

**E-5) - FINAL REPORT ON THE
GEOPHYSICAL INVESTIGATIONS
CONDUCTED AT THE ENVISAGED POWER – PLANT SITE
İNCİRLİK AIR FORCE BASE, ADANA**

1. INTRODUCTION

This report covers the extent, procedures and the final results of the geophysical investigations conducted at the proposed power plant site in the İncirlik Air Force Base at Adana.

The main aim of the tests was the interpretation of the shallow soil structure and characteristic in the proposed site in terms of its physical parameters to aid in the vibration isolation design of the electric generator foundations.

For this purpose extensive surface refraction seismic tests were conducted. An initially planned vibration generator test to analyse the foundation response was later abandoned due to the unavailability of proper testing facilities near by the site and further classification of the scope and coverage of the investigations by Mr. Hüsamettin Güz, geotechnical consultant to Yalçın Teknik Consulting Firm.

2. SURFACE REFRACTION TESTS

Conventional surface refraction seismic tests were conducted at the site using the 6-channel Engineering seismograph unit. Refraction lines run at the site were 100 ft (30 m) in length. Horizontal geophones were spaced at 20 ft (6 m) intervals with the first geophone positioned between 1 to 2 meters from the energy source. The energy was initiated along the edge of 50 kg. cone-shaped weight which was buried into the ground. A spherical- shaped weight was then dropped from a height 2.5 m. on the top of the cone-shape weight.

Fourteen locations were probed by the seismic method inside the proposed power – plant location.

These tests consisted of three profiles. The orientation and location of the probing stations and the profiles are shown in the test lay out in Figure – 1.

For each probing station the depth distribution of the P and S wave velocities are evaluated and plotted. Examples of these travel – time curves are shown in Figure 2, 3, and 4.

The P and S wave velocities determined from such analyses can be converted (e. g. See Dobrin, 1976) to elastic parameters of the soil such as shear modulus, G, Young's modulus, E, and Poisson's ratio, σ , for use in vibration isolation design of the power plant foundation.

2.1. Seismic Results

On the basis of distribution of P and S wave velocities recorded at various profile locations and inferred subsurface structure, the studied portion of envisaged power plant site can be divided into three different layers (see Table-1).

Figures 5, 6 and 7 are diagrammatic section along the profiles showing depths to the various layers inferred from the seismic data.

These are idealized soil profiles that would be suitable for design calculations.

FIRST LAYER : Surface S wave velocities of 31 to 88 mps underlain by a 191 to 359 mps layer at depths between 0.93 and 3.48 m. Surface P wave velocities of 88 – 187 mps underlain by 609 to 1219 mps at 3.48 m. or less. Surface Poisson's ratio ranging from 0.23 to 0.474. Surface shear modulus ranging from 0.02 to $0.16 \cdot 10^3$ kg / cm². Surface Modulus of Elasticity ranging from 0.09 to $0.47 \cdot 10^3$.

SECOND LAYER : Second layer S wave velocities of 191 – 359 mps underlain by a 251 to 659 mps layer at depths between 6.6 and 10 meters. Shear Modulus ranging from 0.8 to $3.14 \cdot 10^3$ kg / cm². Modulus of Elasticity ranging from 2.3 to $10.2 \cdot 10^3$ kg / cm². Second layer P wave velocities of 609 to 1219 mps underlain by a 813 to 2032 mps at depths up to 10 meters.

THIRD LAYER : Seismic refraction data from lower part of second layer show that S wave velocities ranging from 813 to 2032 mps.

Poisson's ratio of the third layer ranging from 0.06 to 0.48 Shear Modulus of third layer ranging from 0.8 to $2.8 \cdot 10^3$ kg / cm². Third layer Modulus of Elasticity ranging from 6.5 to $22.2 \cdot 10^3$ kg / cm².

Low S-velocity layer can be seen under the high-velocity layer at the probing stations IS-5 and IS-12. Considerable decrease in the shear modulus was found at the same probing stations. Shear modulus, G, SPT values, N, and Modulus of Elasticity, E, have been presented in Figure-7 along the profile C - C¹.

2.3. Damping of S wave in soil

An approximate formula for amplitudes of spherical waves propagating over the soil surface given by Berkan, 1960 as follows,

$$A_r = A_o \sqrt{\frac{r}{r_0}} \cdot e^{-\alpha(r-r_0)}$$

Where A_r , A_o – amplitudes of soil vibrations at distances r , r_0 .

α - Absorption coefficient (or decay in intensity of elastic wave with distance and having dimensions meter^{-1} or centimeters^{-1}).

The coefficient of shear – wave energy absorption (α_b) can be obtained by using the above formula. From this experiment the value of α_b equaling 0.068 m^{-1} was obtained for plastic clay.

2.4. S-Wave Amplitude Distance Relationship

In addition to the routine seismic – refraction survey, continuous S – wave amplitude recordings were carried out site. Energy were received from the operating generators near the proposed power-plant site. All recordings were made on photographic paper with fixed gain.

The amplitude of the first S – wave were measured by a method similar to that of Kovach et.al. (1963), i.e. reading the distance from the first peak to the first trough.

The measured amplitudes were then plotted against distance from the energy source to the horizontal geophones on log – log paper.

Figure – 8 shows a plot of A as a function of d . A straight line estimate of the best fit of the data was drawn through the plotted points and the slope of this line calculated from the formula

$A = N \cdot d^{-a}$ where “ A ” is the amplitude of shear – wave. “ d ” the distance. The attenuation law for P - wave found by Kovach et.al.(1963) is $A = N \cdot d^{-2.3}$ on alluvium, while our estimate for a for S wave at the observation point 13 gives a value of 3.

2.5. Seismic Microzonation Studies

Medvedev, 1961 used the product of the velocity of the longitudinal wave (V_p) and the density (ρ) of the material, the impedance as a basis for estimating the relative differences in intensity, also rendered by the water content of the ground.

He determines that,

$$n = 1.67 [\log(V_s \rho_s) - \log(V_n \rho_n)] - e^{-0.04 h^2}$$

where “n” is the increase in intensity on the GEOFIAN scale, for ground with characteristics V_n and ρ_n , with respect to standard ground, with characteristic V_s (5600 mps), and ρ_s (2.9 gr / cm³), and “h” equals depth of ground – water level.

Increase in seismic intensity from the ground at the power-plant site were calculated and the results are presented along the profiles. The “n” values ranging from 1.49 to 1.78 at the envisaged power-plant site.

2.6. Predominant Period of The Soil

The soil parameters needed for the computation of the predominant period, T_{pp} (sec) of the profile are : the shear – wave velocity (V_s), and thickness of the deposits, H.

The relationship between predominant periods, T_{pp} , and layer, thickness H, can be expressed in the following form.

$$T_{pp} = \frac{4H_1}{V_{S_1}} + \frac{4H_2}{V_{S_2}} + \frac{4H_3}{V_{S_3}}$$

In this expression, H_1 , H_2 and H_3 represent the thickness of first layer, and the lower two layers. V_{S_1} , V_{S_2} and V_{S_3} represent the S- wave velocities in the first layer, the second layer, and the third layer. The predominant period of soil at the observation points IS-3, 4, and 8 were about 0.2, 0.31, and 0.43 sec. respectively. The soil resonant frequency is $w_s = 2\pi \cdot V_s / 4H$. The predominant frequencies of the soils were about 0.89, 1.94 and 1.256 rad. / sec. at these points.

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