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Behaviour of Sandy Gypseous Soil Under Dynamic Load

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Abstract
The soils with gypsum salts content are caused great engineering problems especially with the strategic projects. These problems were observed in Iraq country during the construction of some large structures. The exposure of the gypseous soil to the water over time causes the change of properties and collapse under the impact of loads on the soil. The leaching of gypsum increases the collapsibility potential and causes serious damages to structures that are constructed on these soils. The present research investigates the collapsibility of gypseous soil due to immerse and flow of water (soaking and leaching) through special model tests that were designed and manufactured for this purpose. The coefficient of permeability has been measured also for samples at density equal to 90% from max. dry density. Moreover, dissolution of gypsum is observed by measuring the Total Dissolved Salts (TDS) during leaching process. Gypseous soil with gypsum content 65, 45 % brought from Tikrit city, which is located almost in central of Iraq and take the samples. The results exhibit that increasing of gypsum content led to increasing in collapse potential with percentage of 25% approximately. Also, the result shown that increased of the stress from 25-50 Mpa caused a decrease hydraulic conductivity of gypseous soil and investigated that the behaviour of settlement increase with time sucking and leaching.

INTRODUCTION

The soils with gypsum salts content are caused great engineering problems especially with the strategic projects. These problems were observed in Iraq country during the construction of some large structures. The exposure of the gypseous soil to the water over time causes the change of properties and collapse under the impact of loads on the soil. Gypseous soils distributed one and a half percentage of the world surface area[1]. In Iraq country concentrated in region like Sammrra, Mousl, Tikrit, Najaf and Basrah, with a gypsum content content of up to 70[2]. Many trial tests in laboratory or field have been done to understand the behavior of these soils, due to their complex behavior under different environmental conditions. Many engineering problems related to construction on or by gypseous soils were noticed. The major source of these problems is that gypsum is dissolved when these soils are exposed to water.

Gypseous soils are generally stiff when dry but lose a great part of their strength when are brought in contact with water. The dramatic change in their behaviour under these circumstances depends primarily on the properties of soil, percentage of gypseous, duration of water, source of wetting, applied stress. Ultimately lose of bonds and generating cavities, lead to reduction in strength and sudden increase in collapsibility.

The objective of this paper to investigate the collapsibility of gypseous soil due to soaking the soil sample due to rising of underground water table as a source of wetting, also the collapse result from flow of water through the sample and estimate the coefficient of permeability and the leaching strain caused by gypsum dissolution through leaching process. The investigation was performed through specially designed model.

Literature Review: Gypseous soils under building have big problem therefore many researchers try studied properties and behaviour such as the permeability. Alphen and Romero, (1971), explain and defined the parameter of permeability for gypseous soils in Syria[3]., concluded that the collapse of dry gypseous soils when wetted by water is usually occurs get low stresses. The collapse of soil The soil may be sensitive to the following factors: the infiltration rate, water content and void ratio at dry state. As the gypsum content increase, the collapse increases and stress level with decreasing rate as the voids and water are added to destroy all the gypsum structure. (Al-Barzanji, 2003 and Al-Ameery, 2003) conducted a model test on gypseous soil obtained from Al-Dour site with (G.C. = 66.4%) compacted at maximum dry density of 15.2 kN/m^3. They found that the model test exhibited a high reduction of 86% in settlement as compared with the corresponding model test compacted at field density of 12 kN/m^3.

[4]concluded that the collapse potential obtained from full soaking of soil sample may not be reached in the field, because of the incapability to arrive complete soaking state by a single step wetting. As a result, the multi-step saturating method is more suitable because of the gradually increasing of ground water by capillary forces, mainly in the low precipitation areas.

The permeability is an important soil property which is highly affected by leaching process. As a general behavior the permeability decreases during leaching. Many of researcher studied the permeability or hydraulic conductivity of gypseous soil from different location in Iraq by more than one method ,it is described very tedious to predict because of gypsum dissolve through flow produce additional free void for the soil particles to rearrange themselves to a more dense state of packing, causing a sudden oscillation of speed of flow through test. (Al-Kaisi 1997 and many others). [5]concluded that.

