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THE EFFECT OF MATERIAL CONSTITUTIVE MODEL ON SEISMIC RESPONSE OF CONCENTRIC BRACED FRAMES

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Based on seismic design provisions, earthquake-resistant structures are allowed to dissipate seismic energy through inelastic behavior. Thus, the designer must be aware of the material behavior in the inelastic range to estimate the true performance of the designed structure. Effects of the chosen stress-strain constitutive model as well as the behavior of steel in the strain-hardening range may be significant on the actual seismic response of the structures. In this article, seismic response of concentric braced frames is studied considering the aforementioned parameters.

Nonlinear analyses based on actual stress-strain curve of structural steel, shown in Figure 1, is rather complex and time-consuming; instead, simplified models of different types are generally used to avoid this complexity. As shown in Figure 2, each of these models includes some simplifications that may affect the results of analyses considerably.

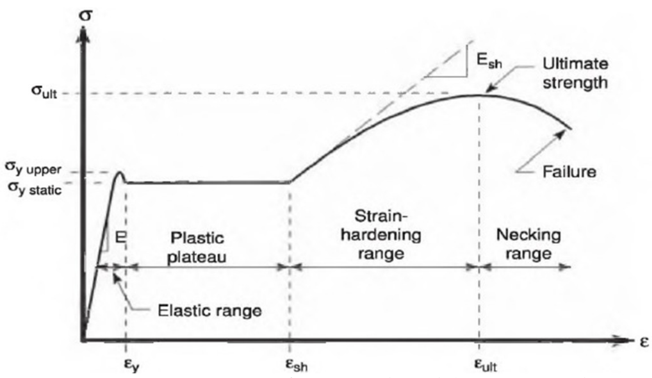

Figure 1. Stress-strain curve of structural steel (Bruneau et al., 2011).

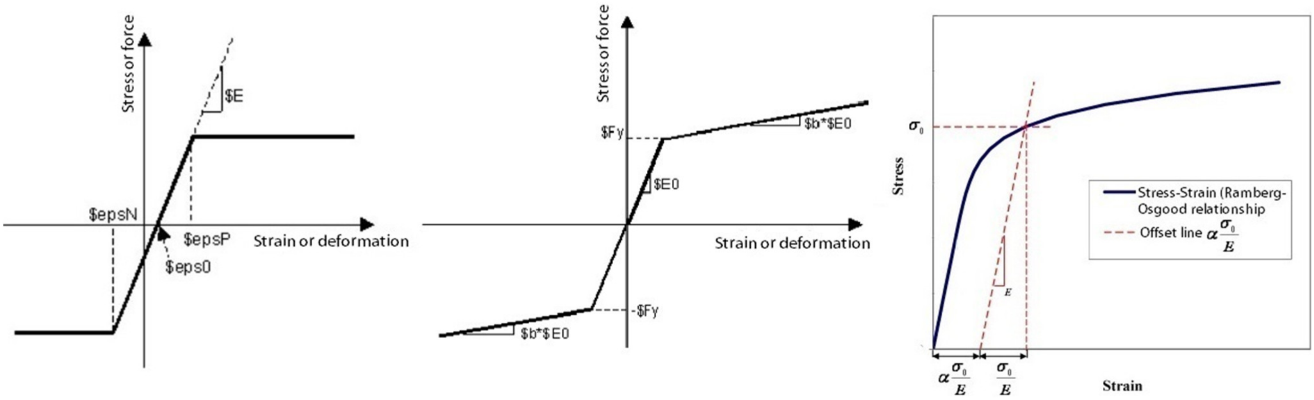

Figure 2 . Simplified steel material models (Mazzoni et al., 2006).

Two types of bracing systems including conventional concentric-braced and cable-braced frames are considered. All frames are extracted from a regular building with three and five stories each of 3.2 m height. The plan has a square shape of 15 m×15 m. Total dead and live loads on slabs are considered to be 6.0 kN/m^2 and 2.0 kN/m^2, respectively. The building is located on Type II soil in a region with "High" seismic hazard level, having an importance factor equal to 1 in accordance with the Iranian seismic provision, Standard No. 2800. The buildings were analyzed and designed to the conventional equivalent lateral procedure and AISC 360 (2016b) and AISC 341 (2016a) using SAP2000 software. The column and bracing members are made of box-shaped sections and, the beams were selected from IPE sections.

Nonlinear response history analysis is deemed to provide more realistic results than other methods to simulate behavior of a structure subjected to earthquake ground motion; however, analyses results depend greatly on the chosen ground motions and inelastic modelling parameters. In this research, three near-field and three far-field ground motions were selected and scaled in a period range of 0.2 to 1.5 times the empirical fundamental period of the structure. Two-dimensional modeling and analysis were performed in OpenSEES software (Mazzoni et al., 2006). Beam and column members were modelled elastically but bracing members were modelled by appropriate inelastic elements to consider material nonlinearity and buckling. Stress-strain relationships are assumed to be of different types: 'Elasto-Perfectly Plastic' lacking hardening portion, 'Steel01' with only isotropic hardening, and 'Ramberg-Osgood' all available in the software material library.

As the steel material used for cable bracing provides less ductility and larger elastic strengths compared to the conventional steel bracings, the effect of modeling parameters are not significant on cable braced frames. However as shown in Figure 3, even for the most insensitive case, i.e. cable braced frames, changing the constitutive material model has increased the base shear demand of the five-story frame about 20%. As conventional structural steel materials exhibiting larger nonlinear ranges of greater complexities, their computed seismic response under severe earthquake ground motions is more sensitive to the chosen material model. Therefore, further investigations are required to adopt the best choice for the constitutive material model for different performance levels.

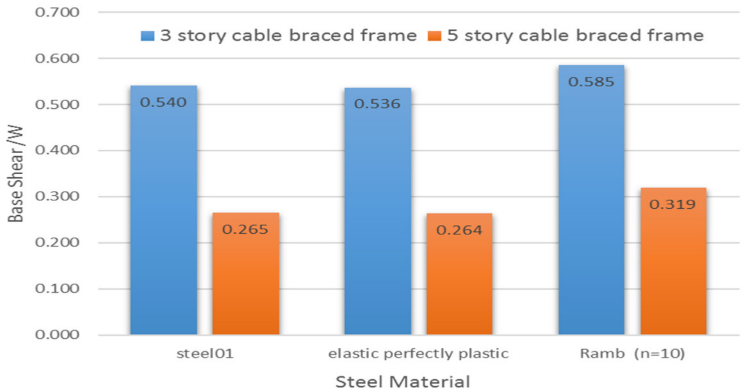

Figure 3. Maximum base shear demand computed under Northridge earthquake ground motion with three different constitutive models for brace material.

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