State of California
Seismic Safety Commission

Memo

To: Seismic Safety Commissioners

From: Richard McCarthy
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Subject: Existing Tall Buildings Case Study

Background

Several hundreds of buildings 20 stories or more in height were designed and constructed in highly seismic metropolitan regions of California from 1960 through 1990. During this time, earthquake-resistant design procedures were not as fully developed as they are today. These buildings are occupied by hundreds and in most cases thousands of people, and house the offices and headquarters of many organizations, businesses and corporations that contribute significantly to the economy of California. The seismic performance of these existing tall buildings is being investigated as part of an expanded program conducted by the Pacific Earthquake Engineering Research (PEER) Center under its Tall Buildings Initiative (TBI) program. The purpose of the expanded research program is to understand the seismic performance of these vintage tall buildings, and to explore efficient and economical strategies to improve their seismic performance, if vulnerabilities are identified.

As part of a project jointly funded by the California Office of Emergency Services and the Pacific Earthquake Engineering Research Center (PEER), a 35-story steel building located in San Francisco and designed in 1968 was selected as a case study for detailed seismic evaluations and retrofit studies. Three primary earthquake hazard levels were considered. Several different high fidelity numerical models were developed in accordance with recommendations of ASCE 41-13 and other relevant guidelines, and three-dimensional nonlinear time history analyses were performed. Analysis results were evaluated using current methodologies and performance criteria outlined in guidelines ASCE 41-13, FEMA 351 and FEMA P-58.

The analysis results revealed that the case study building would perform well, with modest nonstructural damage under small, frequent events, but that even moderate shaking would likely result in red tagging of the building and necessitate lengthy and costly repairs. Earthquakes of the intensity considered in the design of tall buildings today would likely result in damage where repair might be infeasible, or where collapse was likely. Such findings are not new. In this study, however, considerable effort was directed at investigating the technical and economic feasibility of retrofit measures that might mitigate the vulnerabilities identified.

A number of low cost, relatively simple approaches were explored, as well as more costly and complex solutions that use supplemental energy dissipation devices. The study showed that retrofit could improve the seismic safety and performance of the case study building substantially. An analysis measuring loss, using a performance-based earthquake engineering approach, further demonstrated the cost-efficiency of the proposed retrofit strategies for this case study tall building.

The study recommendations additional investigations of other existing tall buildings in California, with emphasis on evaluating and improving guidelines for assessing the risk they pose and for retrofits that would improving their safety and resilience.

This study was the recipient of a 2016 Award of Merit for Research Studies by the Structural Engineers Association of California.

Recommendation

Staff recommends that the Commissioners listen to Dr. Steven Mahin's presentation and be prepared to ask questions.