ISSN:1306-3111
e-Journal of New World Sciences Academy
2009, Volume: 4, Number: 4, Article Number:1A0054

ENGINEERING SCIENCES
Received: March 2009
Accepted: September 2009
Series : 1A
ISSN : 1308-7231

Savaş Karabulut
İlhan Osmanşahin
Istanbul University
savask@istanbul.edu.tr
Istanbul-Turkey

ON THE USE OF MICROTREMOR DATA FOR MICROZONATION IN BUYUCEKMECE (ISTANBUL), TURKEY

ABSTRACT

The recent August 17, (Izmit) and November 12, 1999 (Duzce) earthquakes have clearly shown that near surface geological structure and topographical conditions play an important role in the level of ground shaking. In mitigation, first of all, information on soft soil response to earthquakes has prime importance. The mapping of dynamic properties of site can assist in mitigation in earthquake prone areas. Microtremor recordings are useful for determining site effects in Buyukcekmece. Microtremor observations can be used to determine the predominant period and amplification of soil at any site, hence can be used for microzonation. These records are analyzed by Nakamura's method to obtain the predominant period and amplification of soil at selected sites. Nakamura's method which proposes a practical and inexpensive procedure for estimation of the fundamental frequency of the site, assumes that the spectral ratio of horizontal to vertical components yields an estimation of site effects. The obtained results range from 0.11 s to 1.36 s and from 1.0 to 3.4 for predominant site periods and amplifications, respectively.
Keywords: Microzonation, Soil Response, Microtremor, Amplification, Soil Fundamental Period

BÜYÜKÇEKMECE İLÇESİNDE MİKROTREMOR VERİLERİYLE MİKROBÖLGELEME ÇALIŞMALARI

ÖZET

17 Ağustos 1999 Kocaeli Depreminde oluşan büyük hasarlar ve yüksek depremsellik nedeniyle Marmara Bölgesi özellikle İstanbul Kenti deprem bilimcilerin daha yakın ilgisini çekmiştir. Bu anlamda mikrobölgeleme çalışmaları önemli hala gelmeye başlamıştır Avcılar ve Büyükçekmece 1999 depreminden büyük ölçüde etkilenen İstanbul'un önemli semtlerindendir. Bu çalışmanın temel amacı, zemin tepkisinin belirlenmesinde mikrotremor verilerin kullanımı ve bu amaçla bölgenin zemin hakim titreşim periyot haritasının oluşturulmasını kapsamaktadır. Böylece çalışma alanının mikrobölgeleme çalışması bağlamında önemli bir girdi verisi elde edilmiştir. Bu amaçla 18 noktada mikrotremor ölçümü alınmıştır. Zemin Hakim periyot ve Bağıl büyütmeleri elde edilmiş ve zemin sınıflamaları yapılmıştır. Elde edilen sonuçlara göre hâkim periyotlar, bağıl büyütmeler sırasıyla 0.10-1,36 ve 1.0-3,4 arasında değişmektedir.
Anahtar Kelimeler: Mikrobölgeleme, Zemin Tepkisi, Mikrotremor, Büyütme, Zemin Hâkim Periyodu

1. INTRODUCTION (GİRİŞ)

"Manual for Microzonation on Geotechnical hazards", prepared by the International Society of Soil Mechanics and Foundation Engineering's technical Committee for Geotechnical Earthquake Engineering, includes accepted approaches for assessing tree kinds of phenomena: local ground response (amplification), slope instability and liquefaction [ISSMFE, 1993]. Safety against earthquake hazards has two aspects: firstly, structural safety against potentially destructive dynamic forces and secondly, safety of a site itself related with the phenomena such as amplification, slope instability. For each kind of phenomenon local ground response, slope instability and liquefaction, three grades of approach to microzonation are described. Zoning for earthquake ground motions addresses one of the most fundamental aspects of seismic hazards assessment. Firstly, the ground motions are directly related to the seismic forces acting on structures, and hence seismic zoning for ground motions provides an important initial indicator of seismic risk. Secondly, ground motions are directly related to soil failure, for example in foundations and slopes, which can further lead to damage to structures.

