Multidirectional negative-stiffness isolation system offers improved seismic protection

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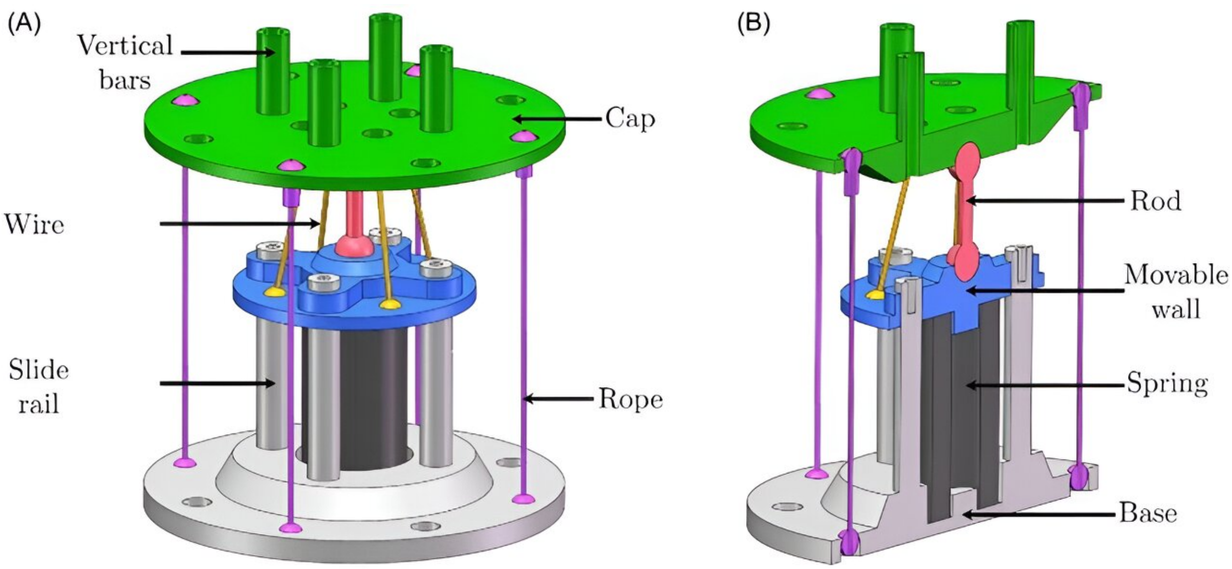

Three-dimensional virtual prototype model of the proposed negative-stiffness device: (A) full view and (B) cross-sectional view. Credit: *International Journal of Mechanical System Dynamics* (2024). DOI: 10.1002/msd2.12118

Seismic isolation is crucial for safeguarding buildings from earthquake damage. While traditional systems are effective, they struggle with multidirectional forces and adequate damping. These challenges highlight the need for innovative solutions that provide enhanced protection against the complex dynamics of seismic activity. Addressing these issues necessitates in-depth research into advanced seismic isolation technologies.

A research team from Sapienza University of Rome has introduced a cutting-edge negative-stiffness device for seismic isolation, detailed in a 2024 publication in the *International Journal of Mechanical System Dynamics*. The device was invented and patented in 2021 by the team, with the prototype being manufactured and tested in Rome in 2021 and 2023. The current paper reports a set of simulation results based on different models carried out during the study abroad of Wei Dai at Sapienza University. The study examines the nonlinear response of this multidirectional negative-stiffness device, which modifies the apparent stiffness of supported structures, improving their resistance to seismic forces.

The innovative design of the negative-stiffness device enhances seismic protection by offering multidirectional negative stiffness and energy dissipation. It features a lower base, upper cap, connecting rod, vertical movable walls, and a precompressed elastic spring, integrated with circumferentially arranged ropes and inclined shape memory alloy (SMA) wires. This configuration reduces seismic forces by limiting the acceleration and forces transmitted to the superstructure.

Using a two-step semi-recursive multibody dynamic modeling approach, the research optimized the negative-stiffness device design through extensive parametric studies. Findings show that adjustments in rod length, wire inclination, and precompression force greatly impact performance, providing key insights for future seismic isolation applications. This negative-stiffness device represents a promising solution for enhancing the resilience of buildings in earthquake-prone areas.

This innovative negative-stiffness device shows great potential for seismic isolation in various structures, especially in high-seismic-risk areas. Its capacity to deliver multidirectional protection and enhanced damping without external power makes it a valuable addition to existing seismic safety strategies. Future research will focus on practical implementation and integration of this technology into current building designs to further improve earthquake resilience.

More information: Wei Dai et al, Nonlinear response of a multidirectional negative-stiffness isolation system via semirecursive multibody dynamic approach, *International Journal of Mechanical System Dynamics* (2024). DOI: 10.1002/msd2.12118

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