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Treatment of Failure Vulnerability Section Quattamiya - Sokhna Highway Road through Integrated Geophysical and Geotechnical Studies

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TREATMENT OF FAILURE VULNERABILITY SECTION QUATTAMIYA - SOKHNA HIGHWAY ROAD THROUGH INTEGRATED GEOPHYSICAL AND GEOTECHNICAL STUDIES

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ABSTRACT

A geophysical investigation and geotechnical technics were carried out at Quattamiya - Sokhna highway, passing through the study area to evaluate the effectiveness of electrical resistivity imaging for assisting in site characterization. The prevailed subsurface structures such as shale layer, clayey soil, fractures, faults, voids, cavities, and other features are affecting the Eocene limestone bedrock of the study area. The aim was to determine which method or methods could be best used to discover surface or subsurface geotechnical problems.Investigate the future of pavement research directions for applying engineering geophysical technologies and possible challenges that may face pavement engineers. Results showed that the integration between the geophysical method and geotechnical indicates the way to map subsurface geology and its characteristics quickly and inexpensively (e.g., air - filled cavities, voids, sinkholes, cracks, and fractures) which can cause damage to Cairo - Sukhna highway in the study area. From the previous discussion there are several geotechnical hazards in the study area including, shale layer (very high expansive) must be removed and replaced by a pure sand, clayey soil can be improved it properties and change it is classification by adding pure sand and gravel and water saturation and water saturation area after removing shale must be create water drainage system to remove the free water which will destroy the pavement section in the future.

Keywords: Clayey soil; Electrical resistivity; Geotextile and pavement surface; Water drainage system

I. Introduction

Installation of new modern industrial areas in the new Egyptian cities is now taking much attention from the decision-makers in Egypt. Geosciences (geophysical and geological) investigations are normally carried out prior to construction to identify the engineering characteristics of the foundation soils and the study of the geological setting of the near-surface rocks. Many geosciences have applied various geophysical techniques to decipher the prevailed geologic features at engineering sites.

Where the geophysical methods are in discovering problems such as caves, cracks and the presence of water, while solutions remain hostage to the correct geotechnical recommendations to treat every problem, especially serious problems such as groundwater under the road, where we recommended the work of a drainage system based on Geotextiles which used for subsurface drainage systems perform the filtration function as part of a drainage structure [1]. The primary geotextiles functions in roads way application are separations [2]. Where the layers of the soil are separated from each other while preventing them from mixing and maintaining the movement of water and its drainage without the erosion of soil particles.

2. Location

The study area is located on both sides of the toll stations of the Cairo-Ain Al-Sukhna Road, the main entrance to the new administrative capital, east of Cairo (Fig. 1). The studied district is an elongated strip of land located in the Qattamiya–Sukhna Road East of Greater Cairo and it is surrounded on the north by the industrial zone of New Cairo and the city of the Fifth Settlement, on the south by the quarry service road and the neighborhood of Wadi Degla in Helwan city, on the east by the Ring Road and Maadi, and on the west by the central road and the Quattamyia Cement Factory.

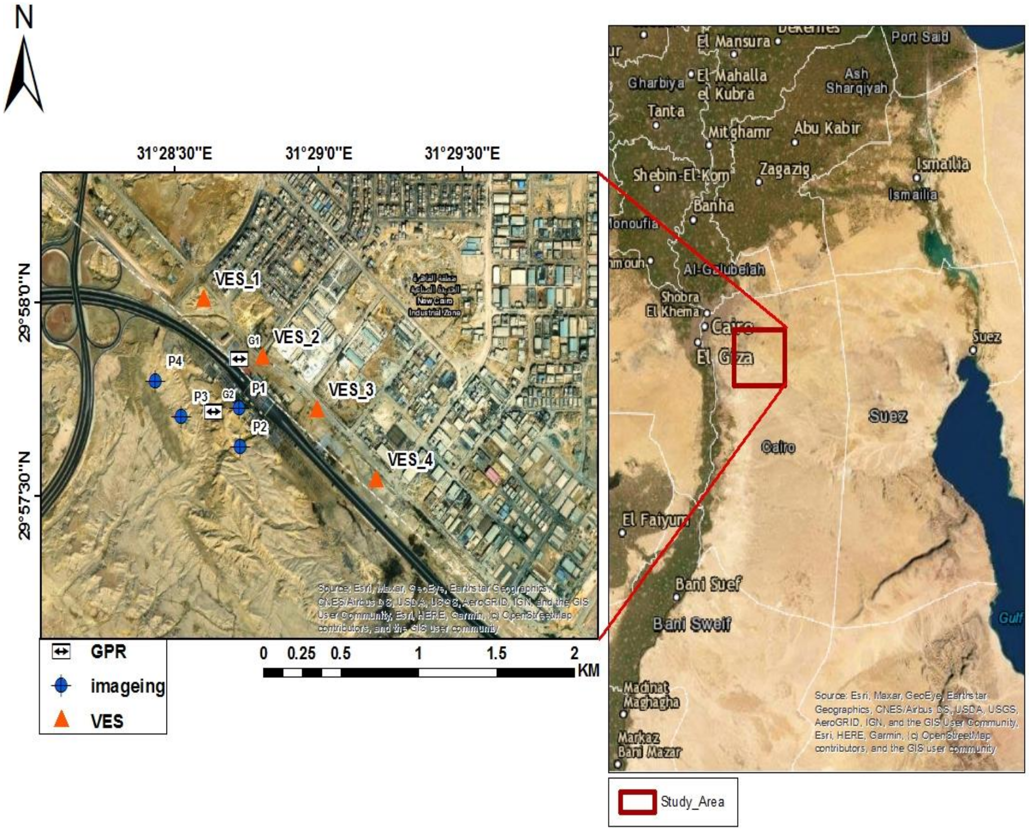

Figure 1. Location map of the study area.

3. Geological Setting

The studied parts of Northeastern Desert represent the unstable shelf units, which comprise the greater part of northern Egypt [3]. This shelf shows tectonic disturbances and as a result, structural heights and depressions are well developed in this area. The study area is covered essentially by sedimentary rocks with limited basaltic sheets (Fig. 2).and through the field examination, it was possible for us to identify the stratigraphic sequence of the study area, which is made up of three rock units represent the middle upper Eocene. and they are from base to top:

1. Observatory Formation:

The base of the Observatory Formation is unexposed and located in Wadi Degla, Gebel Abu-Shama and Gebel Qattamia. It is overlain conformably by Qurn Formation and composed of grayish to yellowish white limestone with brownish white cavernous siliceous limestone interbedded by dolomitic beds.

2. Qurn Formation:

Qurn Formation overlies conformably the Observatory Formation. The lower parts are composed of yellowish white marly limestones.while it is composed of chalky limestone with interbeds of varicolored shales at the upper parts.

3. Maadi Formation:

Maadi Formation overlies unconformably the Qurn Formation in Gebel Abu-Shama only. It is composed mainly of varicolored clastic sediments, shales, sandstones and fossiliferous yellowish white marly limestones.

