Caltrans vs. fiber hinge

What is the difference between a Caltrans hinge and a fiber hinge?

**Extended Question:** The Caltrans hinge appears to be conceptually similar to the fiber hinge in that both are based on strain compatibility and equilibrium of forces. As shown in Figure 3.7 of the *Caltrans Seismic Design Criteria v. 1.4*, the Caltrans hinge can be idealized as elastic-perfectly plastic. Does the software use this idealized model, and what are the main differences between the Caltrans and fiber hinge?

**Answer:** A comparison between these two hinge options is given as follows:

**Caltrans hinge**

The Caltrans hinge is a P-M2-M3 hinge based on the 3D interaction surface which defines coupling between axial and biaxial-bending behaviors. Its mathematical formulation and elastic perfectly plastic behavior distinguishes the Caltrans hinge from others. Similar to other P-M-M hinges, once loading conditions combine to induce yielding, plastic behavior follows an energy dependent moment-rotation curve which extends along the angle between M2 and M3, normal to its yield point on the interaction surface. Monotonic loading is best suited for this phenomenological approach. Significant hysteresis should be avoided in dynamic applications.

**Fiber hinge**

The fiber hinge is useful for defining coupled axial and biaxial-bending behavior in frame objects, though it follows a different approach. The cross section is discretized into a series of representative axial fibers which extend longitudinally along hinge length. Depending on the material in its tributary area, each fiber has a stress-strain relationship. Integrating behavior over the cross section, then multiplying by hinge length, provides axial force-deformation and biaxial moment-rotation relationships. The fiber hinge model is more accurate in that the nonlinear material relationship of each fiber automatically accounts for interaction, changes in along the moment-rotation curve, and plastic axial strain. A trade-off is that fiber application is more computationally intensive. Fiber hinges are ideal for dynamic behavior since they capture nonlinear hysteretic effects.

**How is I<sub>cr</sub> determined for Caltrans hinges?**

**Answer:** I<sub>cr</sub> represents the cracked moment of inertia, calculated through basic principles as follows:

\[
I_{cr} = \frac{M_p}{(C_p \times E)}
\]

where:

\[
C_p = \frac{(C_y \times M_p)}{M_y}
\]

and where:

- \(M_p\) = Plastic moment (idealized)
- \(C_p\) = Plastic curvature
- \(E\) = Modulus of elasticity
- \(C_y\) = Yield curvature
- \(M_y\) = Yield moment

**See Also**

- P-M2-M3 hinges article