The use of microtremors in site response analysis has been introduced long years ago in the world. Microtremors have been used basically in three different ways in relation with site conditions: absolute spectra, spectral ratios with respect to a reference site, H/V spectral ratio [Bard, 1999; Field and Jacob, 1993; Nakamura, 1989; Karabulut, 2007].

2. RESEARCH SIGNIFICANCE (ÇALIŞMANIN ÖNEMİ)

The study of subsoil, a matter of great importance in civil engineering, is usually performed by drilling boreholes. However, this method is expensive and slow, and although the information obtained is precise, it is also extremely localized. An attractive alternative is microtremor measurement, which provides the soil fundamental frequency and soil amplification depending on the method, certain mechanical parameters as well. Geophysical techniques provide less information on the subsoil than drilling, however they offer the great advantages of covering a greater extent of ground in less time and at a lesser cost. The method of *H/V* spectral ratios of microtremors is characterised by the ease and speed with which it determines the main resonance frequency of the soil.

3. METHOD (YÖNTEM)

The technique was originally used by Nakamura [1989] to interpret microtremor measurements. According to Nakamura [1989] technique, it is possible to estimate the relative amplifications and predominant period by Horizontal/Vertical spectral ratios of microtremor records. Site effect due to surface geology are generally expressed as the spectral ratio (A)between the horizontal to vertical component of background noise recorded at the surface of the soft layer enables the effects of the Rayleigh waves to be eliminated, conversing only the effects resulting from geological structure of the site:

$$A = H / V \qquad (1)$$

where A, H and V respectively are relative amplification level, horizontal and vertical spectral components of microtremor records.

4 THE FIELD STUDIES (SAHA ÇALIŞMALARI)

Microtremors are useful for evaluating site amplification and site predominant period. The main purpose of this study is mapping the predominant period and amplification by using microtremor observations for the area of Büyükçekmece which is one of the districts of Istanbul city and placed at the shore of the Marmara Sea as an earthquake prone area especially after the destructive earthquakes in 1999. For this aim, microtremor observations were performed at 18 sites near the borehole sites, in Büyükçekmece (Istanbul) region, using Güralp CMG-40T portable equipment on 20-21 July, 2004. Records consist of three components, two horizontal and one vertical. According to microtremors, soil classifications of NEHRP were made and site predominant periods were determined for the region. As an example, Figure 1-2-3 and 4 shows the soil amplification factors by using microtremors. Microtremor data to use in site response analysis, H/V spectral ratios were obtained at these sites. In Table 1, obtained amplifications, soil clasifications, site periods were given.

