BRACELESS SEISMIC RESTRAINT

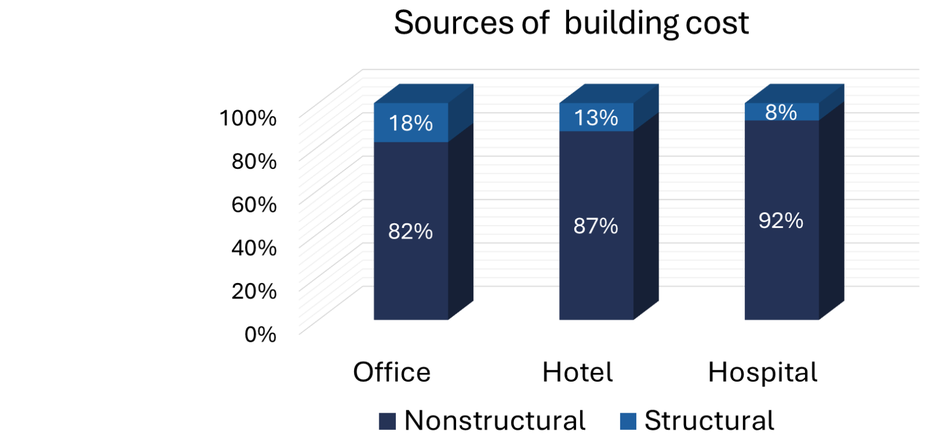
for suspended nonstructural elements

Bryan Chalarca[1], Daniele Perrone[2], André Filiatrault[3], Roberto Nascimbene[4], Emanuele Brunesi[5]

[1] University of Pavia, Pavia, Italy
[2] University of Salento, Lecce, Italy
[3] University at Buffalo, State University of New York, Buffalo, United States
[4] University School for Advanced Studies IUSS Pavia, Pavia, Italy
[5] European Centre for Training and Research in Earthquake Engineering, Pavia, Italy

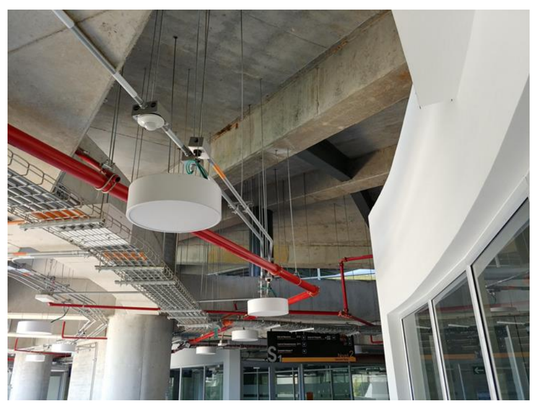
Problem

- Nonstructural elements play a crucial role in a building's overall seismic performance due to their high initial investment cost and significant vulnerability to seismic activity.



(a)

- Suspended nonstructural elements (SNSEs), such as piping systems, cable trays, lighting, and ducting systems are acceleration-sensitive components typically attached to the supporting structure via the slab or structural elements above.



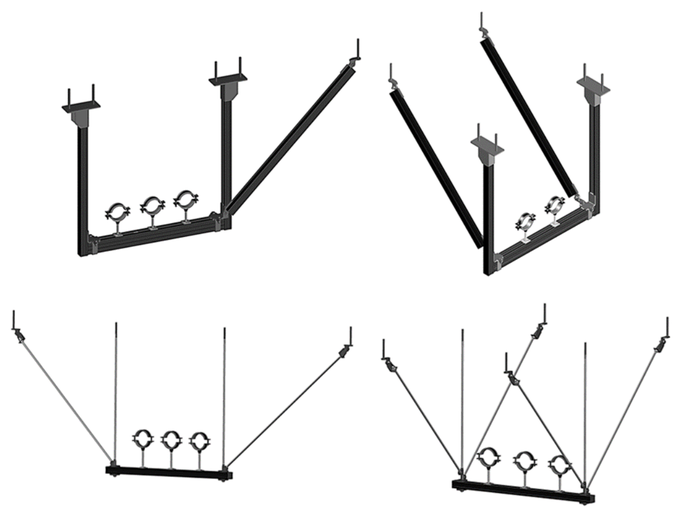
- In SNSEs, gravity loads are typically supported by vertical hangers, while lateral loads are resisted by trapeze restraints or sway bracing. Seismic forces on SNSEs can lead to an inelastic response in the lateral restraints, causing potential damage to both the SNSEs and their restraint elements.

