EVALUATION OF DISPLACEMENT AMPLIFICATION FACTOR FOR ECCENTRICALLY BRACED STEEL FRAMES

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Evaluation of maximum lateral displacement is important in the seismic design of structures. Structures can dissipate a significant amount of earthquake energy when deforming into the inelastic range. Seismic codes reduce the elastic seismic force demand by a force reduction factor (R). Since the design seismic force level decreases, the obtained displacement from elastic analysis will be less than the actual displacement of structure. To achieve the maximum lateral displacement, building codes usually use a displacement amplification factor (DAF) as follows:

$$\Delta_{\max} = \Delta_e \times C_d \tag{1}$$

Where Δ_{max} is the maximum lateral displacement and Δ_e is the elastic lateral displacement calculated from elastic analysis; C_d is displacement amplification factor.

Figure 1 shows the actual response envelope and idealized elasto-plastic response curve which can be obtained by pushover analysis (Uang, 1992).

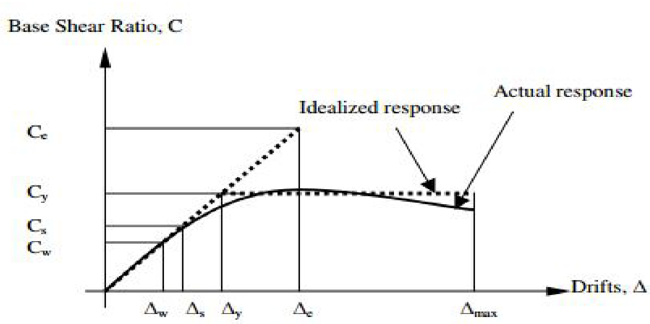

Figure 1 : General structural response

The structural ductility factor (μ) can be defined as:

$$\mu = \frac{\Delta_{\max}}{\Delta_y} \tag{2}$$

Where Δ_y is the yield displacement of structure. The overstrength factor Ω is defined as follows:

$$\Omega = \frac{C_y}{C_s} \qquad (3)$$

Where C_y is the yield strength level of structure and C_s is the first significant yield level. Structural overstrength results from redundancy, multiple load combination, the difference between the actual strength of the material used in construction and the strength used in calculation of the capacity, code minimum requirements regarding proportioning and detailing, etc.

Based on these definitions, the displacement amplification factor (DAF) can be derived from Figure 1 as follows:

$$DAF = \frac{\Delta_{max}}{\Delta_s} = \frac{\Delta_{max}}{\Delta_y} \frac{\Delta_y}{\Delta_s} \qquad (4)$$

Where Δ_{max}/Δ_y is the structural ductility factor (see Eq. 2) and Δ_y/Δ_s is derived as follows according to Figure 1:

$$\frac{\Delta_y}{\Delta_s} = \frac{C_y}{C_s} = \Omega \qquad (5)$$

Therefore Eq. 4 can be expressed as:

$$DAF = \mu \times \Omega \qquad (4)$$

This paper attempts to determine ductility, overstrength and displacement amplification factors of Chevron Eccentrically Braced Frames (EBFs). Because of inelastic behaviour of link beam, eccentrically braced frames have more ductility than concentrically braced frames (CBFs). In these systems, the link beam acts as a displacement controlled element and other members act as a force controlled one. Nonlinear static analysis and incremental nonlinear dynamic analysis was performed for building models with various lengths of the link beam and with 2, 5, 10 and 15 stories. These frames were designed in accordance with AISC 360-10 and ASCE 7-10 codes. The results show that ductility, overstrength and the displacement amplification factor was significantly affected by variations of link beam length and structure height, hence the consideration of unique value for displacement amplification factor (C_d) in eccentrically braced frames isn't true .The values of overstrength and displacement amplification factors obtained in this investigation are compared to those of ASCE 7-10, NEHRP and Iranian seismic design codes.

Table 1. A comparison of overstrength factor and displacement amplification factor between some common codes

Steel eccentrically braced frames	Overstrength Factor, Ω	Displacement amplification factor, C_d
ASCE 7	2	4
NEHRP	2	4
Iranian seismic design code (standard 2800)	2	4

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