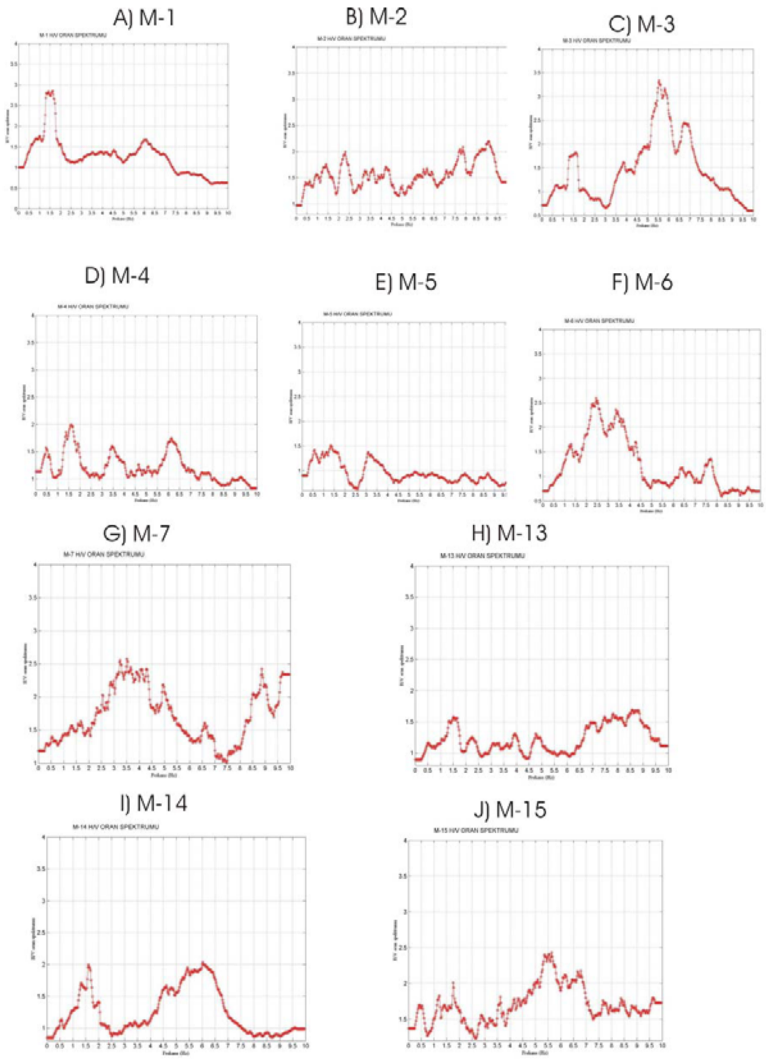


Figure 1. For gürpınar formation: A) M-1, B) M-2, C)M-3, D) M-4, E) M-5, F) M-6 G) M-7 H) M-13 I) M-14 J) M-15 H/V spectral ratios.
(Şekil 1. Gürpınar formasyonu üzerinde alınan mikrotremor ölçümleri: A) M-1, B) M-2, C) M-3, D) M-4, E) M-5, F) M-6 G) M-7 H) M-13 I) M-14 J) M-15 Noktalarına ait H/V oran-Frekansları)

