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DELINEATION OF SUBSURFACE FEATURES USING SHALLOW GEOPHYSICAL SURVEYS AT NEW CAIRO CITY

H.H. El-Kadi*, M.A.H., Abdel Aziz ** and A.M. Saad*

** Geology Department, Faculty of Science, Al-Azhar University*
** * Atomic Energy Authority*

استنباط الخصائص التحتسطحية لمدينة القاهرة الجديدة باستخدام المسح الجيوفيزيقى الضحل

الخلاصة: يلعب الوضع الجيولوجى العام وكذلك الخصائص الفيزيقية والديناميكية لطبقات الأساس دوراً فعالاً فى استقرار المنشآت وخاصة فى حالة تعرض المنشآت لقوة ديناميكية مصاحبة لحدوث الزلازل ويتعلق هذا البحث بتطبيق الطرق الجيوفيزيقية الضحلة واستخدامها فى استنباط الخصائص الفيزيقية والديناميكية للطبقات الضحلة وذلك لتحديد طبقة الأساس. وقد استخدمت طريقة المقاومة النوعية الكهربية لتحديد المقاومة الحقيقية للطبقات الضحلة وكذلك أسماك تلك الطبقات وأعماق المياه الجوفية. ومن ناحية أخرى فقد استخدمت طريقة المسح السيزمى الانكسارى لتقسيم القطاع الضحل إلى طبقات ذات سرعات سيزمية محددة والتى استخدمت فى تحديد معاملات المرونة لطبقات الأساس.

وقد استخلص من الدراسة أنه قد أمكن تقسيم القطاع الضحل لمدينة القاهرة الجديدة إلى أربع طبقات ذات خصائص صخرية وفيزيقية مختلفة وتتراوح قيمة المقاومة النوعية للطبقة الأولى من ١٥ إلى ١٠٠ أوم متر، كما يتراوح سمكها من ٠,٦ إلى ٣٦ متراً. بينما تتراوح قيمة المقاومة النوعية للطبقة الثانية من ١٠٠ إلى ٥٠٠ أوم متر، وسمكها يتراوح من ٠,٧ إلى ٣٧ متراً. وتتميز الطبقة الثالثة بمقاومة نوعية أقل من ١٥ أوم متر وسمك يتراوح من ٠,٧ إلى ٢٥ متراً. بالنسبة للطبقة الرابعة فتصل مقاومتها النوعية إلى أكثر من ٥٠٠ أوم متر. كما بينت الدراسة أن سعة التحميل القصوى للطبقة الثانية تتراوح من ٨٩٨ إلى ١٦١٤ جرام/سم٢ بينما تتراوح سعة التحميل المسموح بها من ٢٩٩ إلى ٥٣٨ جرام/سم٢ .

ABSTRACT: *The geologic setting and physical and dynamic properties of foundation beds are playing a crucial role in the stability of building, especially in case of the subjection of building to dynamic forces associated with the earthquake occurrence. The present work is concerned with the application of shallow geophysical investigations to delineate the shallow subsurface geologic characteristics and determine the physical and dynamic properties of foundation beds in New Cairo city. The electric resistivity survey was applied by using Schlumberger array to identify the resistivity and thickness of the different shallow layers. The shallow seismic refraction technique was also used to evaluate the foundation rock properties in the area by recording the time arrivals of seismic waves and their interpretation in terms of subsurface geoseismic layers and their physical and dynamic properties.*

The shallow section of New Cairo city, could be divided into four types of lithologic units; sandy soil (a resistivity from 15 to 100 Ohm-m and thickness from 0.6 to 36m), gravely soil (sand and gravel with a resistivity from 100 to 500 Ohm-m and thickness from 0.7 to 37m), clayey soil (silty clay of less than 15 Ohm-m and thickness is varying from 0.7 to 25m) and rocky soil (sandstone, sandy limestone and weathered basalt of more than 500 Ohm-m). The ultimate bearing capacity in the second layer is ranging from 898.72 to 1614.07 gm/cm^2,the allowable bearing capacity in the second layer is between 299.57 and 538.02 gm/cm^2 and hence the factor of safety is equal to 3.

INTRODUCTION

The New Cairo city is located at the eastern part of Cairo. It is bounded by Cairo Suez desert road from the North, El-Qattamiya-Ain El-Sokhna road from the South, Ring road from the West and Gebel El-Anqaabiya from the East Fig.(1). The study area lies between latitudes 29°55′ and 30°05′ N and longitudes 31°20′ and 31°40′ E. The New Cairo city is characterized by an arid climate, very low rainfall, high temperature and high evaporation rate.Geomorphologically, the New Cairo area has a moderate relief. The elevation ranges from 50 to 460 m above sea level. There are three main geomorphologic units; the lime plateau, cuestas hills and rolling palm unit.

