GENERATING THE EQUIVALENT LINEAR SYSTEMS OF NON-LINEAR MULTI-DEGREE OF FREEDOM STEEL MOMENT RESISTING FRAMES

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The purpose of this study isto find the propertiesof an equivalent linear Multiple Degrees of Freedom (MDOF) system, or so-called substitute structure, that its response is an approximation of the target actual nonlinear MDOF structure's response (Shodja, 2013). In that regard, the stiffness and damping matrices of the substitut estructure are considered as functions of the stiffness and damping matrices of the actual nonlinear structure. In this way, the substitute structures can be constructed through trial and error for structures with different fundamental periods, damping ratios and number of floors. In that regard, a number of multi-story steel moment resisting frames are considered. The ductilities of these structural models were calculated using the nonlinear static analyses provisions provided by ASCE 41-13 (Chopra and Goel, 2001; Miranda, 1991). Then, using the FEMA 440 criteria, the effective period of those models were determined based on their ductilities. Using a trial and error approach, the stiffness of the considered structural models are adjusted such that the first modeperiod (T_0) of the linear substitute structuresbe equal to the effective period that was obtained using the FEMA 440 provisions. Finally, the damping ratios were computed by equalizing the maximum roof displacement response of the linear and non-linear structural models. Linear and non-linear time history analyses were performed using the SAC structural models to verify the applicability of the suggested substitute structure in capturing the seismic demands of the real nonlinear steel MRF structural systems (FEMA 368, 2000).

Five models with different number of story and length of bays were designed according to AISC2010. Then by using the push over method and finding the equivalent SDOF behavior and ductility factor, the effective period of structures were found according the FEMA440 relations. In this way, for reducing the stiffness of structures, the modulo of elasticity was reduced through trial and error so that the period of equivalent structures be equal to effective period. Finally, for finding the effective damping ratio of structures, the maximum displacement of roof was considered equal in two equivalent linear and real nonlinear structures according to the time history analyze. The result of this study are some relations which state the effective damping ratio according to the ductility factor and first and second damping values (β_0) as below:

$$\beta_{eff} = A(\mu-1)^3 + B(\mu-1)^2 + C(\mu-1) + \beta_0 \qquad , \qquad \mu \le 2/5$$

The coefficient of A, B and C are gotten from table below:

Table 1. The coefficient of A, B and C

Behavior of Material	Strain hardening of material	A	B	C
Bilinear hysteretic	0	-0.03556	0.08492	0.004313
Bilinear hysteretic	2	-0.0353	0.0872	0.00449
Bilinear hysteretic	5	-0.0401	0.1002	0.005301
Bilinear hysteretic	10	-0.03887	0.10465	0.00567
Bilinear hysteretic	20	-0.03652	0.11322	0.005783

Considering these equations, for verifying the relations, the SAC models were modeled and according the some scaled Time History records which have been identified by FEMA440-Table C2. For 3 and 9 steel moment resisting frames are as below in Figures 1 and 2.

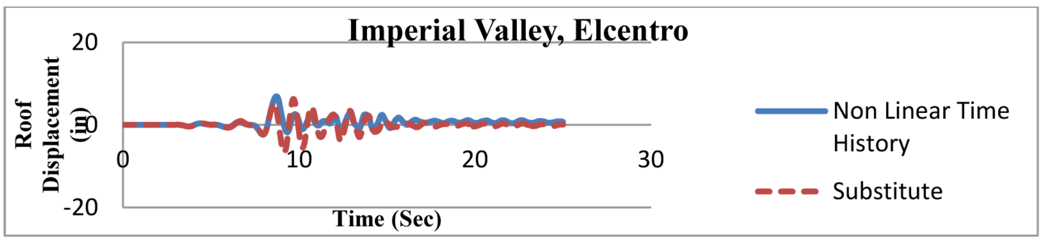

Figure 1. Roof Displacement of 3 story of building under the Imperial Valley earthquake

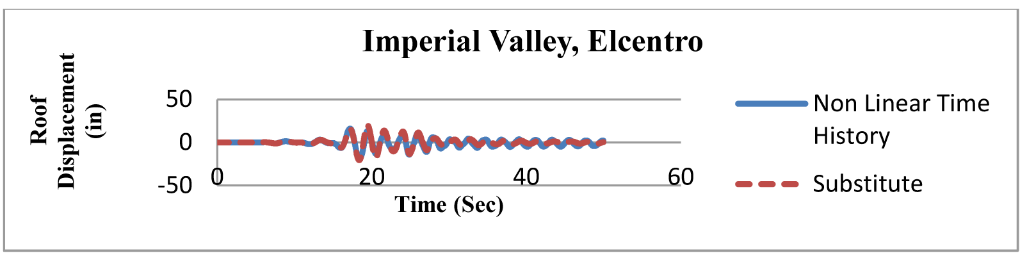

Figure 2. Roof Displacement of 9 story of SAC building under the Imperial Valley earthquake

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