EVALUATION OF COLLAPSE MARGIN FOR RC FRAMES DESIGNED BASED ON IRANIAN SEISMIC CODE

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One of the main goals of the seismic design philosophy is to design structures so that the structural collapse to be prevented under intense ground motions. Therefore it is important to quantify the margin of safety against structural collapse. Nonetheless due to high level of nonlinearity involved in vicinity of structural collapse the analytical modeling and assessment is complex and demanding, and includes several sources of uncertainties. Although this issue has attracted considerable interest among seismic engineers and researchers during several past decades no standard method has been introduced. During the past few years FEMA has published a guideline for quantification of the building Seismic Performance Factors, i.e. response modification factor, overstrength factor and displacement amplification factor (FEMA, 2009). As part of the proposed methodology one can assess the structural collapse potential. The approach includes a combination of incremental nonlinear dynamic analysis (Vamvatsikos and Cornell, 2002) and suggested criteria based o semi-probabilistic method to evaluate Collapse Margin Ratio (CMR).

The main objective of this research is to study the collapse margin ratio for reinforced concrete frame buildings designed according to Iranian seismic standard (Standard 2800). Incremental dynamic analysis (IDA) is carried out using 22 scaled natural ground motion records. The study includes RC moment resisting frames with 3, 6 and 10 stories considering two types of soil classifications (Type II and III) and two alternatives of ductility levels (Intermediate and high ductilties), according to standard 2800.

All structures are first designed according to Standard 2800 and ACI 318-11. They are then modeled and analyzed using SAP2000 program and incremental dynamic analysis. The 22 ground motions used in this study are those suggested by FEMA P695. The collapse is assessed for each record and the median value is calculated among the 22 records (median value of collapse, S_{CT}) .The ratio of median value of collapse to spectral response acceleration at the fundamental period (S_{MT}) is called collapse margin ratio (CMR) (FEMA, 2009).

$$CMR = \frac{\hat{S}_{CT}}{S_{MT}} \tag{1}$$

Adjusted collapse margin ratio (ACMR) for each archetype is calculated using spectral shape factors (SSF) which are calculated based on fundamental period (T) and period-based ductility (μ_T).

$$ACMR_i = SSF_i \times CMR_i \tag{2}$$

Adjusted collapse margin ratio (ACMR) is modified to reflect modeling related and record to record and other sources of collapse uncertainties.

Acceptable performance is achieved when the following two criteria is met for each performance group and each index archetype:

• The average value of adjusted collapse margin ratio for each performance group exceeds $ACMR_{10\%}$:

$$\overline{ACMR_i} \geq ACMR_{10\%} \quad (3)$$

• Individual values of adjusted collapse margin ratio for each index archetype within a performance group exceeds $ACMR_{20\%}$:

$$\overline{ACMR_i} \geq ACMR_{20\%} \quad (4)$$

The results are summarized in Table 1.

Table 1. Adjusted collapse margin ratio (ACMR)

Seismic Group		S_{MT}	$\hat{S}_{CT}$	CMR	SSF	ACMR	B_{TOT}	$\overline{ACMR_i}$	$ACMR_{10\%}$	$ACMR_{20\%}$
1	1-A	1.125	2.7	2.4	1.113	2.67	0.6	2.93	2.16	1.66
	1-B	0.954	2.7	2.83	1.215	3.44	0.6		2.16	1.66
	1-C	0.738	1.75	2.37	1.13	2.68	0.6		2.16	1.66
2	2-A	0.954	2.7	2.83	1.213	3.43	0.6	2.89	2.16	1.66
	2-B	0.738	1.55	2.1	1.118	2.35	0.6		2.16	1.66
3	3-A	1.2375	2.25	1.82	1.218	2.21	0.6	2.28	2.16	1.66
	3-B	1.2375	2.4	1.94	1.22	2.36	0.6		2.16	1.66

It is concluded that the RC frame structures designed based on the Iranian Seismic code generally have sufficient margin against collapse based on the FEMA P695 approach. However the actual margin of collapse varies depending on the characteristics of the structures. Discussion of the results and recommendations are proposed.

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