Both the resistivity and seismic refraction surveys are broadly used in the civil engineering projects. Electrical survey is used to determine the depth of bedrock, weathered zone thickness, depth to groundwater and clay extension. On the other hand, the seismic refraction survey is generally utilized to divide the shallow section into layers, delineate the geologic structure intersects the continuity of the encountered layers and deduce the physical and dynamic properties of the foundation beds.

Geologic Setting

In the area of study, the exposed stratigraphic units exposed are all sedimentary rocks. The general stratigraphic secessions are belonging to (1)Eocene deposits: These deposits are exposed in this area and can be classified into two units: a-) Middle Eocene deposits: which are subdivided into three Formations: the Observatory , Qurn and Wadi Garawi. The Observatory Formations composed of yellowish white fossiliferous chalky limestone and hard dolomitic limestone. While the Qurn Formation is mainly represented by chalky, marly limestone and limestone alternating with sandy marl. The Wadi Garawi Formation is composed of limestone , marl and sandy shale. b) Late Eocene deposits representing Wadi Hof Formation. They are composed of shale and sandstone with a basal limestone bed. The Wadi Hof Formation overlies conformably the Wadi Garawi Formation and underlies unconformably the Oligocene sediments. (2) Oligocene deposits: represented mainly by the Cairo Facies (Gebel Ahmer Formation), which is composed of sand with gravels and sedimentary quartizites with silicified wood. Basaltic flows are recorded at the top of the Oligocene sediments in this Facies. (3) Miocene deposits: which can be classified into two units: a) Marine Miocene (Homth Formation): The marine Miocene section occurs as patchy, isolated outcrops along the Cairo –Suez road, but eastward it covers larger areas. It is made up of sparsely fossiliferous calcareous sandstone and arenaceous limestone. b) Non-marine Miocene (Hagul Formation): which covers most of north eastern part of the study area. It is composed of white to grayish sand. It intercalated by gravels beds. (4) Pliocene deposits**:** which are found on the top of the non-marine Miocene at gebel El-Nassuri and El- Anqabiya. They consist of cross bedded sand with some clay, conglomerate and white hard and very dense limestone.

INSTRUMENTATION AND PROFILES LAYOUT

For that reason, 22 Schlumberger vertical electrical soundings (Fig. 2) were conducted with a maximum electrode spacing of 200 m. These vertical electrical soundings have been carried out by the Swedish apparatus. ABEM-terrameter SAS 300 C. On the other hand, 24 channels S2-echo seismograph, manufactured by Sintrex was employed during field survey. Ten profiles were surveyed in the studied area. Each profile has 48 m long with 4m geophones spacing. Each profile has two shots located at the ends of the profile as shown in Fig. 2.

DATA PROCESSING AND INTERPRETATION

(A) Resistivity Data:

The resistivity interpretation was carried out using the method developed by Van der Velpen (1988) in which, the values of AB/2 and ρ_a were used in fast iterative procedure to give a multilayer model reflecting the inferred true depths and resistivities. The initial model proposed to the Resist-program is taken to determine the parameters of the bedrock. The geoelectric parameters (resistivity and thickness of the different geoelectric layers) obtained from the interpretation of each VES are given in Table 1. Also, a number of geo-electric cross sections have been established along a number of the executed profiles to define the lithological succession in the shallow section and determine the depth to water table.

Geo-electric Cross-Sections

The interpreted resistivity data have been utilized to construct a number of cross sections that reflect the shallow section underneath the studied area. They show that the shallow section consists mainly of four geo-electrical layers as shown in Fig.3. The first layer exhibits electrical resistivity values varying from 15 to 100 Ohm.m corresponding lithologically to sandy soil. Its thickness varies from 0.6 to 36m. The second layer has resistivity values ranging from 100 to 500 Ohm.m corresponding to gravel. Its thickness ranges between 0.7 to 37m. The third layer has a relatively low resistivity values less than 15 Ohm.m and its thickness varies from 0.7 to 25m, and corresponds lithologically to clayey silt. The fourth layer has resistivity values more than 500 Ohm.m with a thickness varying from 0.3 to 32m, and correspond, to rocky soil.

