A COMPARATIVE STUDY ON ESTIMATION OF LATERAL DISPLACEMENT AT FIRST YIELDING OF MRF STRUCTURES

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The accurate estimation of the structural displacement under the earthquake excitation has been known as important step in seismic analysis and design of buildings. Different structural design procedures rely on the lateral displacement as design criteria. The method of seismic design of structures to reach a specific target is known as performance based seismic design (PBSD) procedure. Generally, the main aim of PBSD is to predict the realistic seismic behaviour of structures at the time of earthquake that will probably occur with different intensities during the structure's lifetime.

It generally is very time consuming to perform dynamic time history analysis to evaluate the seismic response of structures especially in large frames in which the number of degrees of freedom increases. On the other hand, in some cases it's not feasible and practical in terms of cost to analyse the existing structures precisely to determine their behaviour at the time of earthquake. Hence, utilizing the approximate methods to evaluate the seismic behaviour becomes important since they can estimate the structural response with acceptable accuracy. In the literature, there are several formulas, proposed by researchers for fast estimation of structural displacement. Characteristics of near field earthquake records can be different from far-field motions. Accurate modelling and analysis of structures due to these motions is an impetrative concern in PBD for the reliable design of structures located near active faults.

Some of the formulas which have been proposed by researchers and are used in this study are summarized herein:

Priestly and Calvi (1997) recommended Equation 1 for the estimation of yield displacement based on the equivalent single degree of freedom systems.

$$\Delta_y = 0.002H \tag{1}$$

Equation 2 has been proposed by Aschheim (2004) on the basis of results of nonlinear static analysis of steel MRFs and has been suggested for roof displacement determination.

$$\Delta_y = 0.011\ H \tag{2}$$

Dimopoulos et al. (2012) proposed Equation 3 to approximate the response of steel MRFs in which the *b* constants are obtained from nonlinear regression of the results obtained from the analysis of numerous steel frames with different heights, spans and yield stresses.

$$u_{yi} = h_i^{b_1} \cdot \left(\frac{h_i}{H}\right)^{b_2} \cdot n_s^{b_3} \cdot e^{b_4} \tag{3}$$

Where h_i and n_s denote the height of floor i and number of storey, respectively and H is the total height of the frame.

The present paper aims to evaluate the accuracy of the existing formulas for estimating the seismic response of structures at first yielding under near-field earthquake records. For this purpose a number of typical steel MRFs including 3, 6 and 9 storey heights are studied. Performing nonlinear dynamic time history analysis for the frames, the results are compared to the responses obtained from the proposed approximate formulas. The analyses are performed by the aid of OpenSees applying 7 real near-field ground motion records, presented in Table 1, to the frames. The mean first yield displacement as the interested response is compared with the similar displacement obtained using formulas for each frame.

Table 1. Near-field records used for analysis

No.	Earthquake/date	Station	Comp.	Magnitude	PGA(g)
1	Coalinga 1983/07/22	1162 Pleasant Valley	D-PVY045	5.8	0.602
2	Northridge 1994/01/17	6604 Cerro Prieto	STM090	6.7	0.883
3	Duzce, Turkey1999/11/12	Bolu	BOL090	7.1	0.822
4	Landers 1992/06/28	24 Lucerne	LCN000	7.3	0.785
5	Landers 1992/06/28	22170 Joshua Tree	JOS090	7.3	0.284
6	Loma Prieta 1989/10/18	57007 Corralitos	CLS000	6.9	0.644
7	Loma Prieta 1989/10/18	57007 Corralitos	CLS090	6.9	0.479

The average lateral displacement results obtained based on 7 records is compared with those of equation (3) in Figure 1. The results showed that the approximate formula proposed by Dimopoulos et al. (2012) can predict the displacement of 3 story frame with good accuracy. However, accuracy of results is decreasing by increasing the number of stories. For example, in the 6 story frame,the approximate formula showed larger displacement at higher stories and smaller values for lower stories. In the case of 9 story frame, the results obtained from approximate method showed a good congruence at lower stories however, formula demonstrated larger displacement in higher stories.

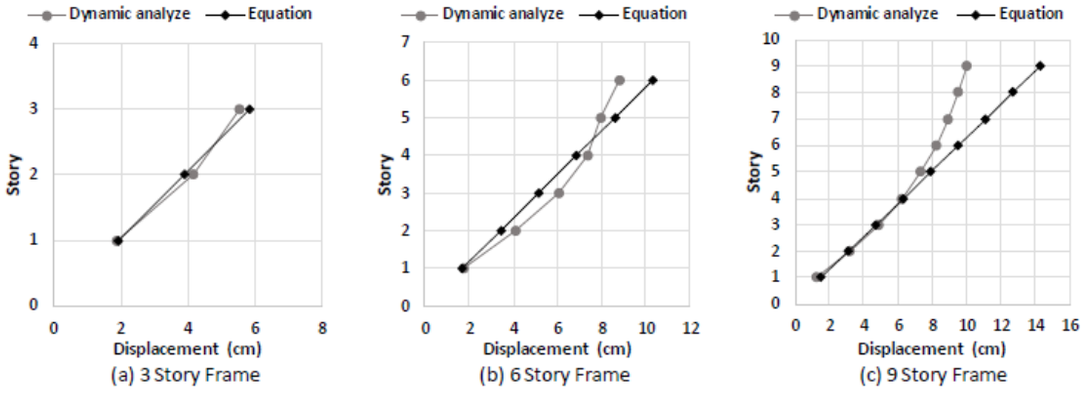

Figure 1. The comparison between the results of dynamic analysis and approximate equation

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