DOI	https://doi.org/10.1002/eqe.3436
Title	Damping implementation issues for in-structure response estimation of seismically isolated nuclear structures (NPP)
Background	
Why this paper? How'd you find it?	Rayleigh damping is often seen as a one-size-fit-all solution for structural modeling. Many researchers and practicianers, myself including, use Rayleigh damping for even structures with complicated damping behaviors, such as those using fluid viscous dampers or isolation.
Study Objective	Properly model complex damping behaviors in isolated nuclear power plants
Intended gaps to fill	- Viable solutions to remedy "damping leakage" that occurs in models -
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Journal / Field	Earthquake Engineering and Structural Dynamics
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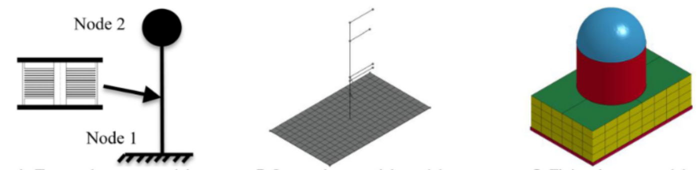
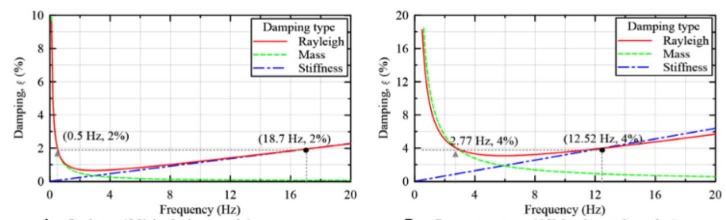
Historical Context	Spurious damping forces may arise when using Rayleigh damping. This is well studied and brought up in detail in Keri and Polanco (2008) and Hall (2005).
Relationship to SEMM	Rayleigh damping as discussed in CE 225, isolation and damping as discussed in CE 223, nonclassical damping as discussed in CE 228
Methods	
Given:	3 models of base-isolated NPP: two-node, lumped mass, detailed FEM
Find:	Structural response
Experimental Design	-Three models built (two-node, lumped mass stick, FEM), tested under 30 sets of ground motions. A myriad of damping strategies are tested. Collect mean response: isolator displacement, fixed period acceleration, spectral acceleration
Test Subjects	Some damping method trialed: Modal damping, mass proportional, stiffness proportional (all at various frequencies corresponding to different directions), Rayleigh damping with and without stiffness updating, Rayleigh damping applied locally to superstructure vs. isolators at various levels
Results	
Baseline for comparison	No supplemental damping results? No idea what "under" and "over" damped are comparing to
Metric for comparison	mean response: isolator displacement, fixed period acceleration, spectral acceleration
Difference from baseline	Frequencies: w/in 0.9% difference and 0.04Hz stdev, but FDD and SSI missed the fundamental lateral mode; Mode shapes (FDD and SSI only): most MAC > 0.9, and MAC decreased for higher order modes; Damping: (SSI only) stdev of 0.2-0.5%
Conclusions	
Authors'	Modal damping can cause isolation regime to be overdamped even when specifying modal damping only to higher modes (superstructure-related). Mass-proportional and Rayleigh contributes to small isolator displacement (leakage), and can be remedied by utilizing stiffness proportional damping to the superstructure. Acceleration is more affected than displacement.
Yours	This paper is all over the place. Utilize local-region damping when possible to prevent leakage. Specify stiffness-proportional damping to prevent leakage. Personally, I work with designs where moat impact is important, thus it might be prudent to choose damping methods that minimize damping in the isolator regime.
Applications	Dynamic modeling of isolated structures.



A Two-node macro model B Lumped mass stick model C Finite element model



A Isolator (2% isolation mode) B Superstructure (4% horizontal modes)

$$c = \begin{pmatrix} m_b & 0 \\ 0 & m_s \end{pmatrix} \left[\sum_{n=1}^{N} \frac{2\xi_n \omega_n}{M_n} \begin{Bmatrix} \phi_{nb} \\ \phi_{ns} \end{Bmatrix} \{ \phi_{nb} \ \phi_{ns} \} \right] \begin{pmatrix} m_b & 0 \\ 0 & m_s \end{pmatrix}$$