(B) Shallow Seismic Data

Seismic refraction data have been interpreted using RF software developd by OYO company giving the depth not only at the two ends of the profile but at each geophone. So, It reflects the undulations and irregularities in the strata. The processing and interpretation of the data cited from the apparent velocities, distances between shot points and geophones and depths were carried out using Haigwara method. Table 2 shows the variation of the seismic wave velocities along ten profiles executed in the studied area.

Subsurface Cross Sections:

A number of cross sections reflecting the nature and continuity of the geo-seismic layers in the shallow section underneath the studied area (Fig.4). The shallow section could be divided into two geo-seismic layers with S-wave velocities ranging from 141m/sec to 647 m/sec and P-wave velocities from 240 m/sec to 1100 m/sec for the first layer. Also, seismic wave velocities have been calculated for the second layer to range from 317 m/sec to 3700 m/sec (table 2). The large variation in seismic wave velocities reflect the variation in the rock type occupied the shallow section in the area.

Dynamic Properties of Foundation Bed

The measured P- and S- wave velocities have been used to calculate the dynamic properties of the foundation bed including the Poisson's ratio, standard penetration test, bulk modulus, shear modulus, rigidity modulus, allowable and ultimate bearing capacity using a number of empirical relationships. These relationships were developed by many authors like Gardner et al., 1974, Imai et al., 1976.

Table 1: Resistivity (R) and corresponding thickness (H) of different geoelectrical layers.

VES No. \ Layer No.	I	II		III		IV		V	
	R_1	H_1	R_2	H_2	R_3	H_3	R_4	H_4	R_5
1	2752	4	207	38.2	876	--	--	--	--
2	62	3.6	288	6.7	30	29.4	100	--	--
3	34	0.6	296	4.3	14	15.3	127	--	--
4	80	1.6	134	3.3	42	8.6	78	--	--
5	58	1.6	135	41.6	34	--	--	--	--
6	161	1.5	89	5.1	4	10.7	134	34	8
7	13	2.6	26	13.5	103	--	--	--	--
8	29	0.5	199	12.7	348	--	--	--	--
9	39	2	60	36	20	--	--	--	--
10	107	1.9	111	45.9	134	--	--	--	--
11	62	1.1	292	15.6	55	31	660	--	--
12	167	0.7	277	15.5	12	--	--	--	--
13	111	2.9	136	12.7	100	--	--	--	--
14	114	0.7	1950	1.6	330	37.4	202	--	--
15	482	1	276	1.2	2238	4.4	2	98	233
16	2662	1.3	3639	7	8	25	172	--	--
17	2480	1.2	917	8.9	2	13.2	74	--	--
18	317	1.3	198	6.9	2	9	10	--	--
19	836	0.7	66	24.9	10502	--	--	--	--
20	16382	0.3	117	2.9	920	32.8	7	--	--
21	27	0.6	748	10.7	495	17	105	--	--
22	27	13	186	4.7	34	12.8	244	--	--

Table 2: Distribution of seismic wave velocities along the profiles at New Cairo city.

Profile No.	Velocity (m/sec) 1st layer		Velocity (m/sec) 2nd layer		Expected type of lithology
	P-wave	S-wave	P-wave	S-wave	
1	240	141	850	500	Fill and compacted sandstone.
2	1100	647	1900	1117	Weathered calcareous sandstone and compacted sandstone intercalated compacted clay.
3	760	447	3200	1882	Weathered sandstone and compacted sand with gravels.
4	510	300	800	470	Sand with gravel and compacted sandstone.
5	370	217	3700	2176	Sand with gravel and sandy limestone.
6	560	329	700	411	Loose sand with gravel and compacted sandstone.
7	650	382	750	441	Weathered sandstone and sand with gravel.
8	500	294	750	441	Weathered and graded sand.
9	510	300	550	323	Weathered and graded sand
10	490	288	540	317	Weathered sand and graded sand.

