ESTIMATION OF R FACTOR FOR MDOF SYSTEMS UNDER NEAR FIELD MOTIONS WITH FORWARD DIRECTIVITY EFFECT: MODIFICATION FACTORS

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Keywords: Higher Mode Effect, R Factor, Inter-Story Ductility, Near Field Motions

The main objective of this study is to increase knowledge of the dynamic response of MDOF inelastic structures, and provide a method for measuring the seismic demands of these systems, using strength demands of equivalent SDOF systems. In this regard, the necessary modifications to assess the strength reduction factor of MDOF structure (R factor) are studied and measured. For this purpose R factor of MDOF structures is evaluated by introducing correction coefficients to Uang method (to account for the effect of higher modes) and then modification coefficient to this factor of MDOFs are proposed. For each MDOF structures an equivalent SDOF system, is defined. In this definition, the mass of the equivalent SDOF system is equal to the total mass of MDOF system. Also to equalize vibration period of ESDOF and MDOF systems, lateral stiffness were adapted with trial and error. Modification factors proposed in this study, consist of ratios in which depend on the intensity and duration of earthquakes. The ground motions are near fault with forward directivity effects. The main reason to select near filed earthquakes is the lack of studies on the effect of these types of ground motions on MDOF to SDOF response parameters and also to assess the higher mode effects under near field earthquakes. The modification factor is used to calculate lateral strength of MDOF from ESDOF in such a way that the maximum inter-story ductility is limited to prescribed target ductility. Previous studies show that if the MDOF system design with demand strength of the ESDOF system to limit the ductility to the target ductility, the maximum inter-story displacement ductility of MDOF is much greater than the prescribed ductility of SDOF system. Hence, it is not possible to calculate the R factor for MDOF system only by using ductility and over-strength reduction factor (R_μ and R_s). In this regard, α_{Vmdof} is introduced. This modification coefficient could be calculated by:

$$\alpha_{Vmdof} = \frac{V^{\mu}_{MDOF}}{V^{\mu}_{SDOF}} \qquad (1)$$

In fact α_{Vmdof} is the modification factor to the lateral strength of ESDOF in order to limit the inter-story ductility demands of MDOF to the prescribed value.

To determine the seismic behavior of steel moment-resisting frames with height variation, 2D steel frames with 1, 2, 4, 7, 10, 15, 20, 25 and 30 stories and span number 1, 2, 3 and 5 were selected. The design of each mentioned frame was based on the regulations of AISC10-LRFD and its gravity loading was done based on Iran Structure Loading (code No. 6, Iranian Building National Regulations). on the basis of steel material specifications by Iranian code, steel type ST37 with yield point of 2400 kg/cm2 and ultimate stress of 3600 kg/cm^2 was selected to design and evaluation procedures. The seismic loading was done based on the Iran Practical Code for Earthquake Deign (Standard No.2800, third edition). In all models, 4-m story height and 5-m span length, designed for regions with seismic high hazard level and stiff soil site conditions (same as soil type D on FEMA356). In all models, dead and live load of all stories were respectively 3750 kg/m and 1250 kg/m. For the first mode and all modes with cumulative mass participation factor exceeding 90%, Rayleigh equivalent damping was defined 5%. The strain-stress hysteresis behavior of steel was modeled in the bilinear form with a strain hardening ratio of 3%. To perform NTHA, time steps and sub-steps have been considered to be 0.005s and 1000, respectively. In all analysis, P-Delta effect has been included in NTHA. To scale the earthquake intensity, a new approach has been proposed. In this method, scaling of SDOF yield strength or adjusting MDOFs structure ductility with predefined target ductility through test and trial on the earthquake scale factor were used. For each of intended structures and the studied earthquakes, test and trial on the earthquake scale coefficient was used to conform the inter-story ductility of the structure to the pre-selected target ductility. By using this scaling method, the result depends to ground motion content disappears. Hence, the comparison between local and global ductility will develop the possibility of proposing a practical coefficient for estimation of maximum beam rotation ductility. In Figure 1, the result of a proposed modification factor, α_{Vmdof}, has been illustrated for different span configurations. Regarding to this graph, by increasing the period, the α_{Vmdof} increases for all cases of span and ductility. Also, for long period models (almost greater than 4 Sec), with increasing level of ductility, the α_{Vmdof} increases. But for high values of inerstory ductility, the sensitivity of α_{Vmdof} to the ductility reduces for constant period.

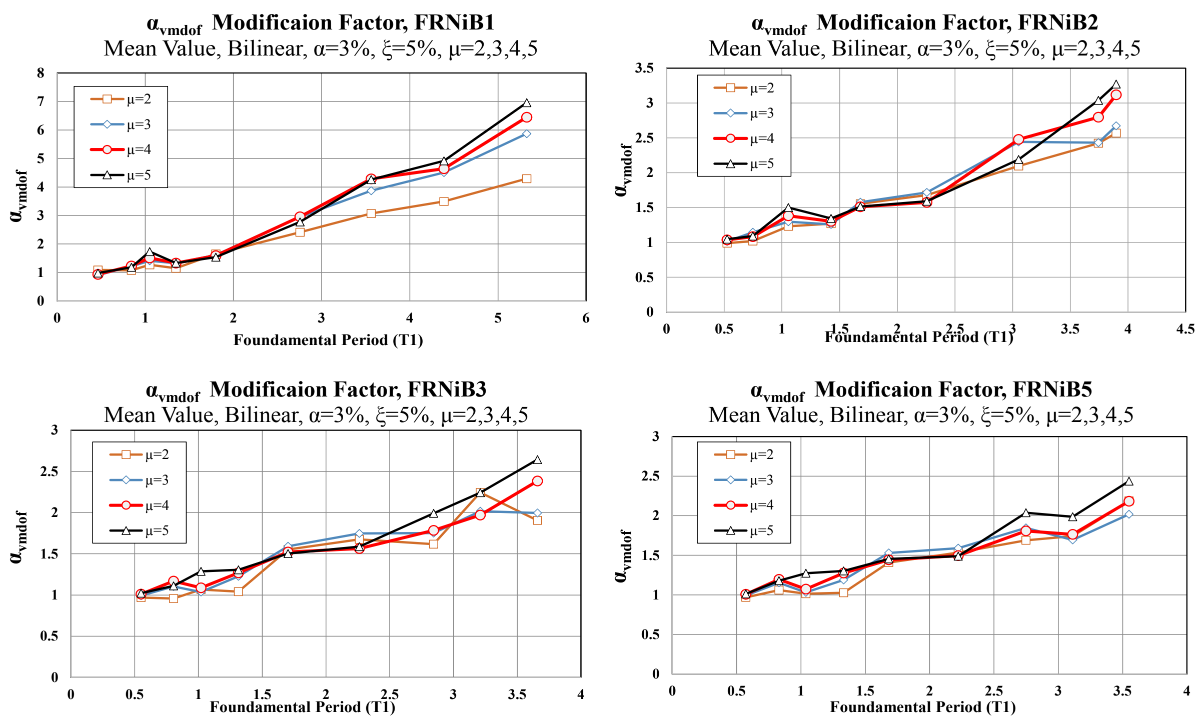

Figure 1. The variation of mean value for α_{Vmdof} 1, 2, 3 and 5 span with μ=2, 3, 4 and 5

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