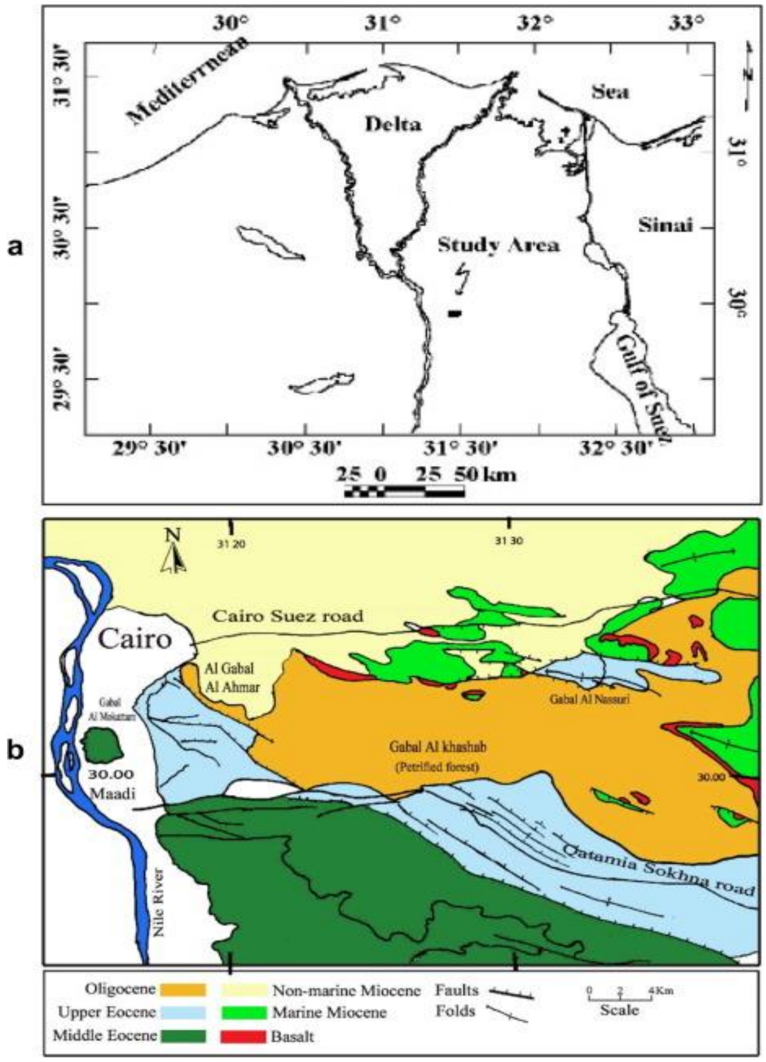

Figure 2. Regional geologic map, Qatamia Ain Al-Sokhna area, East Gulf of Suez, Egypt [4].

4. Problem Statement

The development of any country depends on the transportation facilities and construction projects. For the projects to be successful the foundation beds must be strong which requires better soil properties, so during the geotechnical examination of the road body and conducting palpations to identify the type of soil and sampling for laboratory testing, it shows some serious problems that may lead to the destruction of the road body in the future if it is not addressed by the correct scientific methods. These problems are summarized as shown in (Fig.3):

5. Materials and Methods

5.1. Geophysical Method

5.1.1. Geoelectric (2D) Imaging

Electrical imaging or electrical tomography is a survey technique developed for the investigation in two directions (horizontal and vertical) along profile in the areas of complex geology [5]. Tomographic survey normally employs array of electrodes on the ground surface with Wenner or Dipole-Dipole technique for data collection. According to the aim of study the survey technique involves measuring a series of resistivity measurements for electrodes separation being increased with each successive travers.

Four Two–Dimensional (2D) geoelectrical profiles are carried out at the study area and four Vertical Electrical Sounding (VES). Using SAS 4000 resistivity meter, which enable measuring ($\Delta V/I$) of high efficiency to determining depth of bedrock and the thickness of the subsurface sequence. In this array the measurements start, at the first traverse with unit electrodes separation "a" and it is increased at each traverse by one unit i.e. 2a, 3a, 4a...na; where “n” is the multiplier. The distance between the unit electrode separation “a” of Wenner array in the study area depended on the required depths of the penetration and the resolution as follows: -

The first profiles have length 120m and a unit electrode separation "a" is 5m, and it is increased successively at each traverse by one unit to reach 40 m (i.e. 5, 10, 15... 40 m).

The second profiles have length 240m and unit electrode separation "a" of 10m, which increases successively at each traverse by one unit to reach 80 m (i.e. 10, 20, 30... 80 m).

Figure 3. Example of problems earthworks and structures caused by subsurface conditions.

5.2. Site Geotechnical investigation:

Geotechnical investigations performed by geotechnical engineers or engineering geologists to obtain information on the physical, mechanical of soils and rocks around a site to design earthworks and foundations for proposed structures and for repair of distress to

5.2.1. Physical Properties of Soil:

5.2.1.1. Natural Water Content (Wc) and Particle Specific Gravity (Gs) of Soil:

Water content (W**c**) is also referred to as moisture content and is defined as the ratio of the weight of water to the weight of solids in each volume of soil:

Wc = Ww / Ws

Where: Ww = weight of water Ws = weight of solid soil

The specific gravity of a material is the ratio of the weight or mass of a volume of the material to the weight or mass of an equal volume of water. The specific gravity values of the studied samples shown in (Table 1) and range from (2.63 to 2.72). The results of the water content of the studied samples, its values range from 3.5% to 28.5%5.3.

Table 1: Specific gravity of the studied samples.

Sample No.	Specific gravity (g/cc)	Sample No.	Specific gravity (g/cc)
For Sand			
1-1	2.63	4-1	2.65
2-1	2.67	5-1	2.64
3-1	2.66	6-1	2.67
For organic clay soil			
1-2	2.60	6-2	2.58
2-2	2.62	7-2	2.59
3-2	2.59	8-2	2.60
4-2	2.63	9-2	2.58
5-2	2.61	10-2	2.58
For mixed soil			
1-3	2.69	6-3	2.69
2-3	2.68	7-3	2. 69
3-3	2.68	8-3	2.70
4-3	2.69	9-3	2.69
5-3	*2.70*	*10-3*	*2.72*

5.2.2. Physical Properties of Rocks:

The density (ρ) of a material is defined as the ratio of its mass to its volume. Density can be useful in identifying substances. It is also a convenient property because it provides a link (or conversion factor) between the mass and the volume of a substance The results of this test are shown in (Table 2).

$$\rho = m/V$$

Where ρ is the density, m is the mass, and V is the volume

5.2.2.1. Water Absorption:

The absorption test measures the degree to which water will penetrate a stone, measured as a weight percentage. A stone sample is cut to specified size, kiln dried, and then weighed accurately. The dry sample immersed in water for a specified period (24 hour) and then weighed again. The difference in weight (as a percentage) is the amount of water that penetrated the stone sample. It is indicative of the porosity of the sample. The results of this test are shown in (Table 3).

Absorption % = B – A / A

Where A = dry sample

B = weight of saturated sample with water.

Table 2: Shows the values of bulk density of the studied samples.

