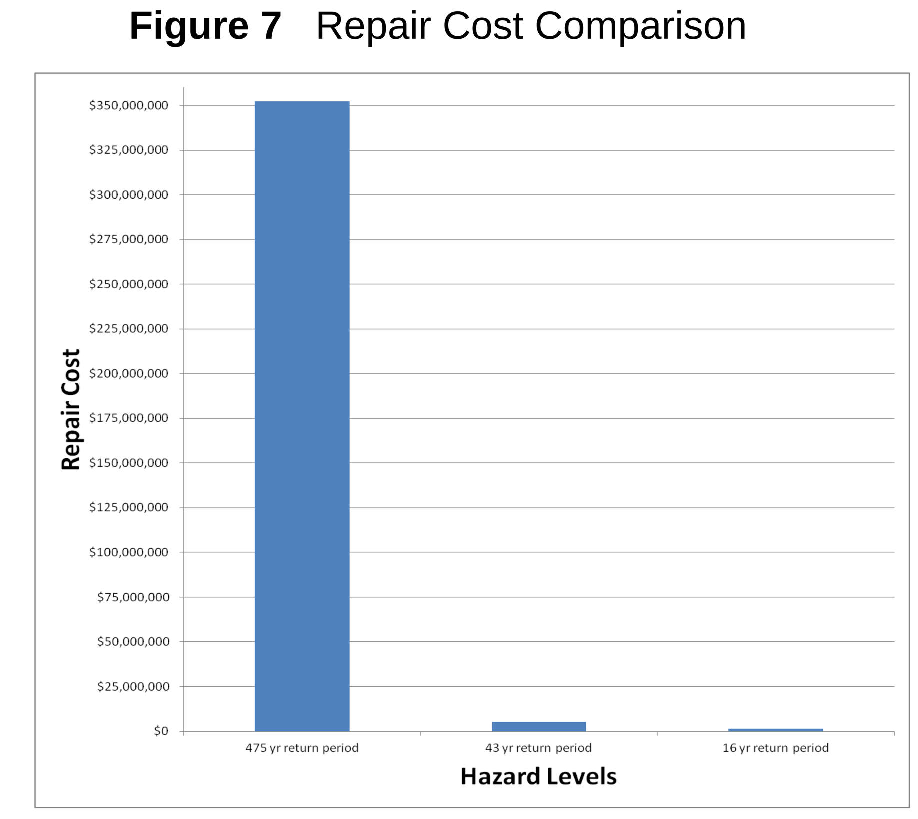


Figure 6 LP Repair Cost Contributors

Figure 7 Repair Cost Comparison



5. Conclusions

- Without being able to compare the results to actual data from the 1989 Loma Prieta earthquake, building's repair cost was higher than expected at $1.63 per square foot.
- In the service level, the building performed poorly since spending $5.2 million every 43 years is not economically feasible for the owner.
- The performance of the 40 story steel MRF building under earthquake shaking levels consistent with the design level and above generate many damages and high repair costs
- In order to reduce post-earthquake repair costs and downtime, structural retrofits should be considered.
- Future Work: 1) Compare the Loma Prieta case study results with typical repair cost, downtime, and damage types for tall buildings and 2) asses building response and PACT economic loss for non-ductile connections and upgraded structural systems

6. Acknowledgments

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