The exposure of the gypsum soil to groundwater causes the breaking of the bonds between the molecules and their rearrangement of the spaces between them as a result of the collapse of the soil structure until it reaches the stability level. [6]explained that the hydraulic conductivity of gypseous soil is very difficult to predict because of gypsum dissolution through flow producing new free voids for the particles to rearrange themselves to more dense state.

[7]studied permeability of gypseous soils in Iran, they showed that the gypseous soils have high coefficient of permeability at the initial stages of test due to dispersal and motion of particles , then reduced progressively until tends to a fixed amount . The authors noticed that the removal of gypsum from soil is not the main reason of collapse in these soils, but they refer to the mellowing or disturbance of gypsum agent between particles cause the collapse in such soils.

MATERIAL AND METHODS

The weak soil such as gypseous soils under foundation cause many problems. These soils have been Covered most of the northern part of Iraq. One of the important city is Tikrit, the centre of Salah-Aldeen governorate located to the north of Baghdad at 180 Km as shown in (Fig. 1). this city has been chosen to study and investigate because of the important location, urban development, several industrial areas, proposed future projects. In Tikrit city were selected location two disturbed samples of gypseous soil had taken from depths until 1.5m and carried out several laboratory tests to indicate their specifications. The samples obtained for the testing program were put in airtight plastic bags, labeled and brought to the soil mechanics lab., Civil engineering Department, at the University of Diyala.

Laboratory Test: The samples of soils were air dried, pulverized and mixed thoroughly and sieved through

sieve No. 4. The particle size distribution of two types soils are shown in (Fig. 2) below. In this paper the testing Laboratory can be explain in the following:

- Firstly tests physical and chemical tests. The physical tests include specific gravity, Atterberg limits, grain size distribution and water content. Chemical tests are carried out on the natural soil, these tests include total soluble salts (T.S.S)%, are determined accordance to the (BS 1377: 1975, Test (9)), Sulphate content (SO3)%, Cloride content (Cl)%, PH value according to BS-1377 test No.(10), Gypsum content is determined according to the British standards (BS 1377: 1990), from the sulfate content of the soil.
- The optimum moisture content measured by using Standard Proctor compaction tests.
- Engineering Test: Engineering properties of the soils include single collapse test.

Laboratory Model Test: The apparatus of the work has been designed by author, then manufactured at local market. It involves of a cylinder shape container from a stainless steel with (6mm) thick, interior diameter of 240mm and depth of 400mm. The container is connected with high water reservoir with dimensions of (500 x500 x 500) mm^3. The reservoir is supplied with water from source by using control system (floating ball), for getting a constant total head. The container which used in the tests, is lined with rubber layer with 20mm thickness for isolation of vibrations and minimized the undesirable interactions. Rubber is commonly utilized as an isolating layer. If it compare with steel, it has great interior damping, and capacity of absorption, which is similar to that used by Skelton (1973), also it can be use below the oscillating motor for same purpose. At lowest of container a filter of 40mm thick is positioned. The filter need to agree with the specifications of filters based on the requirement which is followed to prohibit the migration of small particles of soil. A perforated plate with 8mm thickness is located over the filter., also it is carried by using shafts of steel as a supporter from the end to ensure that any deformation in layer of filter does not gives wrong measuring of change in depth of the soil specimen.

After that specimen of gypseous soil prepared with diameter of 200mm and 300mm thickness, then perforated plate, is placed erected above. At the upper part of perforated plate, outlet opening is prepared to permit water to follow during box and collecting the water at container. The container and reservoir connected by pipe and governed by regulator to close and open it.

As well there is a necessity to using a manometer to determine the difference in level between the outer and inlet flow through the specimen. The total details of the experiential system are showed in (Fig. 3).