(b)

- Complex SNSE layouts may require numerous anchoring points for both gravity and seismic supports, complicating the efficient distribution of support and restraint elements.

Current solution

- Conventional seismic restraint systems for SNSEs consist of bracing elements, such as cables, channels, rods, angles, pipes, or flats, designed to restrain the SNSE in orthogonal directions (i.e., transverse and/or longitudinal).

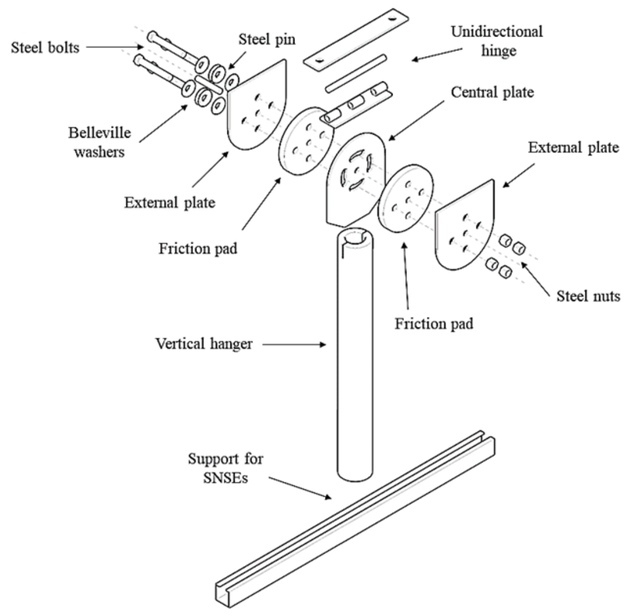


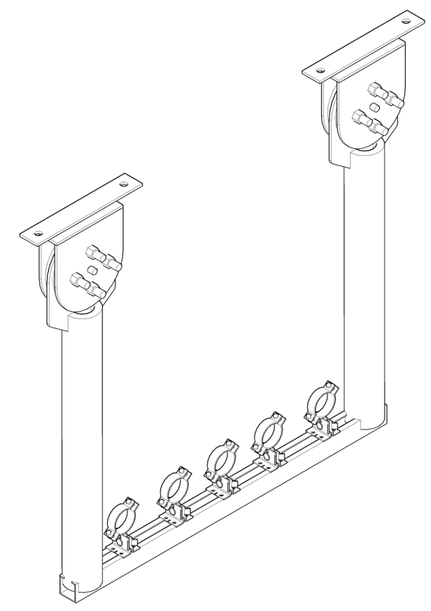
(c)

- Several studies have concluded that, following strong seismic events, conventional seismic restraints often sustain significant damage, requiring repair or replacement of the affected components.

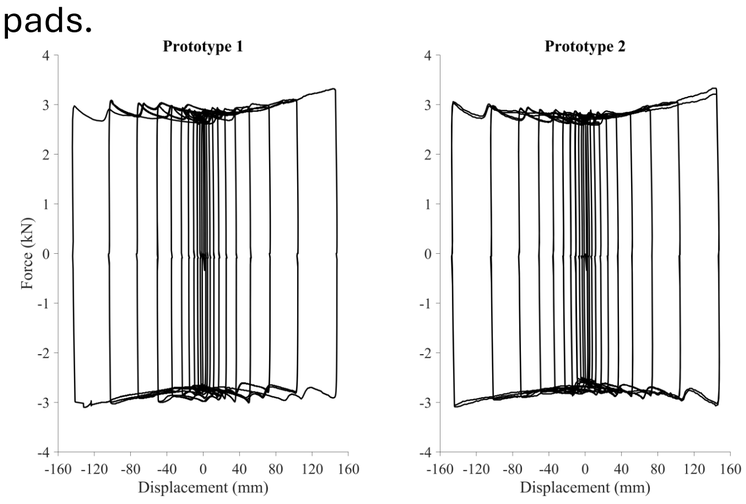
Innovative solution: Braceless Seismic Restraint

- The braceless seismic restraint aims to enhance the seismic performance of SNSEs by increasing the energy dissipation capacity of the lateral restraint system through supplemental damping, which reduces residual deformations and damage to both the restraints and suspended elements. Additionally, the absence of bracing elements facilitates better architectural integration, minimizing the area needed for restraint installation and reducing the number of anchoring points.

