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Site characterizations for the Tehran network (TDMMO) in Tehran Region Using Micro-Earthquake, Microtremor and Quarry Blast Data

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A B S T R A C T

We did a Study of Horizontal-to-Vertical Component Spectral Ratio in the Tehran seismic zone. Micro-earthquakes, microtremors and quarry blasts data were used as an estimation of the site response in the Tehran zone. Site effects were studied based on horizontal to vertical ratios by the Nakamura's technique. Also, we used the spectra of signals for three components with the lowest noise levels for spectral slope studies. The analysis used seismic events from a network of 13 seismic stations by the permanent local seismological network of the Tehran Disaster Mitigation and Management Organization (TDMMO) from 2004 to 2007. The number of events used were different for each station. Quarry blast events were with $1.2 \le M_L \le 2.2$ and micro-earthquakes were with $1.1 \le M_L \le 4.1$.

By comparing results for earthquake, microtremor and quarry blast, we could see that there is a significant difference between them. The data showed clear observations, especially in high-frequencies. The H/V spectral ratios indicate dominant frequency for rock/soft site with a higher ratio level for quarry blast ratios, which are comparable to the earthquake results due to their difference sources. The results derived by spectral H/V ratios and spectral analysis may be used to distinguish between local earthquakes and quarry blasts.

1. Introduction

Local site conditions may affect meaningfully the amplitude of earthquake ground motions known as site effects [1].

Site effect studies were recognized in the Japan earthquake in 1891 [2], the 1906 San Francisco earthquake [3], and the Long Beach earthquake of 1933 [4]. Gutenberg [5] studied sediment amplification in southern California for the first time [6].

Non-linearity of soil response and topographical effects are effective in ground motion parameters [7]. For instance, in the earthquake occurred on September 26, 1997 (Umbria – Marche, Italy), site amplification observed even at large distances from the epicenter [8].

Assessing seismic hazard is very important for Tehran. It is the most populated city in Iran. Some researchers have studied the local site conditions (using microtremors) and site effects in earthquakes recorded in strong motion stations and local temporary network/profiles in Tehran [9–11]. Others have worked on the realistic strong motion modeling, paying attention to site effects [12]. Local site condition analysis is an important issue of seismic hazard, since damages observed for earthquakes are related to geologic conditions and local site effect or site response [13–16]. Site response study is a strong input for microzonation, which has an important role to modify old buildings or to construct new ones [16].

In this study, we assessed site response based on an analysis of seismograms from three kinds of data in Tehran region. We try to estimate the amplification effects for earthquakes, microtremors and small explosions. We concentrate on the weak ground motions including micro-earthquakes, microtremors and quarry blasts in Tehran.

There is a long history of using microtremors to describe site characteristics. In Japan, Kanai et al. in 1950s and 1960s have suggested different methods based on the microtremor data in Tokyo [17]. Spectral ratio of the horizontal component to the vertical component (H/V) was suggested by Nakamura [18]. For engineering purposes, microtremor studies are applied to determine the predominate frequency of surface layers (14).

Records of earthquakes can help us understand the site effects and response of structures. So, we can use H/V spectral ratio not only for microtremor, but also for earthquake. Earthquake records are able to estimate predominant frequency and the amplification factor too. In our region, Tehran city, we do not have strong ground motion records. However, we tried to overcome this lack of data by using weak motions like microtremors, micro-earthquakes or effects due to explosions in order to assess the site effects. Udwadia and Trifunac [19] indicated that the differences might be due to recorded waves related to strong and weak motion. Such differences might be about their different types and their different propagation paths [20].

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In this research, we will show that H/V spectral ratios of microtremor and earthquake usually are the same, especially for rock sites. We observed a special characteristic in H/V spectral ratio for quarry blasts that they generally are different from earthquakes. First, we will discuss about the general tectonic of the region, and then the methodology is described. We present our results and discuss about them afterwards. The concluding remarks are presented finally.

2. General tectonic settings

The Iranian plateau is located on the Alpine-Himalayan seismic belt at the convergence of the Eurasian and Arabian plates. Most deformation in Iran is concentrated in the Zagros, Alborz and Kopeh Dagh mountains and eastern Iran [21]. Alborz is an active mountain trend belonging to the Alpine-Hymalian seismic belt, connecting the Talesh and the Lesser Caucasus ranges to the West, and the Eastern Alborz structures to the East. Central Alborz is subdivided into two main bordering structures: The Qazvin, North Tehran, Parchin and Garmsar southwards thrusting fault zone to the South, and the Khazar fault northwards thrusting fault to the North. Inside Alborz, the Taleghan, Mosha, Firouzkuh and Astaneh faults define a main left-lateral strike-slip corridor attesting of the partitioning of the deformation in Alborz [22].