Sample No	Bulk density (gm/cm3)	Sample No	Bulk density (gm/cm3)
1-1	2.61	13-1	2.58
2-1	2.62	14-1	2.61
3-1	2.58	15-1	2.68
4-1	2.45	16-1	2.36
5-1	2.38	17-1	2.68
6-1	2.49	18-1	2.62
7-1	2.52	19-1	2.72
8-1	2.55	20-1	2.44
9-1	2.41	21-1	2.49
10-1	2.71	22-1	2.51
11-1	2.66	23-1	2.57
12-1	2.61	24-1	2.51

Table 3: Shows the values of Absorption % of the studied samples.

Sample No	Absorption %	Sample No	Absorption %
1-1	1.5	13-1	1.75
2-1	1.2	14-1	1.8
3-1	1.8	15-1	1.2
4-1	2.5	16-1	3.2
5-1	2.6	17-1	1.6
6-1	1.5	18-1	1.7
7-1	1.4	19-1	1.5
8-1	1.7	20-1	2.8
9-1	1.8	21-1	1.4
10-1	1.6	22-1	1.7
11-1	1.2	23-1	1.6
12-1	1.35	24-1	2.3

6. Data Interpretation

6.1. Resistivity Data

The interpretation of the obtained resistivity sounding information is done in two integrated stages (Qualitative and Quantitative).

6.1.1. Geoelectric (2d) Imaging

Acording to the aim of study which is dealt with the evaluation of the shallow bed rock under the road of Quattamyia–Sukhna highway, Four Two–Dimensional (2D) geoelectrical profiles are carried out at the study area (Fig. 1).

For the interpretation of the imaging data, the computer program RES 2D INV, Ver; 3,4 written by [6] was used. It is a window–based computer program that automatically determines a two–dimensional (2–D) subsurface resistivity model from electrical imaging surveys [5]. This program is designed to invert large data sets (with about 200 to 5000 datum points) gathered by the measuring system with large number of electrodes. The 2–D resistivity model, used by the inversion program, consists of a number of rectangular blocks, which automatically generated by the program, so that the number of the blocks does not exceed that number of datum points. The depth of the bottom row of the blocks is set to approximately equal to the equivalent depth of investigation of the datum points with largest electrode spacing. Therefore, the data must be collected with a system, where the electrodes are arranged along a line with a constant spacing. A forward modeling subroutine is used to calculate the apparent resistivities, and anon–linear least–square optimization technique is used for the inversion routine. The program supports both the finite–element and finite difference forward modeling techniques.

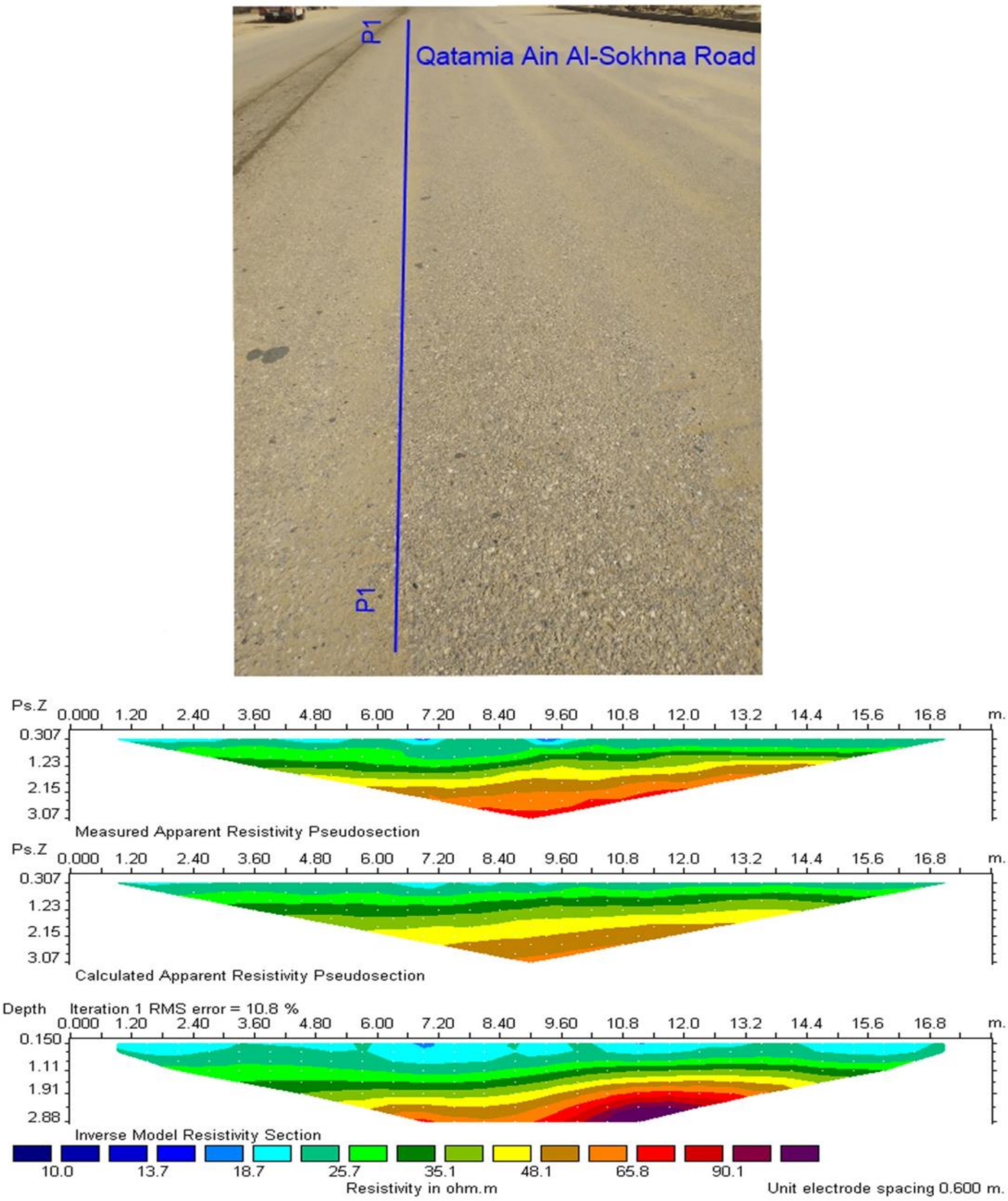

Figure 4. Profile A 2–D resistivity imaging shown layers of pavement structure.

The results of the 2–D geoelectrical survey are illustrated in electrical resistivity sections by (Fig.4,5,6&7). These sections show several high and low anomalous resistivity zones of different extensions. The high anomalous zones exhibit two forms, differ in shape and magnitude, and attain wide resistivity values ranging from 1 to 4500 Ohm.m. The first form of the anomaly zones represents wide resistivity up to 100 Ohm which is interpreted as different types of limestones cutting by several minor faults as shown in (Fig. 6). The second form of the anomaly zones, exhibits closed to semi–closed shape anomalies of narrow and limited extension with resistivity up to 4400 Ohm as shown in (Fig. 7), which is interpreted as cavities. The third form as shown in (Fig. 6), the resistivity anomalies ranged from 1 to 20 Ohm.m which may be interpreted to shale intercalated with argillaceous limestones. While the fourth form as shown in (Fig.4), the resistivity anomalies ranged from 10 to 90 Ohm.m. Which may be interpreted as manufacture compacted layers of Base coarse aggregate and Subgrade soils in the pavement systems. These results are correlated with the on–site excavated findings and terrain conductivity of the study area.

