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# *Modification of the Design Response Spectra in Iranian Standard 2800 (Fourth Version) Taking in to Account the Directivity Effects*

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***ABATRACT***

Many populated urban areas of Iran are threatened by near source problems; forward directivity effects and fling step, which may cause huge catastrophic. The major reason is that this country is surrounded by the two huge mountain chains, Alborz and Zagross. As an example, Tehran is a city faced around with four near active faults, Mosha, North, Ray, and Karaj faults, which are potentially hazardous. This is under the condition that the design response spectra [A*B(T)] in Iranian Standard No. 2800, which is established on the basis of ten percent chance in fifty years, does not illustratively account for the directivity effects for sites located at near sources. This article is intended to propose a technique to descriptively modify the far field response spectra taking into account such problems for sites 20 Km far away from the active faults. The proposed modification factors are developed based on a limited number of near source data with and without directivity effects (58 recorded data) using three attenuation relationships. The proposed coefficients for four site soil conditions are implemented to the existing far field design response spectra presented in the fourth version of the response spectra. A comparison is made with those of UBC-97 and ASCE-7-2005 corresponding to two seismicity cities in the United State aimed at understanding how to assess their differences. The recommended technique may be interpreted as a start for developing a series of design response spectra having the potentiality of more accurately accounting for the near source problems.

***KEYWORDS***

Standard No. 2800, Near Source Problems, Forward Directivity Effects.

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## 1- INTRODUCTION

It is quite understood that strong motion at a distance of 10-30 Km far away from epicenter (the projection of hypocenter on the ground surface) is associated with special dynamic characteristics which is not seen in far field earthquake. These are termed “forward directivity ” and “fling step” effects, which can cause huge destructive effects over the existing buildings. Examples of the internal modeled events are Bam 2003 M6.3, Zarand 2005 M7.6 earthquakes and those of the external are Izmit 1999 M7.8, Chi-Chi 1999 M7.6, Northridge 1994 M6.7, Kobe 1995 M6.9 and Landers 1992 M7.3 earthquakes. In general, as a fault ruptures and propagates towards a site at a speed close to the shear wave velocity, the generated waves will arrive at the site at approximately the same time producing a “velocity pulse” at the beginning of velocity time-history [1], termed “forward-directivity effect.” Many research works have been performed to qualitatively and quantitatively understand the causes, the faulting factors, and conditions under which this phenomenon occurs [1, 2 and 3]. What makes the problem more complex is the limited number of accurate and reliable near source recorded data. For this reason, attempt has been focused on the development of simulation strong motion models including forward directivity effects. Examples are; omega squared models [4, 5 and 6], Greens Function based models [7, 8, 9 and 10], synchronized wave model [11], and hybrid models [12]. The inversion methods have been extensively used for modeling directivity effects e.g., Generic Algorithm GA, Multi-Objective Particle Swarm Optimization MOPSO [13]. Use of simple sine signal (pulse like) is another method from modeling the directivity effects of the structures responses.

## 2- DIRECTIVITY EFFECTS MODEL

A limited number of research works on theoretically estimating the directivity effects is found in literature. Ben-Menahem [14] is the first scientist who presented a relationship between the fault rupture length, fault rupture velocity, fault slip, and near source site location and pulse velocity in his PhD thesis. This finding has been followed through criticizing and modifying the idea by a number of researchers e.g., Somerville [1] and Spudish [15].

In the model proposed by Summerville [1], the variations in ground motion amplitude due to fault rupture directivity depends on the two geometrical parameters: $\frac{x}{L}\cos(\theta)$ (for strike-slip, and $\frac{d}{W}\sin(\varphi)$ for dip-slip faulting), the angle between the direction of rupture and the direction of traveling waves from the source to the site , and s (for strike-slip faults, or ruptured width, d, for dip-slip faults), the fraction of ruptured length lying between the hypocenter and the site.

## 3- PROPOSED METHOD

The proposed method is established based on the limited number of available data (58 near source strong motions) studied by the researchers and prepared by Somerville [1] together with a number of recorded data from Iran’s extreme events. It is quite understood that the directivity effects on the recorded velocity pulses are strongly influenced by the two seismological source-site parameters; X and cos(Θ) (for strike slip) and Y sin(ϕ) (for deep slip). Therefore, any near source model should take into account these two factors. In order to modify the far field response spectrum including near field directivity effects, these two factors should be extracted from the near source recorded data. This is achievable through a physical simulation process accounting for all the source, site and path effective parameters.

Therefore, having in hand a series of these two factors together with the information of earthquake magnitude M and distance R from site to source, a series of relationships is predicted using regression method. These relationships are cordillera made between these two parameters in the form of (Xcos(Θ)) and the ratio of the two response spectra; the near source response spectra corresponding to each of these two parameters (given a period T) and those of the far field response spectra obtained from the selected attenuation equation at that period as expressed by Equation 2:

$$\ln(\frac{Sa_{observed}}{Sa_i}) = C_1 + C_2 X \cos(\theta) \pm \varepsilon\sigma \qquad [2]$$

This is easily done by performing a linear regression between the two series of data ending up with a median values (the ratio is in logarithmic form) and a standard deviation б at each period T expressed in Equation (2).

Equation 2 is the base of modifying the design spectral shape of the Iranian standard 2800 to include the directivity effects at sites with 20 Km away from the active fault/faults. Equation 2 exposes a probabilistic form of directivity effects, with normal distribution, including the mean value (Equation2) associated with standard deviation б . For the reason that designing of structures based on the Iranian Standard Code (2800) is established on the basis of 10% chance in fifty years and regarding that the data used randomly include those of near and far field, the 25% probability of exceedance of the directivity effects suffices the modification process as an interim step . Undoubtedly, the necessity of reviewing the whole three period-ranges of the existing design response spectra (A*B), (in the fourth version), from the zero period to T0, T0 to Ts, and periods longer than T0 seems to be very necessary even inevitable. This is under the condition that most urban areas in this country are faced with near source problems due to the fact that are surrounded by the two huge mountain chains; Alborz and Zagross.

## 4- REFERENCE


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