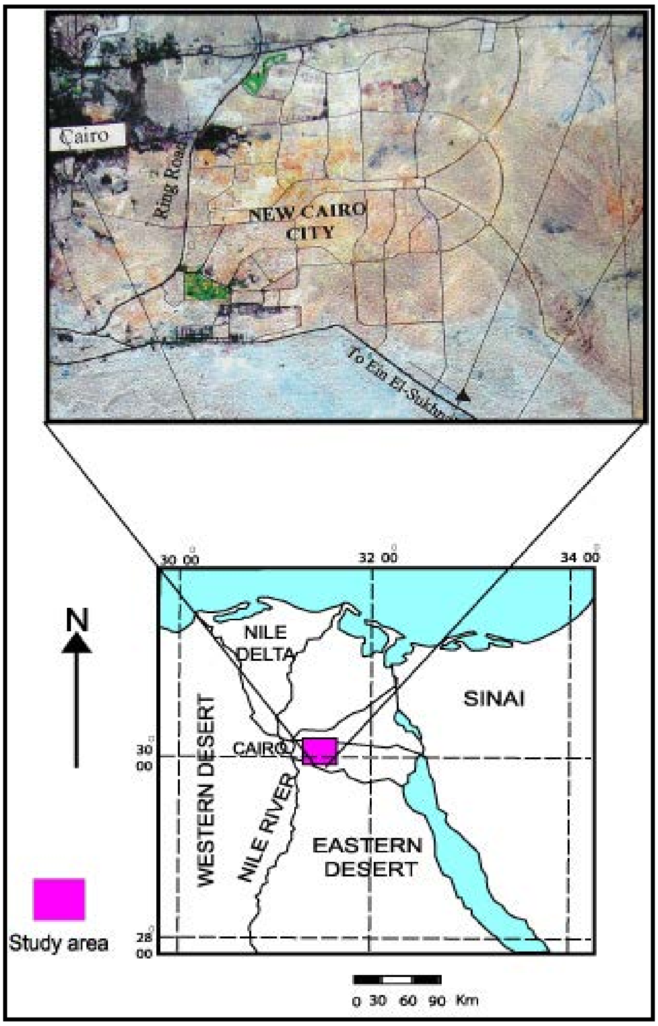

Fig. (1): Location map of New Cairo City modified after. EGSMA, 1983).