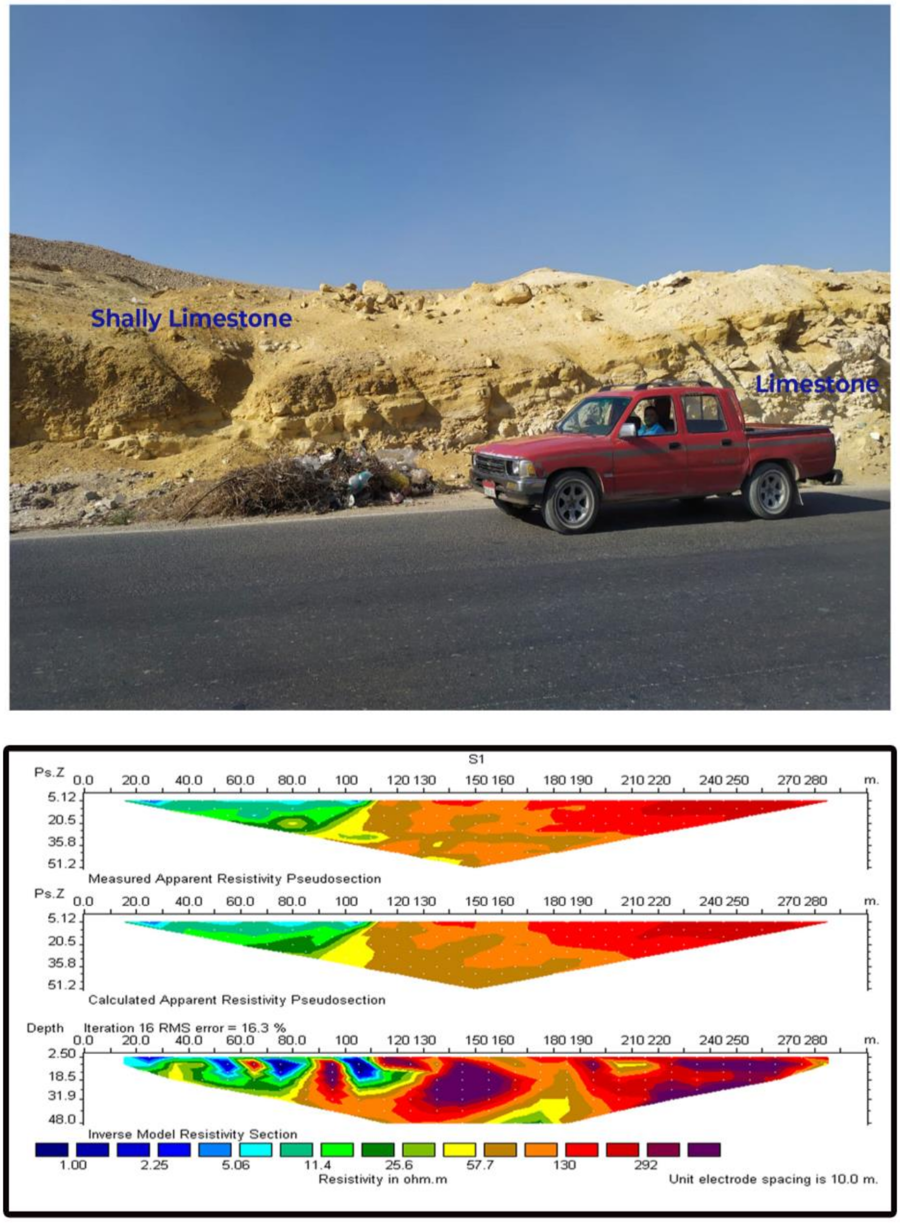

Figure 5. Profile A 2–D resistivity imaging shown shally limestone.

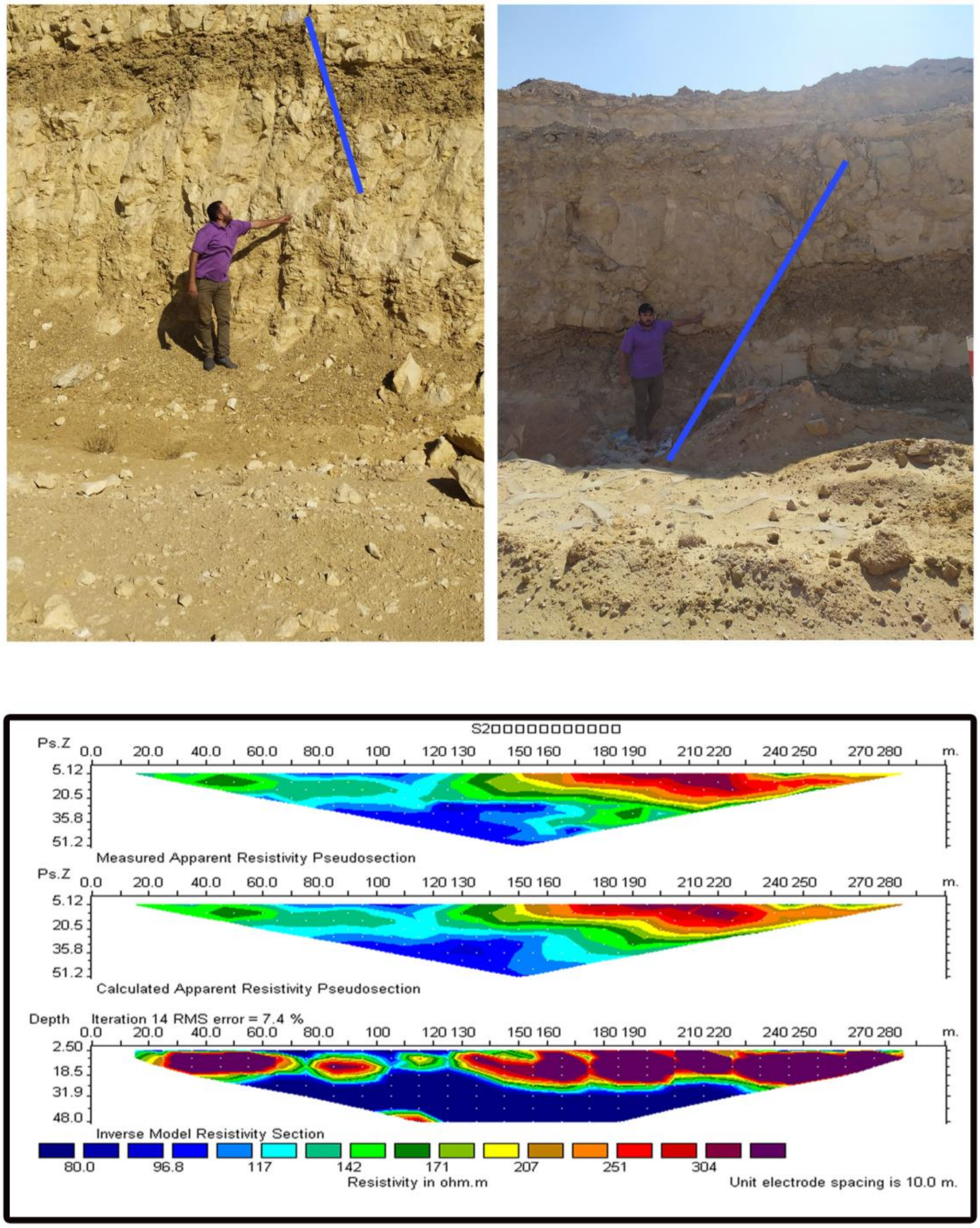

Figure 6. Profile A 2–D resistivity imaging shown faults.

