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IMPACT OF LOAD COMBINATIONS ON RELIABILITY OF STEEL BEAMS ACCORDING TO IRANIAN STRUCTURAL STEEL CODE

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Structural design codes are calibrated to provide a simple, safe and economically design of structures under normal loading, operational and environmental conditions (Faber and Sorensen, 2002). To achieve consistent levels of safety or structural reliability under different uncertainties, the load and resistance factors must be determined using reliability-based calibration methods. According to these methods, the reliability level of structures is assessed based on statistical descriptions of loads and resistance and also consideration of different type of uncertainties such as the physical uncertainty, the statistical uncertainty and the model uncertainty.

In the last decades, the load and resistance factor design (LRFD) method has been developed for steel buildings design. In this method, the load combinations are carried out based on the companion-action format which has been adopted for many codes and standards because of its simplicity and appropriateness for combining loads that can occur simultaneously. Iranian structural steel code has recently been converted to limit state partial factor design. These partial safety factors, especially resistance factor, are generally based on AISC specification, while the effect of Iranian statistical data for load and resistance has not been considered. The design format used in AISC specification based on LRFD method is given by:

$$\gamma_D.D_n + \gamma_i.Q_{ni} + \gamma_j.Q_{nj} \leq \varphi_R.R_n \tag{1}$$

where n stands for nominal value, γ are partial factors applied on loads, D_n is the nominal value of dead load, Q_{ni} is the principal variable load, Q_{nj} is the accompanying variable load, R_n is a nominal resistance and φ_R is a partial safety factor applied on nominal resistance. In this format, partial safety factor applied on nominal resistance (resistance factor φ_R), is determined based on a single load combination (1.2D+1.6L) and a single dead to live load ratio for each element. The impact of this assumption could be resulting in conservative or unconservative design for other load combinations and load ratios (Honfi et al., 2012; Meimand and Schafer, 2014).

This study explores the reliability level of flexural beams in Iranian Structural Steel code for a sample region (greater Tehran) and compares this reliability level with target reliability. Therefore, the statistical parameter for loads and resistance are provided. Statistical descriptions of dead, live and snow loads and also resistance parameters are based on the international researches (Bartlett et al., 2003). While statistical results for wind and earthquake loads, which are completely site dependent and have a high degree of uncertainty, have obtained for greater Tehran. Wind load is obtained based on statistical data on wind speed, pressure factor, exposure factor and gust factor. The main source of uncertainty in wind loads are uncertainty in wind speed. Annual maximum wind speed data are provided for greater Tehran by the climatology data. Wind speeds data were evaluated and they followed Gumbel distributions. The wind speed is transformed using product of pressure factor, exposure factor and gust factor to obtain the wind loads. By considering the uncertainty of these factors and uncertainty of wind speed, wind load has a bias of 0.7 and a coefficient of variation of 0.35.

For earthquake load, the main source of uncertainty is related to ground motion parameters. In general, design base acceleration is modeled as a stochastic parameters and fitted by a Type II distribution of extreme values. Here, by using seismic hazard analysis curve the distribution parameters are obtained. Based on these parameters and statistical calculations, statistical factors for earthquake load in greater Tehran have been estimated. Earthquake load has a bias of 0.68 and a coefficient of variation of 1.75.

In this research the reliability level of steel beams designed for Iranian structural steel code for different load combinations and different load ratios is established based on the Monte-Carlo simulation and compared to the target reliability which is equal to 2.6. According to Table 1, the results have shown that for some of load combinations, Iranian steel code is slightly conservative and for some of them, like earthquake load combinations, the results are very controversial. For instance, in load combination 1, 3 and 4 when dead and snow load are dominant load, the mean value of reliability indices are 3.06, 2.84 and 2.88 respectively, which implies that Iranian steel code is slightly conservative for these load combinations. When live and wind loads are dominant loads, i.e. load combinations 2 and 5 Iranian steel code is slightly unconservative for Tehran. However in earthquake load combination (load combination 6), which has a different design philosophy the results are very unconservative.

Table 1. Reliability index for load combinations 1 to 6 in flexural beam.

Load Combination		Reliability Index (β)	
		Mean	**Standard Deviation**
1	1.4D	3.06	-
2	1.2D+1.6L+0.5S	2.44	0.137
3	1.2D+1.0L+1.6S	2.84	0.272
4	1.2D+1.6S+0.7W	2.88	0.237
5	1.2D+1.0L+1.4W+0.5S	2.21	0.310
6	1.2D+1.0L+0.2S+1.0E	0.46	0.096

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