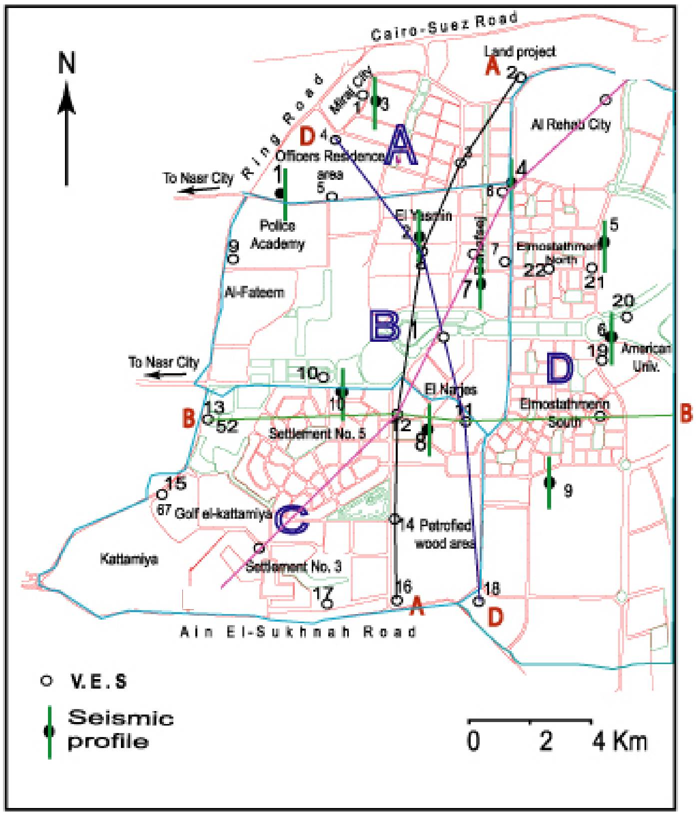

Fig. (2): Location map of VESes and seismic profiles, New Cairo City

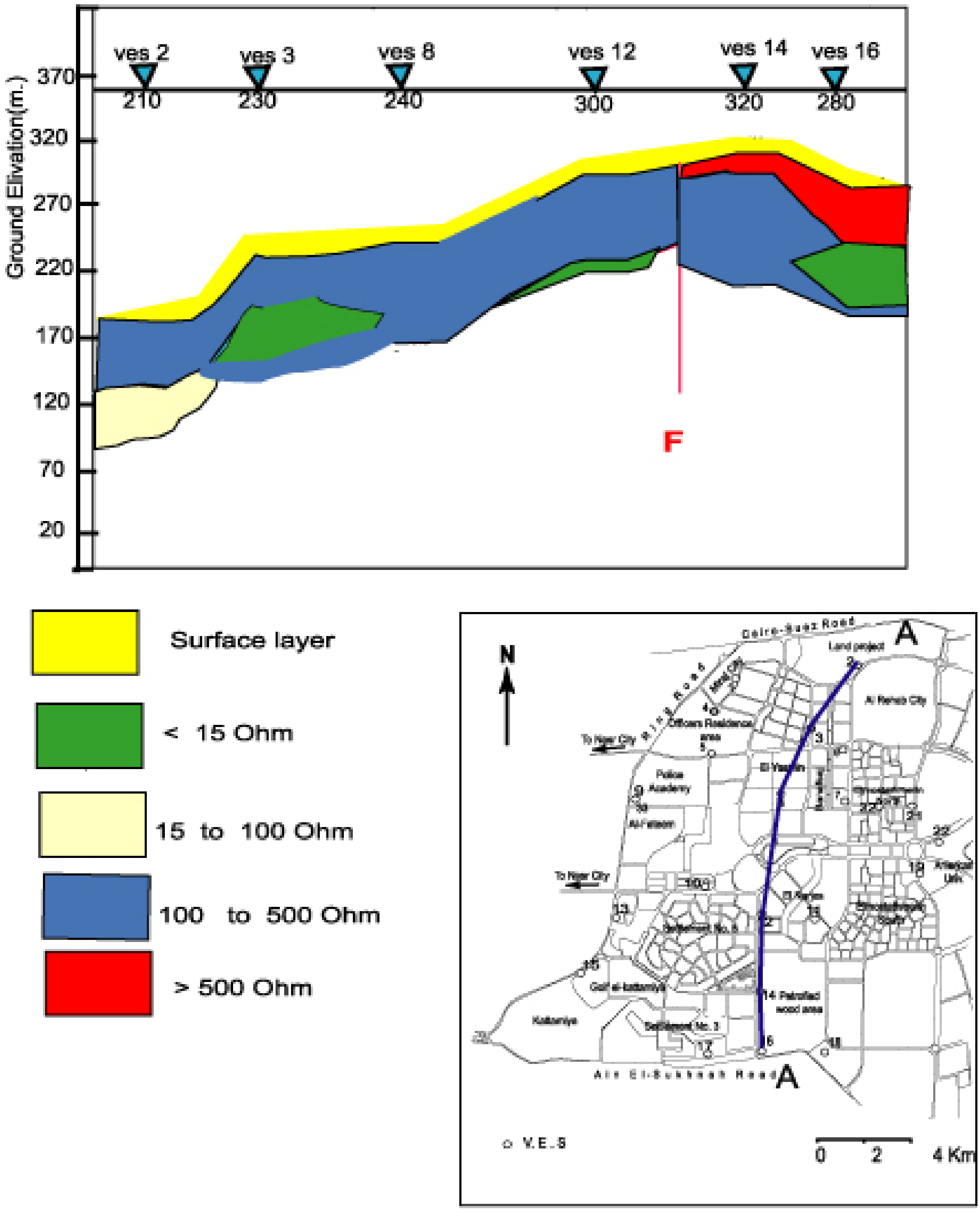

Fig. 3. Geo-electric cross section along profileA-A'