6.2. Geotechnical Tests

6.2.1. Soil Classification Systems According to The AASHTO [7] (American Association of State Highway and Transportation Officials):

Origin of AASHTO: (For road construction) is system was originally developed by [8] as the Public Roads Classification System., AASHTO public Roads introduced a soil classification system still widely used by highway engineers. soil classified based on sieve analysis and Atterberg limits results. All soils were divided into eight groups designated by the symbols A-1 through A-8 (**Table 4**) from studied samples there are four types of soil according to ASHTOO:

A6 for muddy soil &A4 for clayey soil & A1-b for sand & A2-4 for mixed soil (sand+ clayey soil).

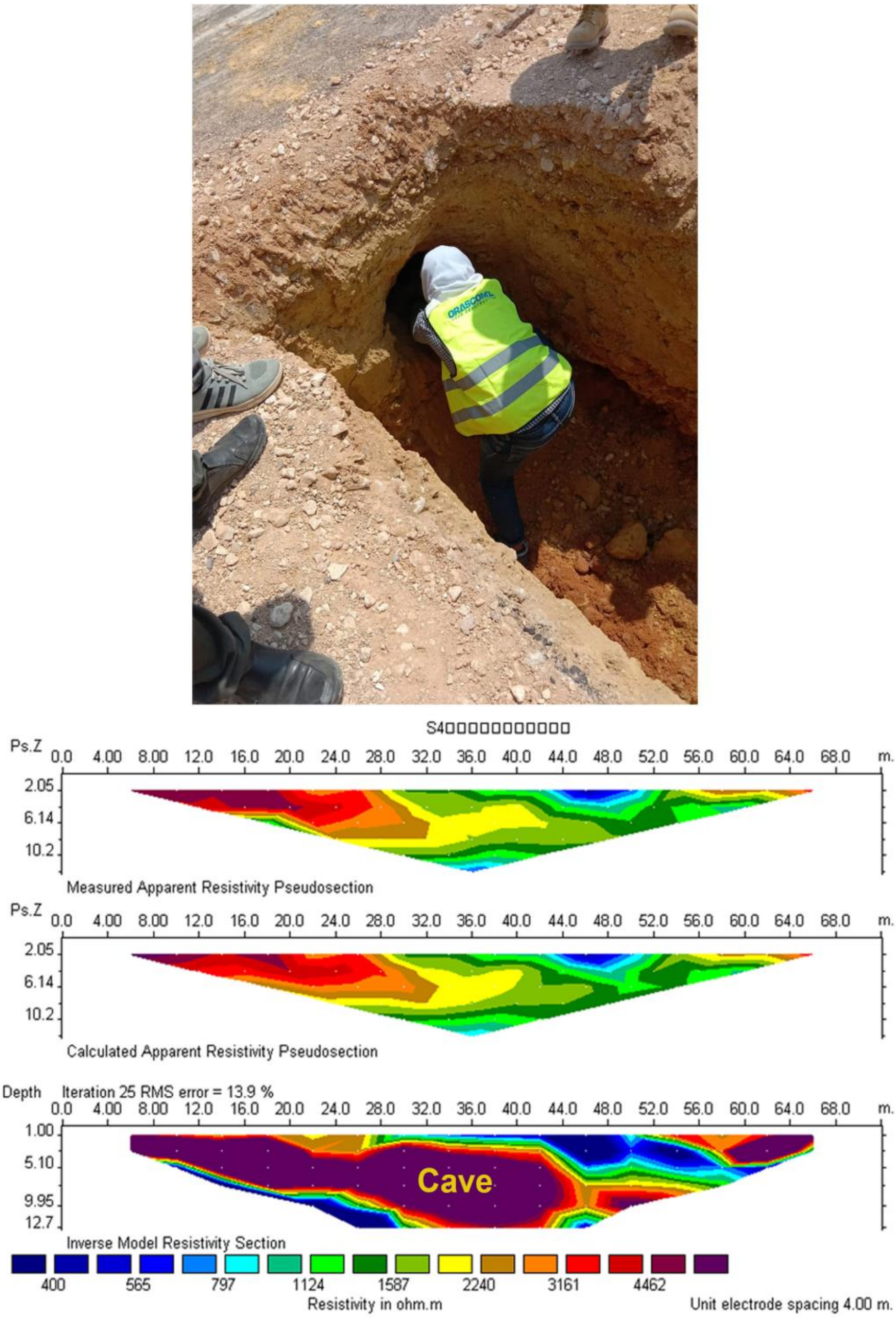

Figure 7. Profile A 2–D resistivity imaging shown cave.

6.2.2. Atterberg Limits –Soils.

Mentioned that a fine-grained soil can exist in four states based on its water content, namely liquid, plastic, semi solid, and solid states. When clay minerals are present in fine-grained soil, the soil can be remolded in the presence of some moisture without crumbling. At very low moisture content, soil behaves more like a solid. When the moisture content is very high, the soil and water may flow like a liquid [9].

Table 4: Soil classification according to ASHTOO

General Classification	General Materials (35% or less passing 0.075 mm)							Silt-clay materials (more than 35% passing 0.075 mm)			
Group Classification	A-1		A-3	A-2				A-4	A-5	A-6	A-7
	A-1-a	A-1-b		A-2-4	A-2-5	A-2-6	A-2-7				A-7-5 A-7-6
Sieve Analysis % passing 2.00 mm (No10) 0.425 mm (No40) 0.725 mm (No200)	50max 30max 15max	50max 25max	51min 10max	35max	35max	35max	35max	36min	36min	36min	36min
Characteristics of fraction passing Liquid limit Plastic Index	6max		N.P	40max 10max	41min 10max	40max 11min	41min 11min	40max 10max	41min 10max	40max 11min	41 min 11min
Usual types of significant Constituent material	Stone fragment Gravel and sand		Fine Sand	Silty or clayey Gravel and sand				Silty soils		Clayey soils	
General rating	Excellent to Good							Fair to poor			
Group index	0		0	MAX 4				MAX 8	MAX 12	MAX 16	MAX 20

GROUP INDEX = (F-35) (0.2+ 0.005 (LL-40))+ 0.01 (F-15) (PI-10)
F= passing % throw # 200
LL= Liquid limit
LP= Plasticity index
IP= LL- LP = Plasticity index

6.2.2.1. Liquid Limit (LL):

The liquid limit is the water content at the point of transition of the clay sample from a liquid state to the plastic state. The values of the liquid limit range from 22.4% to35.5%.