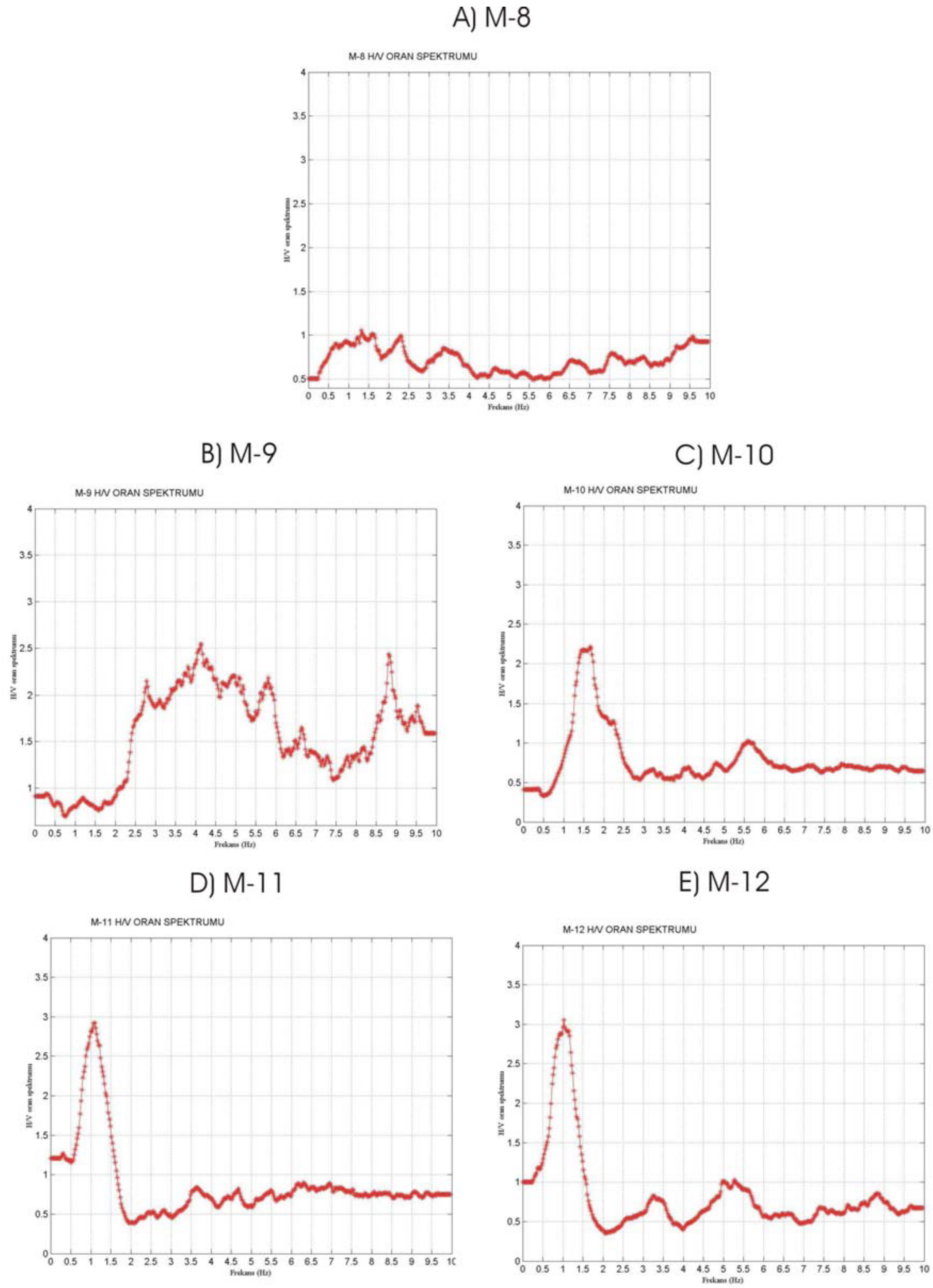


Figure 2. For alluvion deposite, A) M-8, B) M-9, C)M-10,D) M-11 E) M-12. H/V spectral ratio.
(Şekil 2. Alüvyon üzerinde alınan MİKROTREMOR ÖLÇÜMLERİ: A) M-8, B) M-9, C)M-10,D) M-11, E) M-12 Noktalarına ait H/V oran-Frekansları)

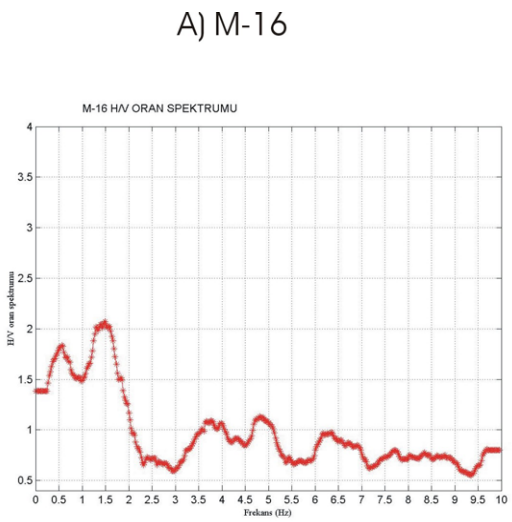


Figure 3. For Bakırköy formation A) M-16 H/V spectral ratio.
(Şekil 3. Bakırköy formasyonu üzerinde alınan mikrotremor ölçümü: A) M-16 Noktasına ait H/V oran-Frekansı)

