EVALUATION OF CONCENTRIC BRACED FRAME MODELING METHODS

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Keywords: Braced frame, Gusset plate, Modeling, Fatigue, Initial imperfection

Special concentrically braced frames (SCBFs) are one of the structural systems resisting against lateral loads in seismic regions. Evaluating the performance of these systems requires accurate modelling of the braces. Various models have been developed to simulate the behaviour of the braces. Some of these methods are more accurate and sophisticated but some are simpler. All the methods attempt to implement buckling, tension yielding, and inelastic post-buckling response in the braces.

This paper focuses on different models to find out which methods are appropriate and practical to use in nonlinear analyses. These models use fiber section with imperfection as the physical model to define the behaviour of the braces. Out-of-plane buckling, low-cycle fatigue, and rigid end zone are also considered in the model. In addition to these specific parameters, gusset plates deformation could impact the out-of-plane buckling behavior of the brace. Hence, three methods are evaluated to simulate the out-of-plane behavior for gusset plates in OPENSEES. The pinned joint, fixed joint (Uriz et al., 2008), and nonlinear spring (Hsiao et al., 2013) models are shown in Figures 1 to 3. In the fixed joint model, the gusset plate between the rigid offset and the brace (the 2tp length) is modeled by fiber element.

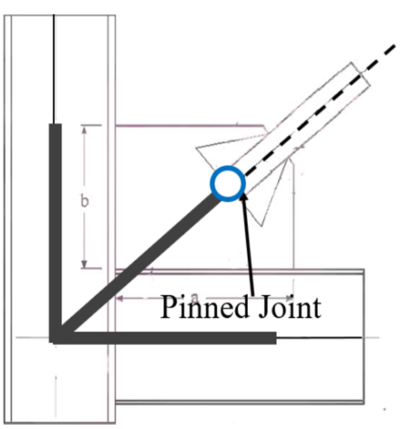

Figure 1. Pinned Joint Gusset.

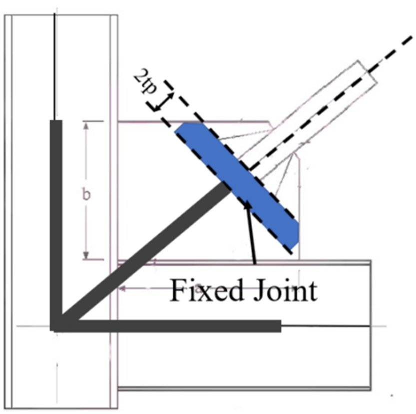

Figure 2. Fixed Joint Gusset (fiber Section).

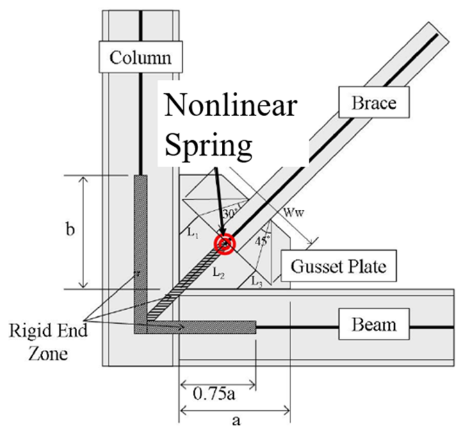

Figure 3. Nonlinear Spring Gusset (Hsiao et al., 2012).

The cyclic test on a two-story chevron-braced frame (Uriz et al, 2008) is analysed to evaluate the analytical models. Figures 4 and 5 illustrate the analytical model for the braced frame and gusset plate, and table 1 lists the properties of the sections.

The experimental and analytical results are compared in Figures 6 and 8. The results show that without the rigid endzone the structures exhibit low strength related to real behavior. Additionally, without low cycle fatigue the loss of strength after several cycles does not occur. Hence, the effects of low-cycle fatigue and the end rigid zone are essential to model braces.

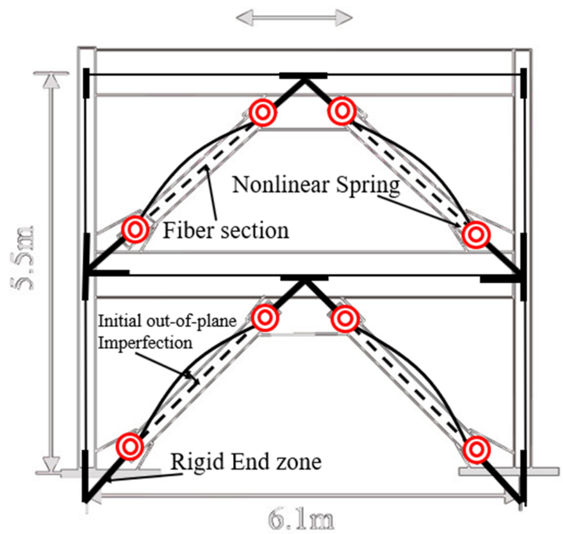

Figure 4. Illustration of braced frame modelling.

