PREDICATION COLLAPSE OF GYPSEOUS SOILS DUE TO WETTING [+]

تخمين انهياريه التربة الجبسية بواسطة الغمر

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Abstract:

The gypseous soils are considered as one type of collapsible soils ; this is because the gypsum present between the soil particles provides an apparent cementation in the form of bonds that tightened the soil particles together. Upon wetting , these bonds are lost gradually leading to the collapse phenomena.

The collapsibility of gypseous soils may occur under conditions that of flowing water, the flowing water will tend to wash salts present in the soil particles.

The collapsing behavior of this type of soil generally occurs when the water is introduced into the soil . technically , the collapsible soil obtains some of its strength from cemented / bonding between the soil particles . in the arid region / Middle East , the Aeolian sand which was loosely placed, and upon some cementation , process may become a collapsible soil (high strength when it is dry) . some cracking of building in this region , however, may be attributed to the introduction of water / moisture after the building is occupied .i.e. settlement of the soil after water is introduced via gardening , drainage, cooking water, bath, sewer line, septic bed, ect., from this research we get that the greater the collapse potential , the greater is the collapse and the damage to structures built on such soils. The soils with Cp less than 1 generally cause no problems to foundations . for Cp =1 to 5 , these will be moderate trouble to the foundation. For Cp≥5 , these there would be trouble if precautions are not taken in the design and construction.

Key Words : gypsum , gypseous soils, collapse soil , soaking and leaching

المستخلص:

تعتبر الترب الجبسية إحدى أنواع الترب الانهيارية وذلك لاحتوائها على نسب عالية من مادة الجبس والذي يعطيها قوة وترابط بين ذراتها فعند الغمر سوف تفقد هذا الترابط تدريجيا مؤديا حدوث ظاهرة الانهيار .

انهياريه تلك الترب تحدث نتيجة لجريان الماء فيها عن طريق رش الحدائق ، البزل ، مياه الطبخ ، الحمامات وأنابيب المياه الصحي والذي يسبب غسل الأملاح الموجودة بين ذراتها مسببا التصدعات في الأبنية الموجودة على تلك الترب في تلك الأماكن. على الرغم من أبداء تلك الترب مقاومة عالية عندما تكون جافة كما هو حال الترب الموجودة في المناطق الجافة والشرق الأوسطية، إن النتائج التي تم استحصالها في هذا البحث أن تربة ذات انهياريه عالية أذا كانت قيمة طاقة الانهيار .C.P عالية، حيث تم حصر قيمها بين

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١-٥ % وتم اعتبار الترب ذات C.P≥5 ترب ذات مشاكل مما يستدعي اتخاذ الاحتياطات اللازمة في التصميم والإنشاء عليها

Introduction:

Gypseous soils are defined as soils containing appreciable amount of gypsum CaSo4.2H2O. it is present in nature in many forms such ; integrated bed through the soil layer, small lumps with in the soil layer, small spots within the soil and gypsum crystal from mainly in the surface horizon as a result of evaporation of ground water [1].

Collapsibility soils may be defined as any unsaturated soil that goes through radical rearrangement of particles associated with great loss of the volume upon wetting with or without additional loading.

Collapse of soil requires the an open or un stable structure, high enough value of an applied stress and a strong soil bonding or cementing (salts) agent which are removed by wetting. These cementing agents (salts) include carbonate, bicarbonate, chloride, sulfate, phosphate, nitrate, calcium, magnesium, sodium and other ions which known as total dissolved salts (TDS) [2]. Damage to surfaced raids attributable to the presence of dissolve salts occurs in parts of the Middle East and is especially significant in areas of high water table (soaking) .Capillary rise of salts solution, may allow salts to enter or pass through engineering structures such as road pavement , drains, and foundation causing distress, heave, physical disintegration and possible failure, TDS, is a term used to describe the salts caused by precipitation and dissolution by rainfall, flash floods, storm tides, or even leaching reaction within months or few years. Hence, the quantity of soluble salts present in a soil may be an important factor when considering the suitability of soil for constructing structures . The effect of soluble salts on earth structures depends on various factors. These factors include:

1- the kind and solubility characteristics of the salts
2- the coefficient of permeability
3- the amount of water passing through the soil
4- temperature, chemical characteristics of the natural water in addition to some other factors [3].

Therefore , the percentage of soluble salts is only as indication of the possible effects, soluble salts are more objectionable in materials with moderate to high permeability than in soils with low permeability.