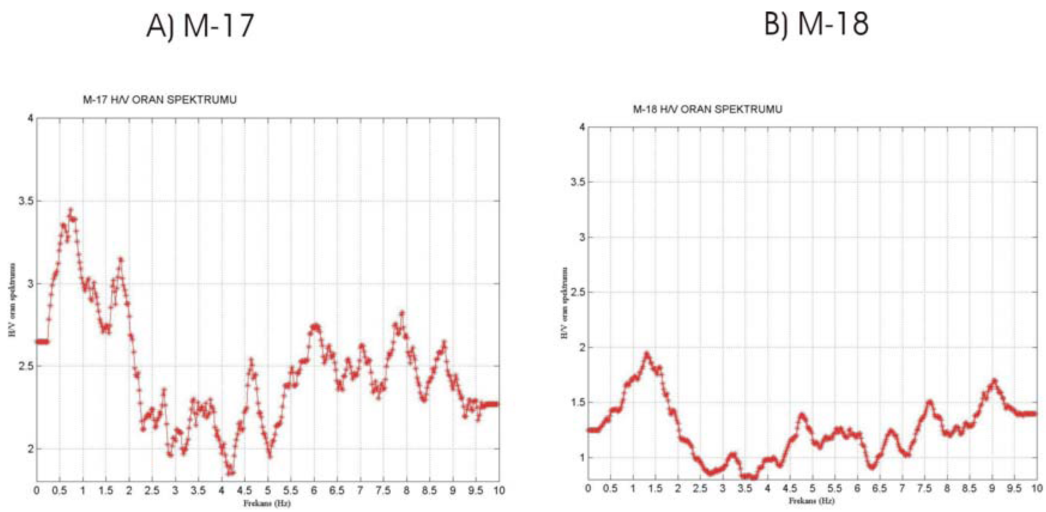


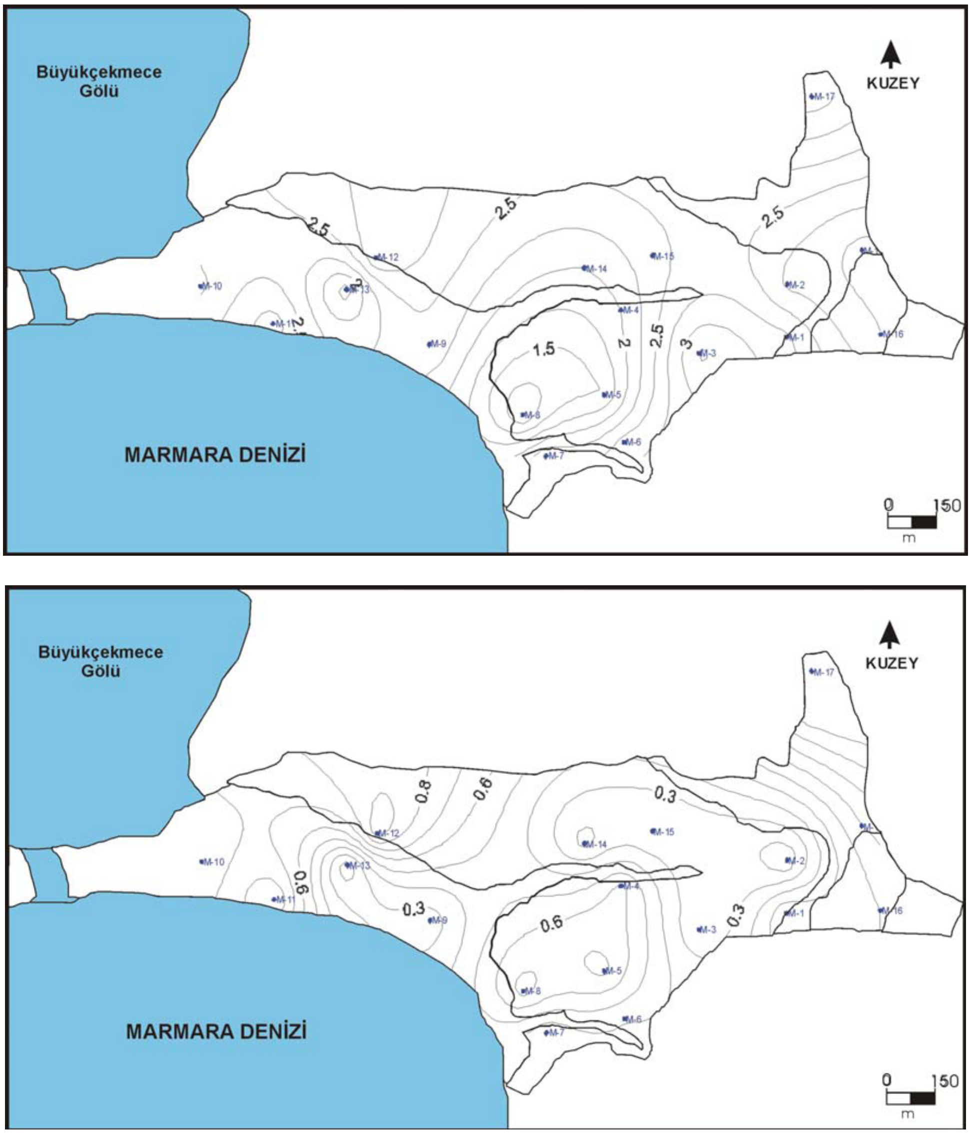
Figure 4. For çukurçeşme formation, A) M-17, B) M-18, H/V spectral ratio.
(Şekil 4. Çukurçeşme formasyonu üzerinde alınan mikrotremor ölçümleri: A) M-17, B) M-18 Noktalarına ait H/V oran-Frekansları)

