INFLUENCE OF GEOMETRIC SCALING ON THE ADAPTIVE BEHAVIOR OF VARIABLE CURVATURE FRICTION PENDULUM BEARINGS

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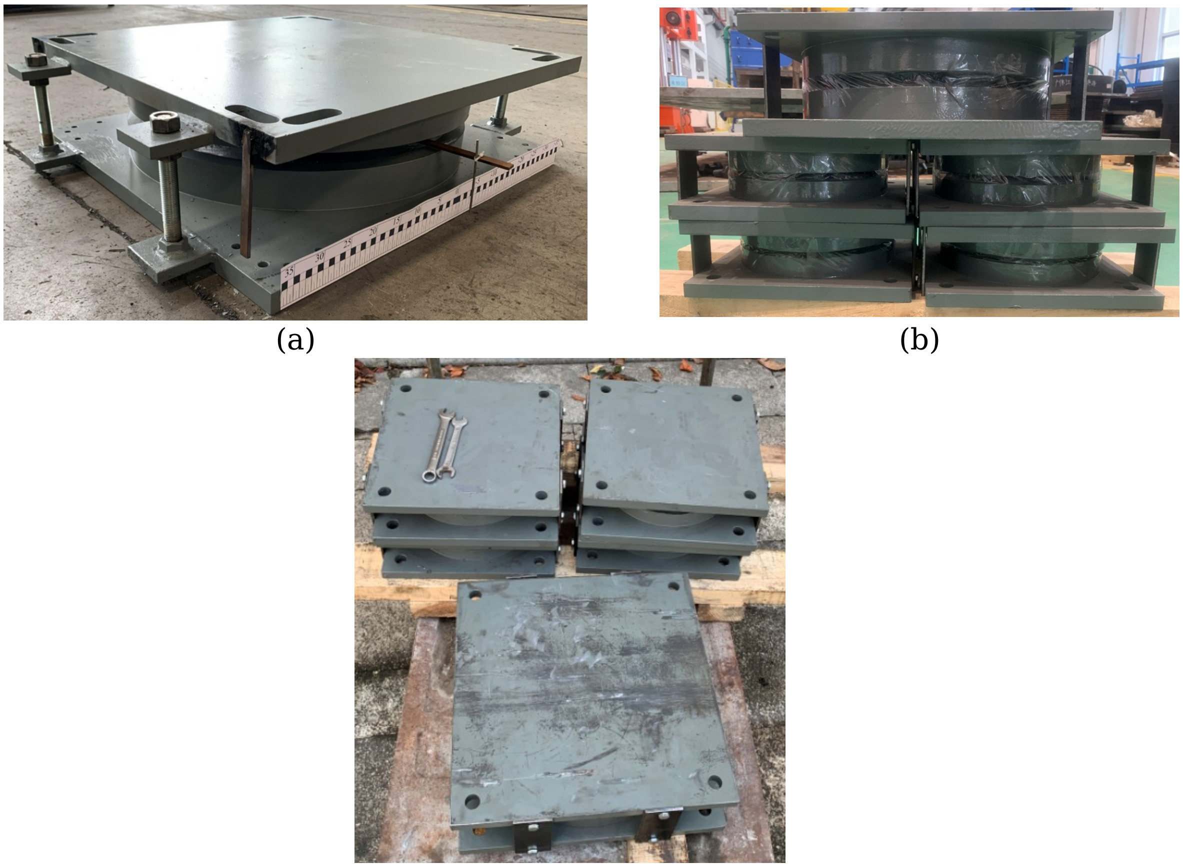
Extended Abstract

Seismic isolation systems with adaptive behavior are essential for ensuring structural resilience under varying earthquake intensities. Variable curvature friction pendulum bearings (VC-FPBs) represent an advanced form of adaptive isolation, providing displacement-dependent stiffness and enhanced energy dissipation. Despite their potential, experimental studies on VC-FPBs are often limited to small-scale models, creating uncertainty regarding full-scale performance due to geometric and frictional effects.

This study investigates the influence of size on the seismic performance of VC-FPBs through combined experimental testing and numerical simulation. As shown in Figure 1, five specimens spanning full-scale, mid-scale, and small-scale dimensions were subjected to cyclic quasi-static loading to evaluate force–displacement responses, adaptive stiffness characteristics, and frictional behavior. Observations indicated that unmodified small-scale specimens failed to reproduce the adaptive stiffness transitions observed in full-scale devices, primarily due to reduced height differences in the variable curvature profiles, confined stress–strain distributions within the friction pads, and scale-dependent wear mechanisms.



(a) (b)

(c)

Figure 1. Specimen photoes for (a) S1, (b) S2 and S3, and (c) S2M and S3M

To address these limitations, modified mid- and small-scale specimens (S2M and S3M) were developed with deepened curvature profiles and enlarged spherical contact regions. These modifications successfully restored the intended stiffness-softening behavior. Finite element simulations captured the experimental trends, highlighting that stress penetration depth and localized deformation mechanisms vary significantly with scale. Notably, smaller specimens exhibited broader, more uniform stress distributions, while larger specimens showed concentrated nonlinear behavior and surface wear effects, affecting the effective friction coefficient and overall adaptive response.

The findings demonstrate that direct geometric downscaling of VC-FPBs is insufficient to replicate full-scale performance. Instead, careful geometric modifications and consideration of friction pad behavior are critical for accurately representing full-scale adaptive properties in scaled models. This work provides practical guidelines for the design, testing, and numerical validation of variable friction pendulum bearings, contributing to more reliable seismic isolation strategies for resilient structures.

***Keywords**: Variable curvature friction pendulum bearing, size effect, seismic isolation, adaptive stiffness, cyclic quasi-static testing, finite element simulation*