The Alborz Mountains Belt is an active E–W trend with 100 km width and 600 km length, which was formed when Gondwana collided with Eurasia in the Late Triassic [23]. The Alborz range comprises several sedimentary and volcanic layers from the Cambrian to Eocene ages that were deformed during the late Cenozoic collision [24–26]. Its total shortening since the early Pliocene has been evaluated to be 30 km at the longitude of Tehran [27]. The mean elevation in the Alborz drops sharply from 3000 m in the inner belt to −28 m at the Caspian shoreline to the North. Alborz was affected by several successive tectonic events, from the Eo-Cimmerian orogeny to Late Tertiary-Quaternary intracontinental transpression [27], and is still strongly seismically active [28].

Tehran is situated in an enlargement along Alborz mountain front filled with alluvial materials originating from the rise of the Alborz range. The abrupt change of 2750 m in elevation between

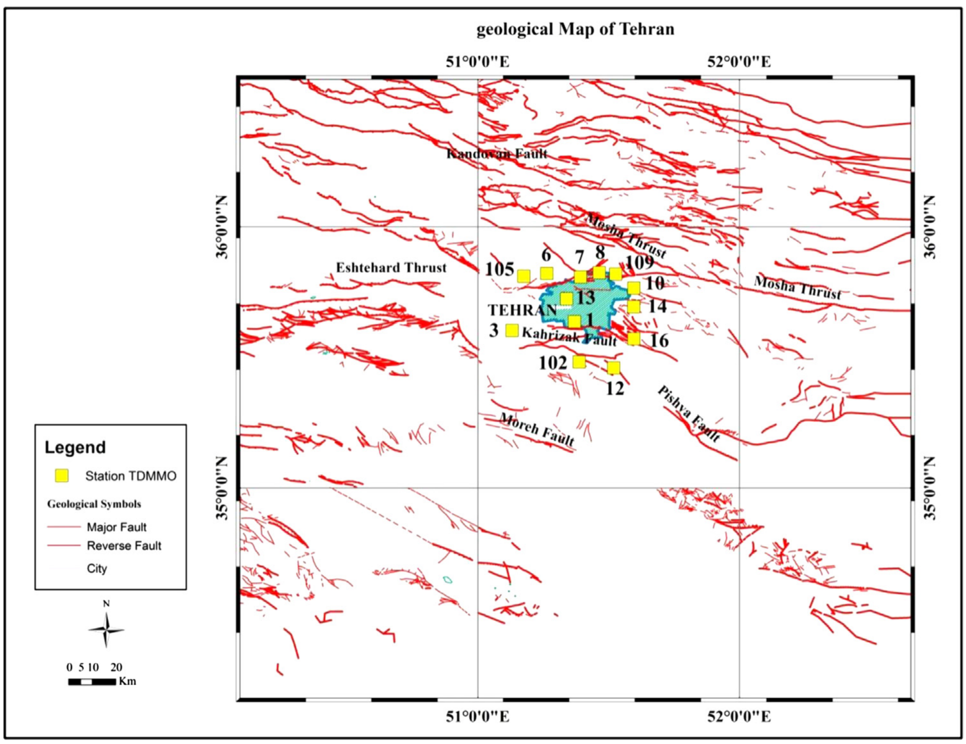

Fig. 1. Location of the seismic stations for Tehran network (TDMMO).

Table 1
Location of seismic stations for Tehran network (TDMMO).

Station no.	Latitude	Longitude	Altitude (m)	Geographic location
1	N 38.24' 35°	E 22.18' 51°	1100	Shariati park
102	N 29.00' 35°	E 23.26' 51°	983	Ghasem abaad
3	N 36.20' 35°	E 7.84' 51°	1090	Saba shahr
105	N48.69' 35°	E 10.51' 51°	1864	Vardyj
6	N 49.34' 35°	E 15.82' 51°	1680	Sulaqan
7	N 48.53' 35°	E 23.55' 51°	1820	Velenjak
8	N 49.52' 35°	E 27.84' 51°	1851	Jamshidieh park
109	N 49.15' 35°	E 31.62' 51°	2110	Shahrak area
10	N 45.93' 35°	E 35.80' 51°	1676	North of Tehran pars
12	N 27.59' 35°	E 31.17' 51°	967	Eshgh abaad
13	N 43.50' 35°	E 20.37' 51°	1274	Tehran disaster mitigation and management organization
14	N 41.69' 35°	E 35.78' 51°	1666	Hameh sin
16	N 34.30' 35°	E 35.79' 51°	1231	Lapeh zanak