5. DISCUSSIONS AND RESULTS (TARTIŞMA VE SONUÇ)

In our study area that located in Büyükçekmece (Istanbul), microtremors have also been obtained near the borehole sites for microzonation. For the study area, the predominant period and amplification was determined by H/V spectral ratios obtained by microtremor measurements. The predominant period, amplification and sediment thicknesses maps were plotted for region. Soil classification was determined according to Turkish Earthquake Code and National Earthquake Hazards Reduction Program (NEHRP) classifications. The soils are categorized as C and D in the study area, according to the soil classification map. The cover thicknesses for each site are calculated by using the relationship between the mean thickness and the site frequency in the spectral ratios, established by Seht and Wohlenberg (1999). The obtained results range from 0.11 s to 1.36 s and from 1.0 to 3.4 for predominant periods and amplifications, respectively. We use relationship which was proposed by [Birgoren and Ozel, 2009]. This relationship is as following:

$$H=150.99\ f^{-1.15} \tag{2}$$

Where f: soil fundamental frequency and H: Sediment thickness.



(A)

(B)

Figure 5. (A) Amplification map, (B) Predominant period map
(Şekil 5.(A)Zemin Büyütme Haritası, (B) Zemin Baskın Periyot Haritası)

The other relationship proposed by [Seht and Wohlenberg, 1999]. It is as following:

$$H= 96*f^{-1,388} \tag{3}$$

Using above relationships, we compared sediment thickness (meter) for this region (Table 2).

Table 1. Obtained amplifications, soil classifications, site periods
(Tablo 1. Zemin büyütmesi, zemin sınıfı ve zemin hakim titreşim periyodu değerleri)

