EXPERIMENTAL AND NUMERICAL ANALYSIS OF A STRONGBACK FRAME AS RETROFIT OF A MOMENT-RESISTING FRAME

Affiliated Principal Investigator: Larry Fahnestock, U. of Illinois at Urbana-Champaign
Co-Principal Investigators: Barbara Simpson, Oregon State University, James Ricles, Richard Sause, Lehigh University
Student Investigators: David Rivera, Oregon State University, Jessica Duke, Lehigh University, Zhuoqi Tao, Setare Hajardasvadi. U. of Illinois at Urbana-Champaign
Japanese Collaborators: Masahiro Kurata, Kyoto University, Akira Nishitani, Waseda University, Taichiro Okazaki, Hokkaido University, Yohsuke Kawamata, NIED/E-Defense

ABSTRACT

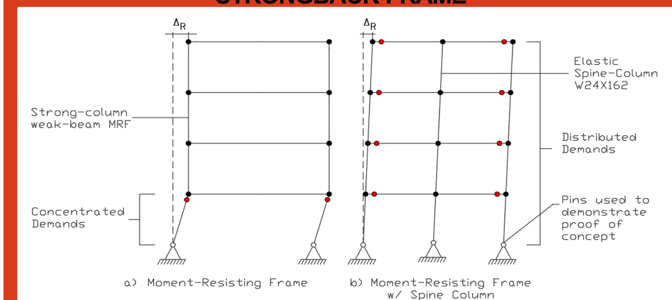
Steel moment-resisting frames (MRF) are widely used in the United States to resist seismic forces. MRFs have many advantages, including high ductility, architectural versatility, and vetted member and connection detailing requirements. However, MRFs require large members to meet story drift criteria. The low elastic stiffness of MRF can also result in greater drift-induced nonstructural damage compared to stiffer systems. Moreover, strong-column-weak-beam requirements can result in significant member sizes, and – even in the cases where strong-column-weak-beam requirements are satisfied – MRFs can still be vulnerable to story mechanisms in one or a few stories. Recently, the concept of a strongback has been utilized successfully to delay or prevent story mechanism behavior in braced frames. The strongback is represented by a steel truss or spine column that is designed to remain essentially elastic, thus allowing the system to transfer inelastic demands across stories. Although the strongback can result in more uniform story drifts and reduced drift response, the elastic nature of the strongback can result in amplified higher-mode force demands. This study characterizes the dynamic response of the retrofit of an MRF with a strongback spine, particularly the higher-mode accelerations and force demands. The base MRF is designed and specially detailed to dissipate energy. The addition of the strongback could also result in relaxed strong-column-weak-beam design requirements. Story drifts and higher-mode forces are compared for strongbacks with varying stiffness and strength with respect to the MRF. Several ground motions are considered to determine which cases produce the largest drifts and higher-mode forces. The results of this study will be used to inform the design of a shake table test using the strongback as a retrofit scheme at E-defense.

ACKNOWLEDGEMENTS

The work reported on this poster titled, "Experimental and Numerical Analysis of a Strongback as a Retrofit of a Moment-Resisting Frame" was supported in part by National Science Foundation (NSF) under grant number CMMI-1926365 as an award to the Principal Investigator, Dr. Larry Fahnestock. Special thanks to my advisor Dr. Barbara Simpson and Principal Investigator, Larry Fahnestock, from the University of Chicago Urbana-Champaign and Co-Principal Investigators Dr. Richard Sause and Dr. James Ricles from Lehigh University as well as their students. The writers also wish to express their appreciation to our Japanese counterpart Masahiro Kurata from Kyoto University, Akira Nishitani from Waseda University, and Taichiro Okazaki from Hokkaido University. Lastly, the writers would like to thank Yohsuke Kawamata for helping us coordinate the experimental testing at E-Defense. The findings, opinions, recommendations and conclusions in this paper are those of the authors alone and do not necessarily reflect the views of others, including the sponsors.

REFERENCE: Simpson, B. G. (2017). *Design Development for Steel Strongback Braced Frames to Mitigate Concentrations of Damage* (Doctoral dissertation). Berkeley, CA. University of California, Berkeley.