6.2.2.2. Plastic Limit (PL)

The plastic limit is defined as the moisture content in percent, at which the soil crumbles, when rolled into threads of 4.2 mm in diameter. The plastic limit is the lower limit of the plastic stage of soil. Table (5) presents the results of liquid limit and plastic limit; these values range from 17.7% to 21.7%.

Table 5: Atterberg limits of the studied clay samples.

Sample No	LL	PL	PI
1-1	35.5	20.7	14.8
1-2	35.5	19	16.5
1-3	32.5	18.5	14
1-4	33.4	19.7	13.7
1-5	34.2	21.7	12.5
1-6	32.8	20.9	11.9
2-1	25.5	18.8	7
2-2	24.5	18	6.5
2-3	24.6	19.2	5.4
2-4	26.4	19.2	7.2
2-5	22.4	17.7	4.7
2-6	27.5	21.1	6.4

6.2.2.3. Plasticity Index (PI):

The plasticity index (PI) is the difference between the liquid limit and the plastic limit of a soil, or

$$PI = LL - PL$$

Classified the plasticity index in a qualitative manner as follows [10]:

From (Table 6) the values of the plasticity index are ranging from 4.7 (slightly plasticity) to 18.5 (medium plasticity).

Table 6: Shows the classification of soil types according to plasticity index.

PI	Description
0	Non plastic
1-5	slightly plasticity
5-10	Low plasticity
10-20	Medium plasticity
20-40	High plasticity
40 <	Very high plasticity

6.2.3. Free Swell Test:

Free swell or differential free swell, also termed as free swell index, is the increasing in volume of the soil without any external constraint when subjected to submergence in water. The free swell test is one of the simplest identifying testes for recognizing the soil expansively. The most common method is given by [11] and [12].

The values of the free swelling of the studied samples are given in (Table 7) and range between (0%) non expansive it is easy to improve and does not change in volume under the influence of changing water content to (152%) very high expansive soil. This mean that this soil can easily swell with the change in the water content and the passage of loads over it, and therefore it will have a devastating effect on the road body in the future and it is difficult to treat it. therefore, it must be removed and replaced with good soil from outside the site.

Table 7: Free swell of the studied samples.

Sample No	Vd	Swell %
1-1	5.5	18
1-2	5	16
1-3	6.5	152
1-4	7.8	45
1-5	4.5	34
1-6	5.4	17
2-1	0.8	2.5
2-2	0	0
2-3	0.45	1.5
2-4	0.65	2
2-5	0	0
2-6	0	0

6.2.4. CBR (California Bearing Ratio) for compacted soil [13]:

Test is a penetration test used to evaluate the subgrade strength of roads and pavements. The results of these tests are used with the curves (load penetration curve) (Fig. 8). to determine the thickness of pavement and its component layers.

The values of CBR of the studied samples are given in (Table 8) and range between (7.5%) fair soil at 0.1-inch penetration to (24.7%) at 0.2-inch penetration good subgrade and subbase soil according [14] soil classification based on cbr values (Table 9).

Table 8: CBR values, maximum dry density and optimum moisture content values of the studied samples.

Sample No.	CBR						
	Pen. At 0.1 inch	Stress (psi)	CBR value	Pen. At 0.2 inch	Stress (psi)	CBR value	Soil Level
1-1	0.2	78.7	7.9	0.44	149.8	10	Fair
1-2	0.15	74.9	7.5	0.42	146.1	9.7	Fair
1-3	0.25	89.9	9	0.48	164.8	11	Fair
2-1	0.3	104.9	10.5	0.81	269.7	18	Fair
2-2	0.25	89.9	9	0.77	258.5	17	Fair
3-1	0.45	153.6	15.4	1.1	363.4	24.2	Good
3-2	0.42	146.1	14.6	1.05	348.4	23.2	Good
3-3	0.32	112.4	11.2	1.12	370.9	24.7	Good

Table 9: Soil classification based on CBR values [12].

CBR%	Level	Objective
0-3	Very poor	Subgrade
3-7	Poor to Fair	Subgrade
7-20	Fair	Subbase
20-50	Good	Base or subbase
50>	Excellent	Base

6.2.5. Mechanical Properties of Rocks Results and Discussion:

Rock mechanics was defined by the Committee on Rock Mechanics of the Geological Society of America in the following terms: "Rock mechanics is the theoretical and applied science of the mechanical behavior of rock; it is that branch of mechanics concerned with the response of rock to the force fields of its physical environment" [15].

6.2.5.1. Unconfined Compressive Strength Test (UCS):

The UCS test commonly used as an easy and less sophisticated among all three compression test types. Other tests are also needed if further understanding of rock failure in semi-natural cases is required. Testing was performed in accordance with the American Society of Testing and Materials (ASTM) code number (D2938-02) requirements. The result of this test is shown in (Table 10).

From (Table 10) the unconfined compressive strength of the studied rock samples ranges from (100 kg/cm2) medium weak to (185 kg/cm2) medium hard Strength according to Egyptian code (Table 11). According to [16] all the studied samples are medium hard (Table 12).

7. Treatment of problems

From the previous discussion there are several geotechnical hazards in the study area including, shale layer, clayey soil, and water saturation. Therefore, there is an urgent need to evaluate these areas before any development to reduce the number of hazards and/or their disastrous impact. It was found that mitigation and remediation methods are most effective to reduce the number of hazards Clayey soils might lead to swelling, settlement and strength issues when considered as foundation or fill material. The use of additives to stabilize soils has been a major concern in the improvement of engineering characteristics. clay cause various geotechnical problems in the study area.

Table 10: Mechanical properties of the studied samples.

Sample No	Compressive strength Kg/cm2	Rock type
1-1	128	Medium hard
2-1	131	Medium hard
3-1	100	Medium weak
4-1	120	Medium weak
5-1	108	Medium weak
6-1	135	Medium hard
7-1	110	Medium weak
8-1	145	Medium hard
9-1	103	Medium weak
10-1	186	Medium hard
11-1	152	Medium hard
12-1	127	Medium hard
13-1	100	Medium weak
14-1	118	Medium weak
15-1	175	Medium hard
16-1	105	Medium weak
17-1	171	Medium hard
18-1	160	Medium hard
19-1	185	Medium hard
20-1	105	Medium weak
21-1	103	Medium Strength
22-1	127	Medium hard
23-1	145	Medium hard
24-1	102	Medium weak

7.1. Treatment of high plasticity soil (clayey soil):

Expansive soils have the tendency to swell when they meet moisture and to shrink if moisture is removed from them. These volume changes in swelling soils are the cause of many problems in road structures.

Table 11: Rock classification according to unconfined compressive strength (qu) in Egyptian Code.

Qu (kg/cm2)	Rock type
>2000	Extremely hard
2000-1000	Very hard
1000-500	Hard
500-125	Medium hard
125-50	Medium weak
50-12.5	Weak
≤12.5	Very weak

Table 12: Rock classification according to unconfined compressive strength after [14].

Uniaxial Compressive Strength (MPa)	Description
>200	Very high strength
110-220	High Strength
55-110	Medium Strength
27.5-55	Low strength
< 27.5	Very low strength

Sand treatment has been extensively used to improve the engineering properties of clayey soils, mainly to increase the workability of high plasticity soils during construction, and for the stabilization of roads and pavements (capping layers, sub-bases, and subgrades). With these applications in mind, research on sand-stabilized clays has historically mainly focused on properties such as plasticity, swelling, CBR.