Site No	Coordinates X	Coordinates Y	Soil Clasification	H/V Period (s)	H/V Amplifications
1	41 00 54.7	28 37 09.9	D_2	0.61	2.8
2	41 01 20.7	28 37 10.0	D_1	0.11	2.2
3	41 01 04.5	28 36 47.5	C	0.2	3.3
4	41 01 14.7	28 36 27.5	D_1	0.63	2.0
5	41 00 54.7	28 36 23.1	D_1	0.73	1.5
6	41 00 43.5	28 36 28.3	D_3	0.41	2.6
7	41 00 40.2	28 36 08.4	D_3	0.3	2.5
8	41 00 50.0	28 36 02.4	D_3	0.75	1.0
9	41 01 06.6	28 35 38.6	D_2	0.24	2.5
10	41 01 20.3	28 34.40.1	D_2	0.60	2.2
11	41 01 11.5	28 34 58.6	D_5	0.91	2.9
12	41 01 27.0	28 35 24.9	D_4	0.97	3.0
13	41 01 19.5	28 35 17.4	-	0.11	1.6
14	41 01 24.6	28 36 18.1	C	0.16	2.0
15	41 01 27.5	28 36 35.5	D_2	0.2	2.4
16	41 01 09.0	28 37 33.9	D_1	0.6	2
17	41 02 05.1	28 37 16.3	-	1.36	3.4
18	41 01 28.8	28 37 29.1	-	0.7	1.9

Table 2. Comparasion of Sediment thickness obtained [Birgoren and Ozel, 2009; Seht and Wohlenberg, 1999]
(Tablo 2. [Birgoren and Ozel, 2009; Seht and Wohlenberg, 1999] tarafından geliştirilen bağıntılar yardımıyla Sediman Kalınlığının Karşılaştırılması)

Measurement Point	Period (sec)	Frequency (Hz)	Sediment thickness (m) (Birgoren, Ozel and Siyahi) 2009	Sediment thickness (m) Seht and Wohlenberg, 1999
1	0,61	1,64	86	48
2	0,11	9,09	12	4
3	0,2	5,00	24	10
4	0,63	1,59	89	51
5	0,73	1,37	105	62
6	0,41	2,44	54	28
7	0,3	3,33	38	18
8	0,75	1,33	108	64
9	0,24	4,17	29	13
10	0,6	1,67	84	47
11	0,91	1,10	135	84
12	0,97	1,03	146	92
13	0,11	9,09	12	4
14	0,16	6,25	18	8
15	0,2	5,00	24	10
16	0,6	1,67	84	47
17	1,36	0,74	215	147
18	0,7	1,43	100	59

ACKNOWLEDGMENT (TEŞEKKÜR)

This work has been supported by Istanbul University, Research Fund Project, No: T350/03112003.

REFERENECS (KAYNAKLAR)

- Bard, P.Y., (1999). Microtremor Measurements: A Tool For Site Effect Estimation?, Second International Symposium on the Effects of Surface Geology on Seismic Motion – ESG98- held in Yokohama, Japan, December 1-3).
- Birgören, G., Ozel, O., and Siyahi, B., (2009). Bedrock Depth Mapping of the Coast South of İstanbul: Comparison of Analytical and Experimental Analyses Turkish Journal of Earth Sciences (Turkish J. Earth Sci.), Vol. 18, pp:1.
- Field, E.H. and Jacop, K., (1993). The Theoretical Response of Sedimentary Layers to Ambient Seismic Noise, Geophysical Res. Letters, 20-24, pp:2925-2928.
- ISSMFE, (1993). Manual of Seismic Microzonation, Japan Society of Soil Mechanics and Foundation Engineering.
- Karabulut, S., (2007). "Mikrotremor ve Analiz Yöntemleri", Meslekiçi Eğitim ve Belgelendirme Kurs Notları-4, ISBN: 978-944-300-8, TMMOB Jeofizik Mühendisleri Odası.
- Nakamura, Y., (1989). A Method for Dynamic Characteristics Estimation of Subsurface using Microtremor on the Ground Surface, Quarterly Reports of the Railway Technical Research Institute Tokyo, 30. pp:25-33
- NEHRP, (2000). Recommended provisions for seismic regulations for new buildings and other structures, Part 1: Provisions, FEMA 368, Building seismic safety council of the National Institute of Building Sciences, USA.
- Seht, I.M. and Wohlenberg, J., (1999). Microtremor Measurements Used to Map Thickness of the Soft Sediment, Bull. Seis. Soc. Am.,