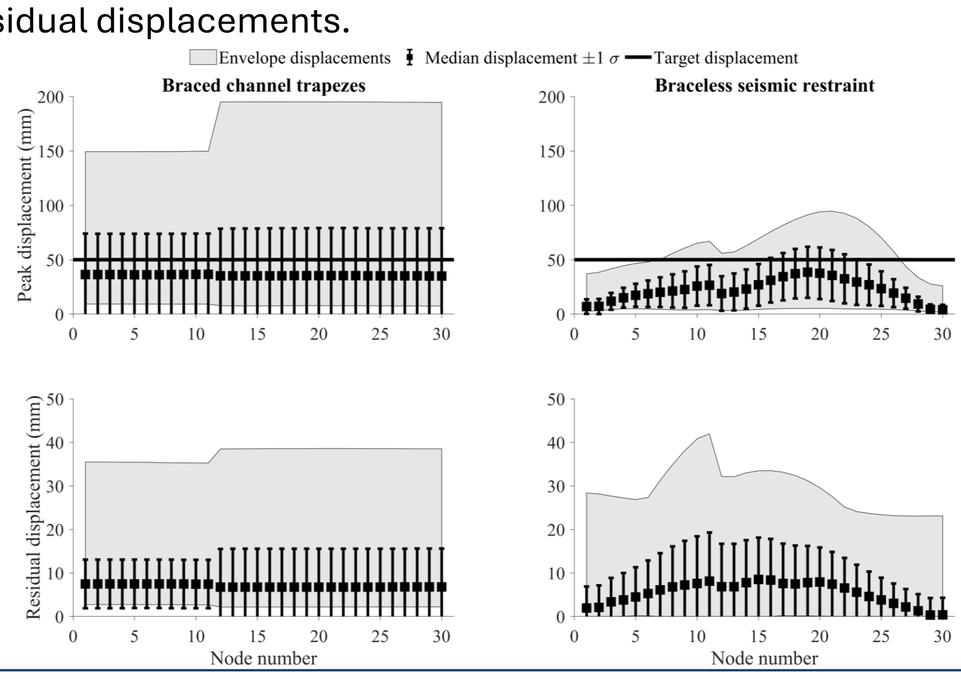




- The braceless seismic restraint consists of a rotary friction damper constructed with three steel plates: two external plates connected to a unidirectional hinge at the top, allowing rotation out-of-plane relative to the damper's rotation, and a central plate with slotted holes attached to the vertical hanger. These plates are held together by a central steel pin, enabling rotation of the vertical hanger. Nonmetallic friction pads are positioned on either side of the central plate, with a normal force applied through steel bolts and nuts. During a seismic event, once the force surpasses the damper's activation threshold, the system rotates around the central pin, dissipating energy as heat through friction between the central plate and the friction pads.



- An experimental campaign demonstrated a stable hysteresis behavior, exhibiting an almost perfect elastic-perfectly-plastic loop typical of friction damping. Additionally, numerical analyses simulating a complete suspended piping system using both conventional braced channel trapezes and braceless seismic restraints indicated that the proposed system offers improved seismic performance, resulting in reduced peak and residual displacements.



(d)

References: (a) Taghavi, S., Miranda, E. (2003). Response assessment of nonstructural building elements, PEER Report 2003/05, Pacific Earthquake Engineering Research Center, Berkeley, United States. (b) Courtesy of the New Zealand Ministry of Business, Innovation & Employment. (c) Perrone *et al*. (2020). Experimental seismic response evaluation of suspended piping restraint installations. Bulletin of Earthquake Engineering 18. (d) Chalarca *et al*. (2022). Seismic Response of a Braceless Seismic Restraint System for Suspended Nonstructural Elements, 5th International Workshop on the Seismic Performance of Non-Structural Elements SPONSE, Stanford, United States.