Testing Model Stages: The Test was conduct in three stages.

- After prepared soil in box test , loading soil in state as in site up to specified stress level (50 Kpa) and left it for 24 hrs. The deformation is recorded periodically, this is the first stage of the test program.
- The controlling valve of inlet is opened and the specimen immediately saturated. Resultant settlement is monitored and the specimen stay for one day to be safe that all specimens is fully saturated and the readings of the dial gage for deformation of specimen is approximately reached constant value.
- There are constant head which is used with soaking gypseous soil that according to ASTM D2434. After that leaching processes start by follow water through the sample gypseous soil in container and collecting it from another side with the time. All the testes used hydraulic gradient equal to 6 and it to be not effected on particles soil (Al-Khuzaie, 1985). Changes in deformation, coefficient of permeability (k) and leachate characteristics were monitored with continuous flow of water.

In these tests the Data collected and calculated such as the coefficient of permeability (ks), dissolved gypsum (%) and leaching strain.

RESULT AND DISCUSSION

Results of Physical and Chemical Tests: Two gypseous sample brought to laboratory to make physical and chemical tests. The particle-size distribution of two types S1 and S2 (Alzuhoor site Gypseous soil e and Shesheen site Gypseous soil) had been tested according to method ASTM 422-79. The results shown in (Table 1 and Fig. 2) . Atterberg limits (L.L) increased with increasing the gypsum content, but the samples exhibit no plasticity. The results of experimental work are presented below. The results of compaction test showed that the sample one has a maximum dry density is (16.15) kN/m^3 and optimum moisture content of (14%).and the sample two has a maximum dry unit weight of (16.45) kN/m^3 and optimum moisture content of (12%)as shown in (Fig. 4).

Collapse Test: Test that is used as index to evaluate the severity of the difficult of collapse. Relation collapse index to severity of foundation problems are according to ASTM-D5333.

From the curves showed in (Fig. 5), which is shows the relation between time and volumetric strain, the test results involves three stages, the results obtained refer to the samples of gypseous soil exposed considerable amount of settlement through the phases

Table I. Results of physical properties for two types soil

Properties	Soil type (S1)	Soil type (S2)
Specific Gravity (Gs)	2.40	2.44
Liquid limit (L.L)%	22	19
Plastic limit (P.L)%	N.P	N.P
Plasticity Index (P.I)	N.P	N.P
Compaction characteristics:		
Max. dry density (kN/m3)	16.10	16.45
Optimum Moisture content %	14	14.5
Initial Void Ratio (eo)	0.68	0.72
Passing sieve No. (200) %	16	5
Soil classification according to USCS system SM	SM Silty Sand	SP Poorly graded sand
Water content %	3	2

Table 2. Results of chemical properties For two types soil

Properties	Soil type (S1)	Soil type (S2)
Total soluble salts (T.S.S.) %	25	22
Sulphate content (SO3) %	30	20
Gypsum content %	66	46
Organic matters (O.M)%	0.21	0.18
Chloride content (CL) %	0.061	0.056
pH value	8	8.4

Table 3. Moisture content determination for 2 minutes Interval.

			Microwave Oven Method			Convection Oven Method		
			AAPt1	AAPt2	AAPt3	Test 1	Test 2	Test 3
Soil Type	Temperature ^{o}C	Time, (min)	m.c (%)	m.c (%)	m.c (%)	m.c (%)	m.c (%)	m.c (%)
Peat	P-Hi	0						
	P-Hi	2	12.5	44.44	42.86			
	P-Hi	4	50	116.67	150			
	P-Hi	6	125	116.67	233.33		Dried for 24 hours	
	P-Hi	8	125	225	233.33			
	P-Hi	10	350	333.33	400			
	P-Hi	12	350	333.33	400			
	P-Hi	14	350	333.33	400			
	105	1440				491.16	489.09	461.65
Total Drying Time (min)			14	14	14	1440	1440	1440
Final Moisture Content (%)			350	333.33	400	491.16	489.09	461.65

of test, the deformation occur during first stage is result from settlement of soil structure at dry, natural case, which represented by first part of curve. The next part of test represents the soaking stage which occurs instantaneously, begin at rapid drop because of soaked breakdown, the curve refer to that most ratio of the deformation is happen at the beginning of stage which represent soaking period. Also from the test results obtained it can be noticed that the firstly deformation is resulting from settlement of the structure of soil in natural state, as well it is obvious that the deformation

