One of the shortages of pushover analysis is that it approximately considers the effects of deterioration pertained to hysteretic loops for structural elements. Many studies have been done for evaluation and improvement of this method considering cyclic loading and deterioration parameters. Among all, Akkar and Metin (2007), Goel and Chadwell (2007), Lin and Miranda (2009), Amiri et al. (2010) and Jaiyong and Chintanapakdee (2011) can be referred to. Song and Pincheira (2000) started studying the effects of strength and stiffness degradation on SDOF systems. In a part of their study, they evaluate the displacement coefficients method suggested by FEMA 273. The results have shown that the amounts of displacement coefficients $C_1$, $C_2$ and $C_3$ in FEMA 273, for the systems with periods equal or greater than 0.3 second are more conservative under earthquake excitations on hard soil. Of course it is not the same for the systems which their periods are smaller than 0.3 second and the structure may experience a larger displacement. Furthermore, in order to improve the inelastic seismic analysis procedures, extensive studies on different soil types have been done by Miranda and presented in ATC55 that leaded to publishing FEMA 440.

According to the research purpose, studying the deterioration behavior of hysteretic loops, it is necessary to perform nonlinear static and dynamic analyses and compare the results. To this end, six different planar frames, each one being a part of three-dimensional designed structures, have been modeled. All of the structures are the same in plan and different in height. Because OPENSEES software benefits from various behavioral characteristics for steel and concrete, and also has the ability to suitably model the structural elements, it has been used for performing nonlinear analyses. The employed material models are REINFORCING STEEL MATERIAL, CONCRETE02 and HYSTERETIC MATERIAL. For modeling the structural elements, stresses and strains for each designed section are considered with respect to confinement effects. The required backbone curve includes cracking, yielding and ultimate stress points which are all derived from USC-RC software, and of course with considering elements cross section, arrangement, number and size of reinforcing bars. After conducting the pushover analyses, in accordance with the displacement coefficients method suggested by FEMA 356 and Publication No. 360, for defining the target displacement, dynamic analyses are also performed considering Deterioration behavior and non-degrading behavior. It is worth mentioning that nonlinear dynamic analyses have been done for 0.35g hazard level. This hazard level is derived by scaling the applied ground motions according to the Iranian Code of Practice for Seismic Resistant Design of Buildings, No. 2800. In order to specify the capacity curve of the structure, the displacement of the control node and the shear force of the base level were computed by OPENSEES software. For accurate calculation of the target displacement and bilinear idealization of capacity curve, a computer program was developed in MATLAB environment to determine the target displacement, strength ratio (R) etc, which its derived parameters have been presented in Table 1.

Finally, maximum displacement amounts derived from inelastic dynamic analyses for 0.35g hazard level are compared with those obtained from nonlinear static analyses, $\delta_c$, which express the maximum displacement of the structure under design earthquake, and consider the effects of different parameters such as deterioration with the coefficient $c_2$. Results show that with increasing the height of frame, the variance between frame displacements with both deteriorating and non-
degrading behavior will be decreased, so that the effect of deterioration behavior could be neglected in target displacement calculation for high-rise frames, Figure 1.

Table 1. Derived parameters from MATLAB

<table>
<thead>
<tr>
<th>Frame</th>
<th>Period T (s)</th>
<th>Effective Period T_e (s)</th>
<th>Target Displacement δ (mm)</th>
<th>Final Target Displacement δ_t,final (mm)</th>
<th>δ_Y (mm)</th>
<th>Strength Ratio (R)</th>
<th>δ_t,final/δ_Y</th>
<th>δ_t,final/δ_t</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-story</td>
<td>0.251</td>
<td>0.252</td>
<td>20.72</td>
<td>20.88</td>
<td>2.98</td>
<td>1.48</td>
<td>1.008</td>
<td>2.373</td>
</tr>
<tr>
<td>5-story</td>
<td>0.460</td>
<td>0.462</td>
<td>60.65</td>
<td>61.20</td>
<td>31.90</td>
<td>2.05</td>
<td>1.009</td>
<td>3.381</td>
</tr>
<tr>
<td>7-story</td>
<td>0.660</td>
<td>0.663</td>
<td>107.83</td>
<td>108.94</td>
<td>62.80</td>
<td>2.22</td>
<td>1.010</td>
<td>3.415</td>
</tr>
<tr>
<td>10-story</td>
<td>0.996</td>
<td>1.006</td>
<td>187.66</td>
<td>190.15</td>
<td>31.90</td>
<td>1.95</td>
<td>1.013</td>
<td>3.028</td>
</tr>
<tr>
<td>15-story</td>
<td>1.954</td>
<td>1.990</td>
<td>460.90</td>
<td>472.25</td>
<td>89.00</td>
<td>1.19</td>
<td>1.025</td>
<td>2.647</td>
</tr>
<tr>
<td>20-story</td>
<td>2.676</td>
<td>2.714</td>
<td>700.95</td>
<td>714.25</td>
<td>187.66</td>
<td>1.11</td>
<td>1.019</td>
<td>2.647</td>
</tr>
</tbody>
</table>

Figure 1. Comparison of proposed C^2 with FEMA 356 requirements

REFERENCES


Goel RK and Chadwell C (2007) Evaluation of current nonlinear static procedures for concrete buildings using recorded strong-motion data, *Department of Civil & Environmental Engineering, California Polytechnic State University, San Luis Obispo*


