18th World Conference on Earthquake Engineering (WCEE 2024)

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IDD - SEISMIC ISOLATION AND ENERGY DISSIPATION/RESPONSE CONTROL DEVICES

IDD4: Friction-Based Structural Components for High-Performance Buildings

In 2011, strong earthquakes occurred in New Zealand. Approximately 1240 buildings were demolished in the central city of Christchurch. For five years, the Canterbury Earthquake Recovery Authority led and coordinated the response and recovery efforts. The damage repairs required after the earthquakes and the associated downtime highlighted the need for the development of low-damage high-performance earthquake-resilient buildings.

Friction-based structural components can be placed in the seismic load path of buildings to limit the building responses and reduce the earthquake damage in the structural and non-structural components. Buildings with these components have the potential to accelerate the post-earthquake functional recovery of a community. Friction-based structural components have been used in various structural systems, including precast concrete structures, reinforced-concrete coupled wall systems, steel braced frames, steel moment-resisting frames, self-centering moment-resisting frames, and timber rocking walls. Friction-based structural components such as friction pendulum base isolators, friction dampers, negative stiffness friction dampers, and self-centering braces with friction-based energy dissipation have been developed, tested, and implemented in practice, as well.

This session aims to disseminate research findings and practical applications related to friction-based structural components used to improve the seismic performance of buildings. Attendees will learn about the state-of-research, state-of-practice, and the potential benefits of friction-based structural components for seismic resilience. Innovative and practical friction-based technologies will be presented. Results from numerical and experimental studies on the seismic response of friction-based structural components will define the state-of-research. Practical applications of friction-based structural components in new and existing buildings will define the state-of-practice.

Seismic Response of Core Wall Building with Friction-Based Force-Limiting Connections

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ABSTRACT

This presentation disseminates numerical earthquake simulation results of an eighteen-story reinforced-concrete core wall building with force-limiting connections. Force-limiting connections allow relative movement between the seismic force-resisting system (SFRS) and the gravity load-resisting system (GLRS) of the building and enable controlled force transfer between the two systems. Force-limiting connections for buildings with planar SFRS[1] and core wall SFRS[2] have been developed to limit the magnitude and variability of the seismic response. The force-limiting connection developed for core wall buildings is termed the Modified Friction Device (Modified FD) and generates predetermined discrete variable friction forces at target design connection displacements. A three-dimensional model of an eighteen-story reinforced-concrete core wall building is developed in Opensees. Numerical earthquake simulations of the building model are performed considering eleven design-level far-field ground motions. The seismic response of the building model with the Modified FDs is compared with the seismic response of the building model with conventional monolithic connections. The numerical simulation results show that the use of the Modified FD mitigates the seismic response amplification due to higher modes. This results in the reduction of the magnitude and the variability of the peak floor acceleration response, the peak base shear response, the peak story torsion response, and the peak wall pier axial strain response without the increase of the story drift demands.

Keywords: friction-based force-limiting connection; reinforced concrete core wall system; multi-story buildings; higher mode responses; floor accelerations.

[1] Georgios Tsampras, Richard Sause, Dichuan Zhang, Robert B. Fleischman, José I. Restrepo, David Mar, and Joseph Maffei (2016), "Development of deformable connection for earthquake-resistant buildings to reduce floor accelerations and force responses", *Earthquake Engineering & Structural Dynamics*, 45 (9), 1473–1494, doi:10.1002/eqe.2718.

[2] Kaixin Chen, Georgios Tsampras, and Kyoungyeon Lee (2023), "Structural connection with predetermined discrete variable friction forces." *Resilient Cities and Structures*, Resilience of Structures to Earthquakes, 2 (1): 1–17. https://doi.org/10.1016/j.rcns.2023.02.006.