In (Fig. 5) shown the relationship between the time with volumetric strain. The sudden change in void ratio took place upon flooding in water is shown clearly. This behavior indicates that the soil is collapsible.

Fig. 1: Local of site study in Tikrit city, Salah-Aldeen govern orate, Iraq

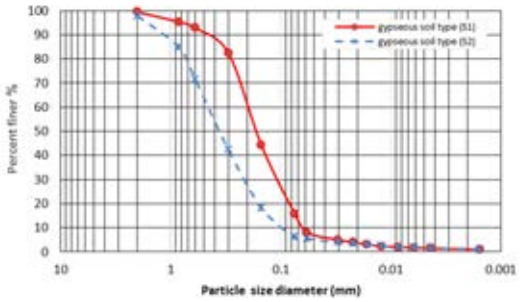

Fig. 2: The particle size distribution for two types of soils, Alzuhoor site Gypseous soil type (S1) and Shesheen site Gypseous soil type (S2)

Fig. 3. Experimental setup of model test

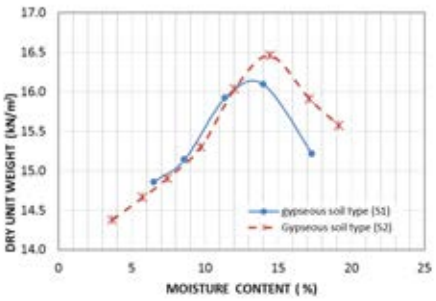

Fig.4. Standard Procter compaction curve test result for Alzuhoor site Gypseous soil type (S1) and Shesheen site Gypseous soil type (S2)

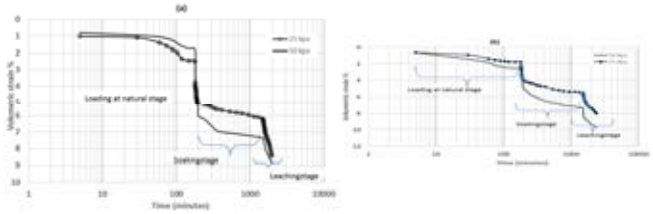

Fig.5. The relationship between time and volumetric strain for three stages dry, soaking and leaching: (a)Gypseous soil type, S1 (b)Gypseous soil type,S2

The results of model test indicate that the collapse of the two soil samples are (8.5%) and (7.2%) respectively. This type of soil is classified as moderate limitations according to the classification of ASTM D5533

CONCLUSIONS

The model tests performed in this paper are conducted on two samples of gypseous soil with different gypsum content. After analysis the data, the resulting conclusions can be obtained:

- Soil permeability is high in the early stages of soil washing and then begins to oscillate until it reaches a regular state.
- The decreasing in the coefficient of permeability is mainly related to the achieved increasing in the soil density which is caused by vibrated loading.
- The decrease in volume of soil sample is continuous because of leaching the salts from soil sample. The coefficient of permeability is affected meanly by the applied stress, decrease with increasing of applied stress.
- The settlement due to loading at dry state, is larger for soil have less gypsum content, than the soil have more gypsum content. Also the collapse due to soaking is grater for the soil had less gypsum content than soil of more gypsum content. Leaching of the soil destroy the inter particles cementing bonds and causes high change in volume and the strain duo to leaching increased with the increasing of percentage of dissolved gypsum.

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