Damping FAQ

This page is devoted to frequently asked questions (FAQ) related to damping.

On this page:

How is damping specified for different parts of the structure?

**Answer:** The Additional Material Damping menu (Figure 1) allows users to specify different material-damping properties for each material present in the analytical model.

![Additional Material Damping menu](image)

Figure 1 - Additional Material Damping menu

Can the software calculate the percentage of critical damping achieved by dampers added to a model?

**Answer:** CSI Software does not directly report the percentage of critical damping achieved by adding discrete dampers to a model. However, users may estimate the percentage of critical damping through either of two approaches:

1. For response-spectrum analysis, the damping for each mode is reported in the Response Spectrum Modal Information table, which users may access through Display > Show Tables > Analysis Results > Structure Output > Modal Information > Table: Response Spectrum Modal Information. The linear, or effective, damping of these dampers contributes to this value, which may be used for estimation purposes.
2. When performing time-history analysis, a single degree-of-freedom approximation method is described in Dr. Edward L. Wilson’s text Static and Dynamic Analysis of Structures (Energy Dissipation in Real Structures, page 228). Here, a static displacement is applied to the structure, then released such that the structure vibrates with displacement decay. The attributes of this decay pattern may be used to calculate critical damping ratio.

Why do results differ between steady-state and modal analyses when damping is apparently consistent?

**Extended Question:** Why does the deflection at resonance not match between results obtained using steady-state analysis, with both mass- and stiffness-proportional damping at 0.05, and modal analysis, with 0.05 constant damping?
**Answer:** Please note that setting a constant hysteretic damping with both mass- and stiffness-proportional damping set to 0.05 is not the same as setting a constant modal damping of 0.05. During steady-state analysis, CSI Software uses hysteretic damping. However, the question fielded concerns modal damping. As stated in the SAP2000 Analysis Reference Manual, for steady-state and power-spectral-density cases, the hysteretic damping matrix is calculated as a linear combination of the stiffness matrix, scaled by coefficient $d_k$, and the mass matrix, scaled by coefficient $d_m$. To approximate modal damping in terms of hysteretic damping, $d_m$ can be set to zero and $d_k$ can be calculated using the relation $d_k = 2d_1$, where $d_1$ is the modal damping ratio. For example, if a constant 5% modal damping is used for all modes, the equivalent hysteretic damping value is a constant $d_k = 0.10$. For each mode, this leads to approximately the same level of response at resonance.

**Does the hysteretic hinge include damping, and if so, does it double when specified in load-case definition?**

**Answer:** If a nonlinear analysis is performed, and energy dissipates within nonlinear hinges, then load case damping should be reduced to prevent double-counting of energy dissipation. Energy dissipation which occurs outside of the hinges should still be modeled using the load-case damping.

Further discussion: damping is useful for simulating energy dissipation that is not explicitly modeled within a structural system. Nonlinear behavior such as friction is an example of such a mechanism. The plastic-hinge formulation will explicitly account for energy dissipation, within the hinge region, which is caused by yielding during dynamic analysis.

**References**