This problem of clayey soil has been overcome by adding a certain amount of sandy soil(non-plastic), to which some gravels are added, in order to reduce the plasticity of clay soils and improve their engineering properties, as the plasticity field has decreased from (16.5%) high plastic soil to (4.7%) low plastic soil and maximum dry density MMD increased from (1.95) to(2.10) and bearing ratio (CBR) at 2 inch penetration increased from (9.7) fair soil to (24.7) good soil ,soil classification changed from (A6) as a muddy soil To (A2-4) good soil ,The soil became operational (Fig.9).

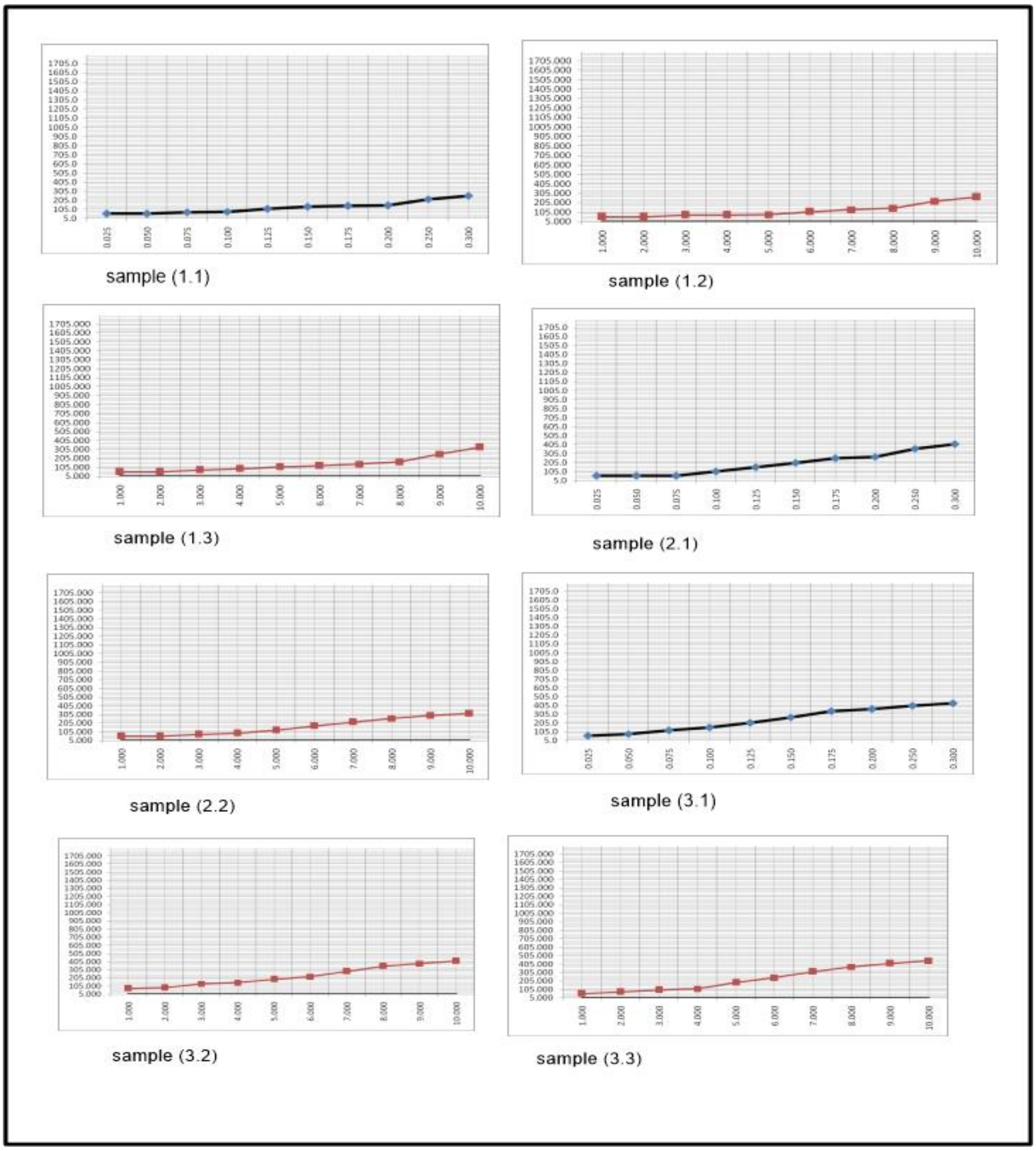

Figure 8. CBR load penetration test

Figure 9.
Soil after Enhancement.

7.2. Treatment of water saturation:

During the geotechnical examination and digging of pits , a saturated area of ground water appeared, where this water appeared in the places of drilling and reaching deep under the level of substitution layers and this a serious problem that lead to destroy the replacement layers that will be implemented if the water problem is not addressed and therefore a special model was created for that area where it was dug deep up to three meters and making a drainage system (Fig.10) consist of a rock fill layer up to 1a meter and above it a layer of gravel (filter layer) up to half a meter topped by a geotextile layer which allow to water move through it while preventing the movement of soil particles from passing through it , especially in fine grained soil of substitution soil above geotextile, a water drainage system has been created to allow water to pass from under the road body through the layer of rock executed into the side trench(open ditch parallel to the road) and then to the place of drainage where the water will settle.

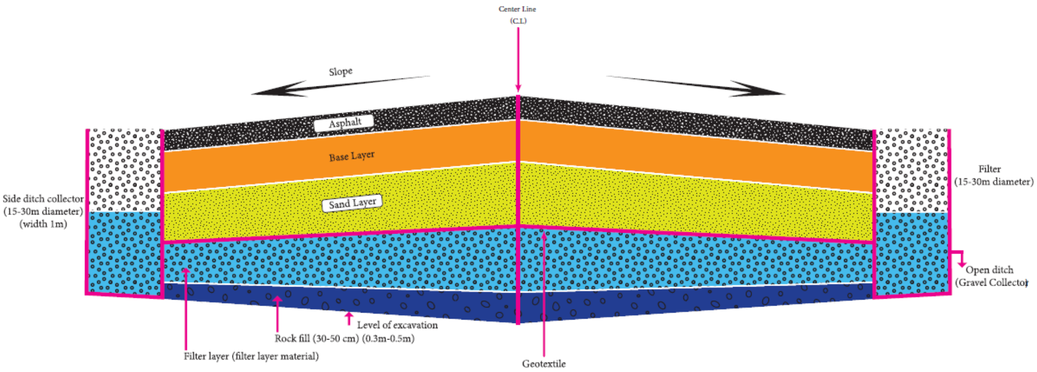

Figure 10. Cross Section of Proposed Drainge System

7.2.1. Rock fill:

The materials used in such a case are the materials that are used for backfilling in swampy places in order to stabilize the soil and stop the subsidence. They are the materials resulting from the cracking and blasting of rocks (Fig. 11), where they are backfilled in layers so that the thickness of one layer does not exceed two-thirds of the diameter of the largest grain in the backfill. It is rolled out with the heavy crawler tractors "Bulldozer" and stacked with the heavy crawler tractors as well. This process helps to mix the different sizes if there is a granular separation during the transportation process. It gives a relatively flat surface on which the mashers can move. It is preferable to use the mechanical vibrator of the mashers during compaction. From 1 cm back and forth and backfilling with these materials continues Until the backfill level becomes 50 cm higher than the highest water level, or at least 25 cm. the backfill layer, along with soil stabilization, creates a highly porous path for water to pass sideways and through the filter layer to the side trench to drain it outside the road body and maintain the permanent lowering of the ground water level so that it does not accumulate and rise to affect the base layers under pavement section.