STRONGBACK FRAME



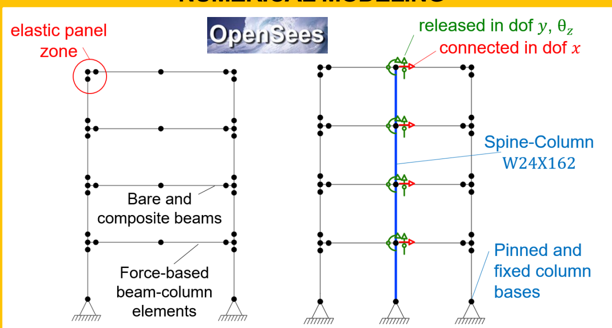
3-Story MRF provided by the Japanese, 4th Story added by US

SHAKE TABLE TESTING AT E-DEFENSE

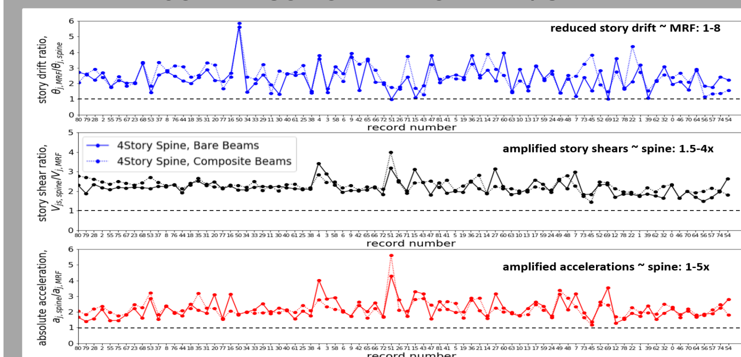
Payload project for shake-table testing of a base-isolated and fixed-base MRF at E-Defense. US-team will lock base-isolated building to test a specimen with a spine-column and FLC connections.

Enhancement of Resilience for Tokyo Metropolitan Area supported by NIED and the Ministry of Education, Culture, Sports, Science, and Technology (MEXT) in Japan

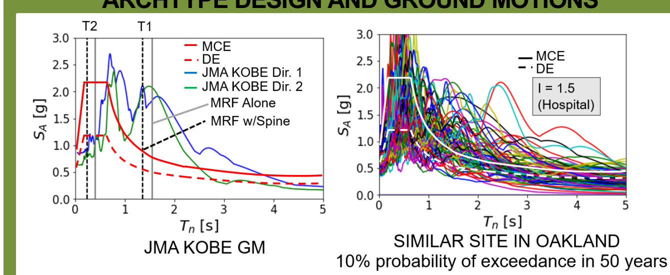
NUMERICAL MODELING



COMPARISON OF MRF TO MRF W/ SPINE

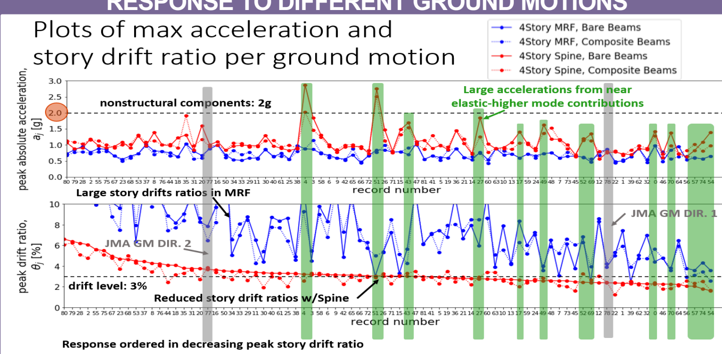


ARCHTYPE DESIGN AND GROUND MOTIONS

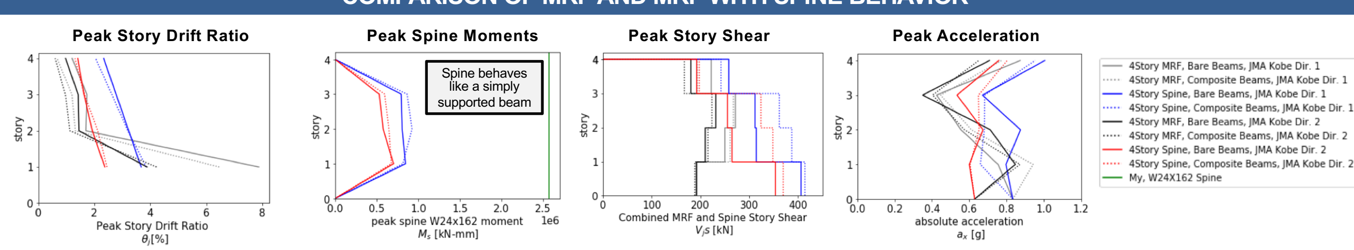


Site-specific ground motions for Oakland selected for a probability of exceedance of 10% in 50 years [Baker, 2010]

RESPONSE TO DIFFERENT GROUND MOTIONS



COMPARISON OF MRF AND MRF WITH SPINE BEHAVIOR



Oregon State University | College of Engineering