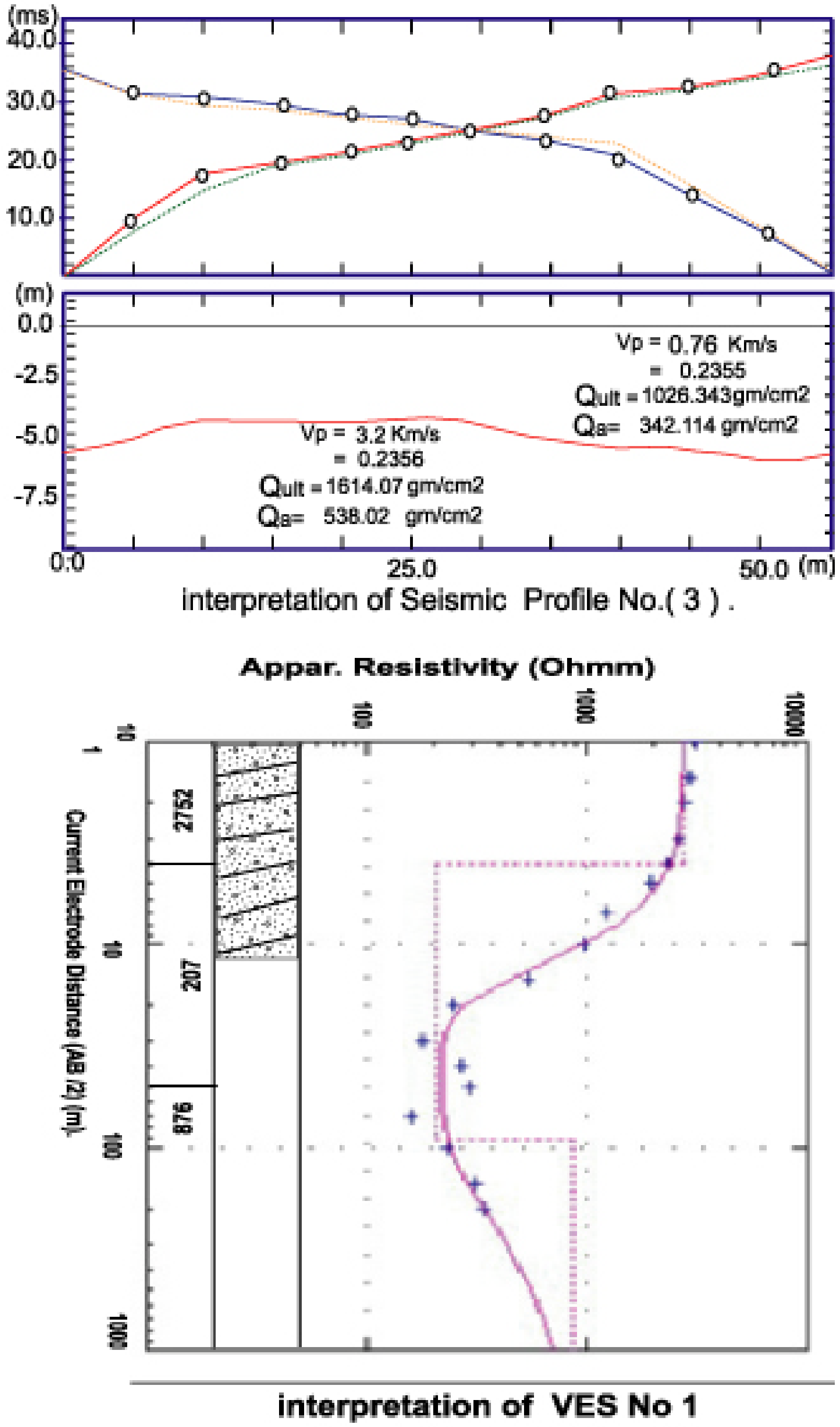

Fig. 4. Travel-time curve and its corresponding geo-siesmic cross section