Figure 11. Rock fill for swamp digging bottom

7.2.2. Filter layer (gravel):

Pavement structures consist of material layers with different grain size gradations and different mechanical as well as permeability properties. As water will flow through the structure it is important that migration of a portion of the fines from one layer to the next will not take place. To achieve this, the principles of filtration/separation must be applied at each interface [17]. This is of special interest where water flows from fine grained material into a coarser grained material on its way out of the structure (Fig. 12).

The filter criteria stipulate that the filter needs to fulfil two functions:

Water needs to drain freely through it (filtration function or permeability criteria).

Only a limited quantity of solid particles is allowed to move from the base layer into or through the filter layer (separation function or piping requirement).

Filter layer put in the top of rock fill to fill the pores between rocks then it is rolled by heavy static compactor (Fig. 13)

Figure 12. Show compaction of filter layer above rock fill

Figure 13. Example of a static steel-wheel roller above filter layer

7.2.3. Geotextile:

Geotextile were used in roadway construction in the days of the Pharaohs to stabilize roadways and their edges.

Geotextiles are large sheets that save our earth soil in rainy days &binds strongly. It is mostly used for filtration and separation in the road constructions (Fig. 14). It protects from migration of small gravels &sand aggregates.

It helps to prevent the erosion of soil but allows the water to drain off. It improves soil characteristics such as Friction or movement restraint, Support of loads and Changes in bearing failure plane. When a geotextile is between two different soil materials, the function of separation plays an important role. The geotextile will separate similar materials so the required soil characteristics can be obtained. The main purpose of this type of geotextile is that when water gets into the soil strata, the geotextile will prevent soils from mixing.

Figure 14.

Geotextile brushes on top of the filter layer**.**

For example, in road construction, you might want to keep fine sub-grade aggregate separate from the coarse aggregates of the bottom layer. The drainage characteristics will be kept intact, preventing the fine aggregate from filling the voids between the larger aggregate. These types of geotextiles have a special thickness and permeability characteristics to prevent soil contamination and allow water to flow through without damaging the strength and structural capacity of the road.

7.2.4- Side open ditch (trench):

Roads will affect the natural surface and subsurface drainage pattern of a watershed or individual hill slope. Road drainage design has as its basic objective the reduction and/or elimination of energy generated by flowing water. (Fig.15 and 16).

Figure 15. Side Collector filled with geotextile

Figure 16. Side open ditch (trench)

8. Conclusions

To investigate the competence of the proposed road for pavement stability, geotechnical and geophysical investigations involving electrical resistivity imaging (EI) method and geotechnical studies were carried out along Quattamiya - Sokhna highway East of Greater Cairo and at distance about 60 km of Gulf of Suez. The geoelectric parameters obtained from the quantitative interpretation of the electrical resistivity imaging (EI) data were used to generate 2 D imaging section. These sections show several high and low anomalous resistivity zones of different extensions. The high anomalous zones exhibit two forms, differ in shape and magnitude, and attain wide resistivity values ranging from 1 to 4500 Ohm.m. Various geotechnical tests were conducted on the soil and rock samples for finding out the effect on various geotechnical parameters to determine their physical and mechanical characteristics. The obtained results of clayey soil at foundation levels reveals that, the values of the initial water content, liquid limit, plastic limit, shrinkage limit, plasticity index, liquidity index and consistency index and California bearing ratio (CBR). The free swell of the studied samples varies from (0%) non expansive This soil can be treated before road constructing on it by adding the pure sand from out of the site to reduce the plasticity index to improve its engineering properties to 150% (very high expansive soil), the sediments are consisting of montmorillonite, illite and kaolinite this soil is difficult to treat and must be removed and replaced by layers of clean sand from outside of the site and it saturated with under drown water under substitution level and this is a very danger that threatens the base and asphalt layers in the future, even if a replacement is made, a radical solution must be taken to drain the excess water and reduce its level continuously so that we ensure that water does not rise in the future The foundation and asphalt were applied and damaged so the water drainage system was achieved.Integration of the results demonstrates that there is a good correlation between geophysical results and the geotechnical results.

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Conflict of Interest and Authorship Conformation Form

The authors declare no conflicts of interest regarding the publication of this paper.

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معالجة حالات الضعف والفشل بالقطامية ـ طريق السخنة السريع من خلال الدراسات الجيوفيزيائية والجيوتقنية المتكاملة

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الملخص:

تم إجراء دراسة جيوفيزيائية وتقنيات جيوتقنية على طريق القطامية ـ السخنة السريع، مروراً بمنطقة الدراسة لتقييم فعالية التصوير بالمقاومة الكهربائية للمساعدة في توصيف الموقع. تؤثر الهياكل تحت السطحية السائدة مثل الطبقة الصخرية، والتربة الطينية، والكسور، والصدوع، والفراغات، والتجاويف، وغيرها من السمات على صخر الحجر الجيري الإيوسيني في منطقة الدراسة. كان الهدف هو تحديد الطريقة أو الطرق التي يمكن استخدامها بشكل أفضل لاكتشاف المخاطر الجيوتقنية للموقع سواء كانت سطحية ام تحت سطحية. كان من الأهمية بمكان أن يكون أفضل نظام جيوفيزيائي، فيما يتعلق بالأجهزة، والإجراءات الميدانية، والتحليل، والعرض التقديمي، لتحديد ورسم خرائط المواد التي ستكون مناسبة لمشاريع إنشاء النقل. التحقيق في مستقبل اتجاهات أبحاث الرصف لتطبيق التقنيات الجيوفيزيائية الهندسية والتحديات المحتملة التي قد تواجه مهندسي الرصف. أظهرت النتائج أن التأكيد بين الطريقة الجيوفيزيائية والجيوتقنية يشير إلى الطريق السريع وغير المكلف لرسم خرائط الجيولوجيا الجوفية وخصائصها (مثل التجاويف المملوءة بالهواء والفراغات والمجاري والشقوق والكسور) والتي يمكن أن تسبب أضرارًا لطريق القاهرة ـ السخنة السريع في المنطقة. منطقة دراسة. من المناقشة السابقة هناك العديد من المخاطر الجيوتقنية في منطقة الدراسة بما في ذلك، يجب إزالة الطبقة الصخرية (شديدة الاتساع) واستبدالها برمل نقي، ويمكن تحسين خصائص التربة الطينية وتغيير تصنيفها بإضافة الرمل والحصى النقي. يجب إنشاء نظام تصريف مياه لإزالة المياه الحرة التي ستدمر قسم الرصف في المستقبل.