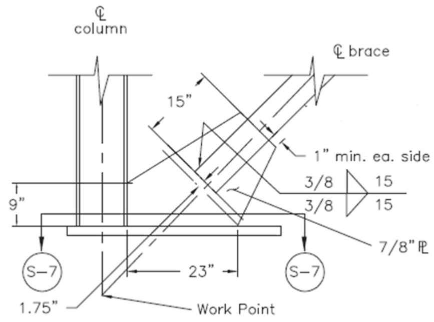

Figure 5. Illustration of gusset plate modelling.

Table 1. Section properties.

Member	Fy (ksi)	Fu (ksi)
Column (W10X45)	55.8	73.7
Beam (W24X117)	58	74.5
Brace (HSS 6X6X3/8)	60.6	65.9

According to the results, implementing the model including the nonlinear spring gusset related to other models accurately predicts the global behavior of the braced frame. By converting the gusset model from the nonlinear spring to the fixed joint, the results have no remarkable change; however, the pinned joint gusset model underestimates the brace strength. To conclude, the model with the nonlinear gusset, fiber element brace, calibrated fatigue model, rigid end zone, and initial imperfection accurately represents the real behavior of the braced frame. The simplest method for modeling braced frame is pinned joint gusset; however, this model underestimates the lateral resistance of the braced frame.

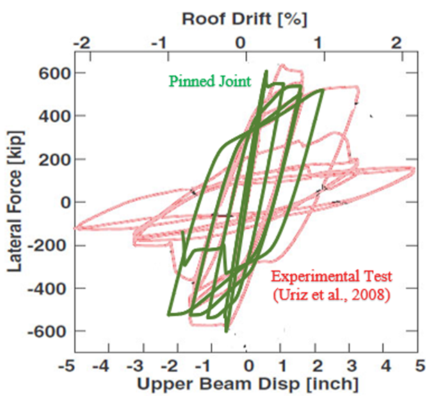

Figure 6. Simulated response of structure with Pinned Joint Gusset.

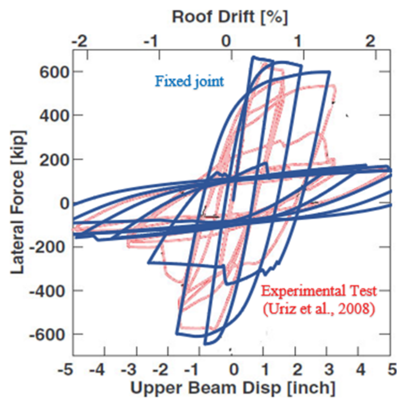

Figure 7. Simulated response of structure with Fixed Joint Gusset.

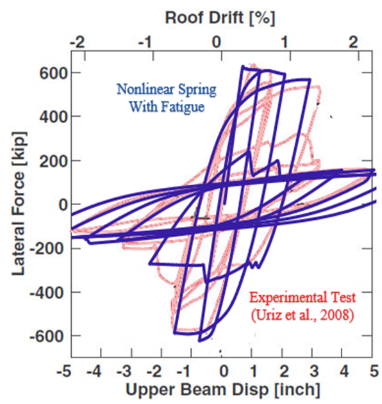

Figure 8. Simulated response of structure with Nonlinear Spring Gusset.

REFERENCES

Hsiao, P.-C., Lehman, D.E., and Roeder, C.W. (2012). Improved analytical model for special concentrically braced frames. *Journal of Constructional Steel Research, 73*, 80-94.

Hsiao, P.-C., Lehman, D.E., and Roeder, C.W. (2013). A model to simulate special concentrically braced frames beyond brace fracture. *Earthquake Engineering & Structural Dynamics, 42*(2), 183-200.

Uriz, P., Filippou, F.C., and Mahin, S.A. (2008). Model for Cyclic Inelastic Buckling of Steel Braces. *Journal of Structural Engineering, 134*(4), 619-628.

Uriz, P. and Mahin, S.A. (2008). *Toward Earthquake-Resistant Design of Concentrically Braced Steel-Frame Structures*. Berkeley, Calif: Pacific Earthquake Engineering Research Center.