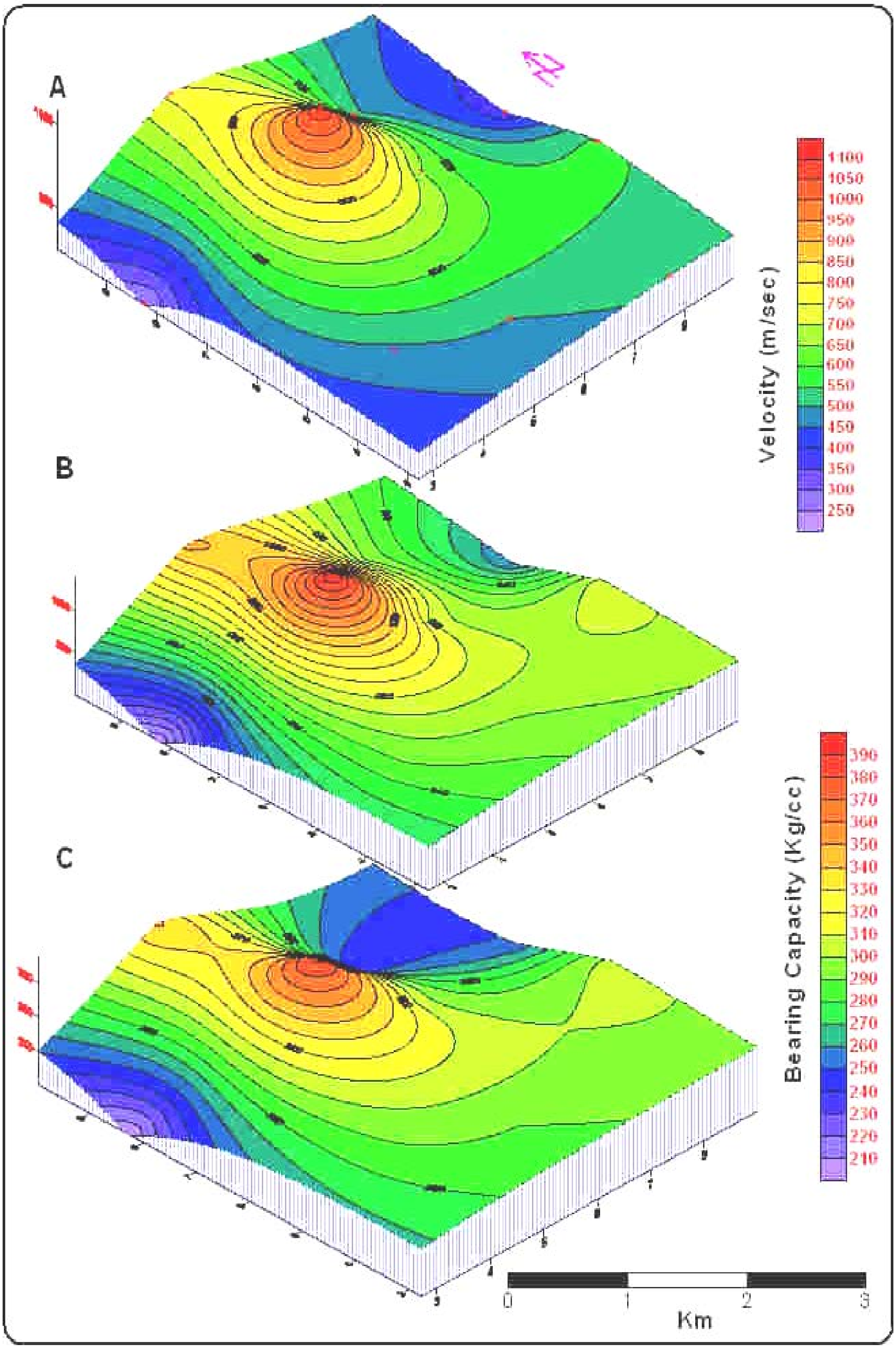

Fig. 5: Compressional wave velocity, ultimate bearing and allowable bearing capacity of the first layer.

