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Iran Seismic Design Code Evaluation Through Comparison with NZS 1170.5 and a Critical Look at its Directivity Effects Implementation

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ABSTRACT: This paper intends to evaluate the existing Iran seismic design code (standard No. 2800) through a comparison process with those of New Zealand seismic code (NZS-1170.5) due to their apparent shape similarity of spectral accelerations being in two parts form. Both standards represent the seismic hazard level of ten percent chance in fifty years. The evaluations made are: the basic design acceleration (A) (in 2800), and the hazard factor (Z) (in NZS), the constant acceleration and constant maximum velocity period ranges of the two spectral shape forms on the four types of site soil conditions, and the approach of implementing the directivity effects by representative parameters, [N(T), in 2800] and [N(D,T), in NZS]. The 2800's spectral accelerations on the four soil types including the FD-pulses are qualitatively evaluated through hazard-based FD-pulse method. The quantitative results of this study expose that the existing 2800 s' spectral accelerations need to be increased at relatively small period ranges of 2 s while be decreased at the period ranges longer than 2 s. In brief conclusion, the required design spectral accelerations for buildings which currently are widely constructed in near field sites, are smaller than those of the rationale hazard-based values.

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1- Introduction

The main motivation of writing this article is the existing challenges of changes performed in the fourth version of Iran design seismic code (No. 2800) relative to those of the third version [1, 2]. Samples of These changes include the variation form of spectral acceleration in the maximum velocity period range (from the corner period Ts to those at longer periods) from $(T_s/T)^{2/3}$ to T_s/T where, T_s and T are the corner period and first mode period respectively. Another important change in 2800 is presenting the first mode period dependent parameter $N(T_1)$ representing the forward directivity parameter at near source site which is unique for the whole types of site soil conditions.

2- Forward Directivity

At sites located near active faults (around 20 km), ground motions might exhibit a large pulse at the beginning of the velocity time history, termed velocity pulse, which can be more severe and destructive than far-fault ground motions [3, 4]. These pulses may represent two near field phenomena; forward directivity (FD-pulse) effects and fling step. Simulating strong motion time-history recorded at near field site haven been carried out by investigators [5], reports on

$$N(D,T)=\begin{cases} N_{max}(T) & D<2 \\ 1+\dfrac{(N_{max}(T)+1)(20-D)}{18} & 2<D<20 \\ 1 & D>20 \end{cases} \qquad (1)$$

The 2800 is free from distance but applicable only at sites located in either very heavy (A=0.35g) or heavy (0.3g) seismicity regions expressed as:

$$N(T)=\frac{0.7}{4-T_S}(T\text{-}T_S)+1 \qquad (2)$$

Where, T_s is a site soil condition factor named the corner period with the maximum value of 1.7 and 1.4 for very heavily and heavily seismicity respectively. As stated the two factors end up with quite different directivity effect values concluding that the 2800's N parameter should be reviewed through performing a real dataset investigation.

3- Evaluating 2800's directivity factor N(T)

The spectral ordinates affected by the existing directivity factor at the period of one second in 2800 code, which is a period at the maximum velocity period range of the design response spectra, is calculated by means of the work carried out by Shahi and Baker [5] and the results are used to evaluate those of the 2800 code.

Regarding that 2800 spectral accelerations are those corresponding to ten percent chance which corresponds to

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the epsilon of 1.28, given the attenuation equation, the mean spectral ordinate (in log form) at the period of one second is simply obtained using the following equation expressed as:

$$lnSa = \mu_{lnSa} + \varepsilon\delta_{lnSa}$$
$$\mu_{lnSa} = lnSa\text{-}\varepsilon\delta_{lnSa} \quad (3)$$
$$\varepsilon = 1.28$$

The mean value f(M,R) and an attenuation equation (we used three attenuation equations to reduce the epistemic uncertainty) is used to calculate the mean magnitude (M_{mean}) corresponding to the 2800's response spectra, given the mean distance (R_{mean}) (see Table 1). This process leads to the mean magnitude of 6.5 Richter in this study (see Table 1). It is to note that this approach is usable only for understanding and evaluating the consistency of spectral ordinate values of existing specified design response spectrum rather than producing new version.

Having the mean magnitude corresponding a specified design response spectrum (M_{mean}), it is possible to predict the corresponding mean pulse period (T_p) at one second [6 Equation (11)]. The obtained (T_p) is used to predict the mean Amplification Factor (AF) i.e. spectral acceleration amplification due to directivity effects $\mu(\ln T_p)=-5.73+0.99M$) [5], which plays identical role as N(T=1).

The above mentioned affairs are followed leading to AF=1.85 assuming that the whole strong motions be associated with FD-pulse which is not a real assumption, regarding that about (25%) of regions surrounding a fault potentially are associated with forward directivity [3] 30% of this value is considered. Therefore, the resulting AF to be used for evaluating design response spectra would be 1.25 [i.e. 1+(0.85*0.3)=1.25]. Figure 5 shows the obtained response spectra over the four site soil conditions along with those of 2800 code.

4- Conclusion

It was highlighted that the Iran seismic design response spectra are borrowed from those of two countries, USA and New Zealand. The maximum velocity period range of the design response spectra is borrowed from USA (variation of spectral ordinates proportional to 1/T) while implementing the directivity parameter N(T) from NZS. These are under the condition that the philosophy behind the two codes are quite different.

Regarding the recently wide construction of tall building, it quite clear that a deeply revision of the existing design response spectra particularly on the methodology of implementing a site-to-source dependent forward directivity effects seems to be inevitable.

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Table 1. Average value magnitude and distance for acceleration spectral 1 sec on four site soil condition in Iranian code. This value present as an average in Iranian code for assessment N(T) parameter

Soil Type	Spectral Acceleration (1 sec)	Booer 2008	Campbell 2008	Abrahamson 2008
IV	0.96	M=6.5, R=9	M=6.5, R=6.5	M=6.5, R=11
III	0.67	M=6.5, R=10.5	M=6.5, R=7.5	M=6.5, R=11.5
II	0.48	M=6.5, R=12	M=6.5, R=8	M=6.5, R=13
I	0.38	M=6.5, R=15	M=6.5, R=12	M=6.5, R=16

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