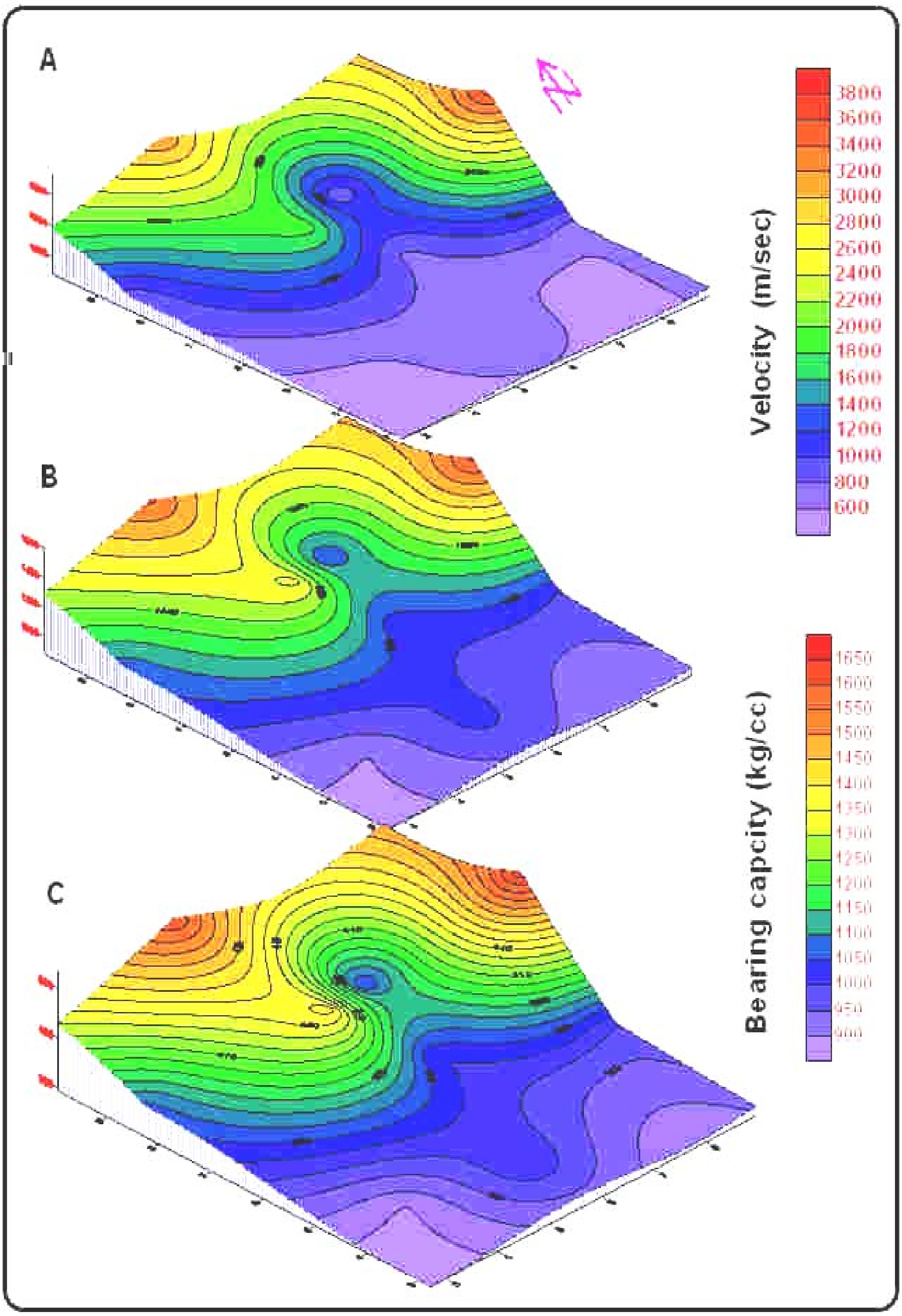

Fig. 5: Compressional wave velocity, ultimate bearing and allowable bearing capacity of the second layer.

Figs (5) and (6) show the distribution of the ultimate and allowable bearing of the first and second layers as an example of one of the dynamic properties. The ultimate bearing capacity of the first layer is characterized by values ranging from 597 gm/cm^2 to 1163 gm/cm^2 . In the second layer, the values range between 898 gm/cm^2 to 1614 gm/cm^2.

CONCLUSION

Processing and interpretation of acquired shallow geophysical data in New Cairo city proved that, the shallow section is divided into four types of lithological units: sandy soil, gravely soil (sand with gravels), clayey soil (silty clay) and rocky soil (sandstone, sandy limestone and weathered basalt).The first type has a resistivity value ranging from 15 to 100 Ohm-m and thickness varying from 0.6 to 36m.The second type has a resistivity value ranging from 100 to 500 Ohm-m and a thickness from 0.7 to 37m . The third type has a relatively low resistivity value (less than 15 Ohm-m) and its thickness varies from 0.7 to 25. The fourth type has a resistivity value more than 500 Ohm-m and its thickness varies from 0.3 to 32 m.

The first and second layers of soil are considered good foundation beds having good allowable bearing capacity but the second layer has an increase in its competence capabilities compared with the first layer. The two types are classified as coarse grained soils with good load bearing capacities and good drainage qualities, and their strength and volume change characteristics are not significantly affected by the change in moisture content.

REFERENCES

Abd El-Rahman, M.M. (1991): Rock material competence assessed by seismic measurements with emphasis on soil competence scales and their applications in some urban areas in Yemen ; EGS. Proc. 9th Ann. Meeting; p. 206-228.

Gardner, L.W. (1974): An areal plan of mapping subsurface structure by refraction shooting ; Geophysics, V.4 pp. 247-259.

Imai, T.; Fumoto, H. and Yokota, K. (1976): P- and S-wave velocities in subsurface layers of ground in Japan : Urawa Research Institute, Tokyo.

Parry, R.H.G. (1977) : Estimating bearing capacity of sand from SPT values. JGED, ASCE, 103 : GT. Vol. 9 pp. 1014-1043.

Saad, A.M.(2000): Geophysical, sedimentological and engineering studies of El-Sherouq city, East of Cairo, Egypt. M.Sc. Thesis, Faculty of Science, El-Azhar Univ. 188p.

Swedan, A.H. (1991): A note on the geology of Greater Cairo area. Annals of the geological survey of Egypt, V. X. VII, PP. 239-251.

Telford, W.M.; Geldast, L.P.; Sheriff, R.E. and Keys, D.A. (1976): Applied geophysics, Cambridge Univ. Press, 860 pp.

Van-der-Velpen, B.P.A. (1988) : Resist, Version 1.0, a package for the processing of the resistivity sounding data. M.Sc. Research Project, Netherlands.

Zohdy, A.A.R. (1975): Automatic interpretation of Schlumberger sounding curves using modified Dar. Zarrouk functions, Bull. 1313-E, U.S.; Geological Survey, pp. 39.