Experimental Works

The selected site was "sodium sulphate factory" 29 km north-west of Samara city at a distance of about 100 km north of Baghdad. The soil was taken from 0.5-1.0 m depth with gypsum content approximately equal to 66.4% which represents high content of gypsum. The laboratory models were carried out inside galvanized steel mold with dimensions of (150l *150w*150t) mm which installed in the lower plastic

box. See Fig (1). Square steel base with plate dimension of (40l*40w*10t) mm was designed and manufactured as a footing at the end passes into the guider to allow vertical displacement only , and to prevent tilting . this shaft has a steel loading plate bolted to the shaft at a suitable distance above the device to measure settlement.

The prepared soil was then spread in layers and compacted uniformly (3 layers each 50 mm thick) to achieve the required density. A square hammer 120*120*120 mm in dimension and about 10 kg in weight carried out the compaction of each layer. At the end of compaction the sample was wrapped with aluminum foil. Sealed with wax and cured at 40°- 45°c for 48 hours.

Testing Procedure

After the completion of the curing time, the test was carried out. The sample was transferred to the setup and installed in the lower plastic box after placing the stand and the plastic perforated plate with the steel mesh, the loading frame was placed so the center of footing coincides with the center of sample.

The load increment applied through the upper plate in the form of load increments each increment was left for 5 minutes or until the deformation reading ceases. The maximum applies stress for the first rewetting cycle was 40 kpa, and for the second rewetting cycle was 80 kpa. At the end of soaking period (5 days) , the lower drain was opened and more water added in the top to control the water level. The leaching process continued until no more settlement is noticed which meant the ending of first rewetting cycle , the water in the container was removed and the load was increased from 40-80 kpa in the pattern of increments used in first cycle. When the settlement reached to a fixed value the drain was then closed and the sample was soaked again for the same period and the procedure was repeated (ending of rewetting cycle).

Analysis and Discussion

This test was carried out in order to simulate the groundwater fluctuation, and to study the effect of this phenomenon on the collapsibility and the reduction of gypsum content in the gypseous soils.

Figure 2 shows a response for collapse potential for the rewetting – draining cycle . Collapse potential can be termed as hydro compression potential or hydro consolidation potential. A open structured soil or weakly bonded soil or soluble bonding agent may lead to the collapse on inundation or submergence of soil. Collapse is differ from consolidation from the fact that consolidation takes long period for settlement to occur while collapse occurs in short duration on inundation also in collapse there is addition of water while in collapse there is expulsion of water. Collapse does occur in all types of soils including sand, gravel or even compacted soils. Wetting induced collapse may occur in compacted soils. From this figures it can be said that the tested soil can be considered as trouble soil for the five hydraulic gradients. The collapse will happen within the first 24 hours . in sand and silts, it is immediate i.e. within 30 minutes , However, in certain heavy clays that may swell as well as collapse. Its need to 72 hours to happen.

Figure 3 , shows the results of 5 tests to determined the effect of soaking pressure on collapsibility , gypseous soils are strong when dry , but presence of water decreases the resistance of these soils when they are subjected to soaking. After the soaking period . each sample was subjected to leaching. At the leaching the sample is presoaked again to the soaking pressure. This rewetting caused additional collapse but

less than the collapse in the preceding soaking cycle , i.e. the additional collapse potential gained is decreased with increasing number of wetting-draining cycle. Flooding the gypseous soils with sufficient amount of water prior to construction will control (i.e. decrease) the effect of collapse expected due to pre flooding is lower than the amount needed because of low overburden pressure in the field.

Figure 4 shows final dissolve salts virus soaking and leaching period. It can be observed that the values of dissolve salts at the beginning of leaching process are high and then they become smaller with time. This is because dissolve salts are related to the amount of water that is washing soil, i.e. permeability , and since permeability decreased with time , so are dissolve salts concentrations, then the total amount of dissolve salts will decrease subsequently. This agree with [4], the rate of TDS is high for lower values of permeability and vice versa, this attributed to that when permeability is low there will be more time for dissolution of gypsum than when the permeability is high , in contrast to that the solubility of salts increased with time [5]

Figure 5 shows that the concentration of dissolve salts fluctuates randomly and tend to decreased in a descending order. Both dissolve salts and their concentration become small when permeability reaches steady state condition. The Iraqi soil engineers must deals with gypseous soil as a permanent construction material in which gypsum cannot be removed by flooding if soil is required to be improved for engineering reasons.

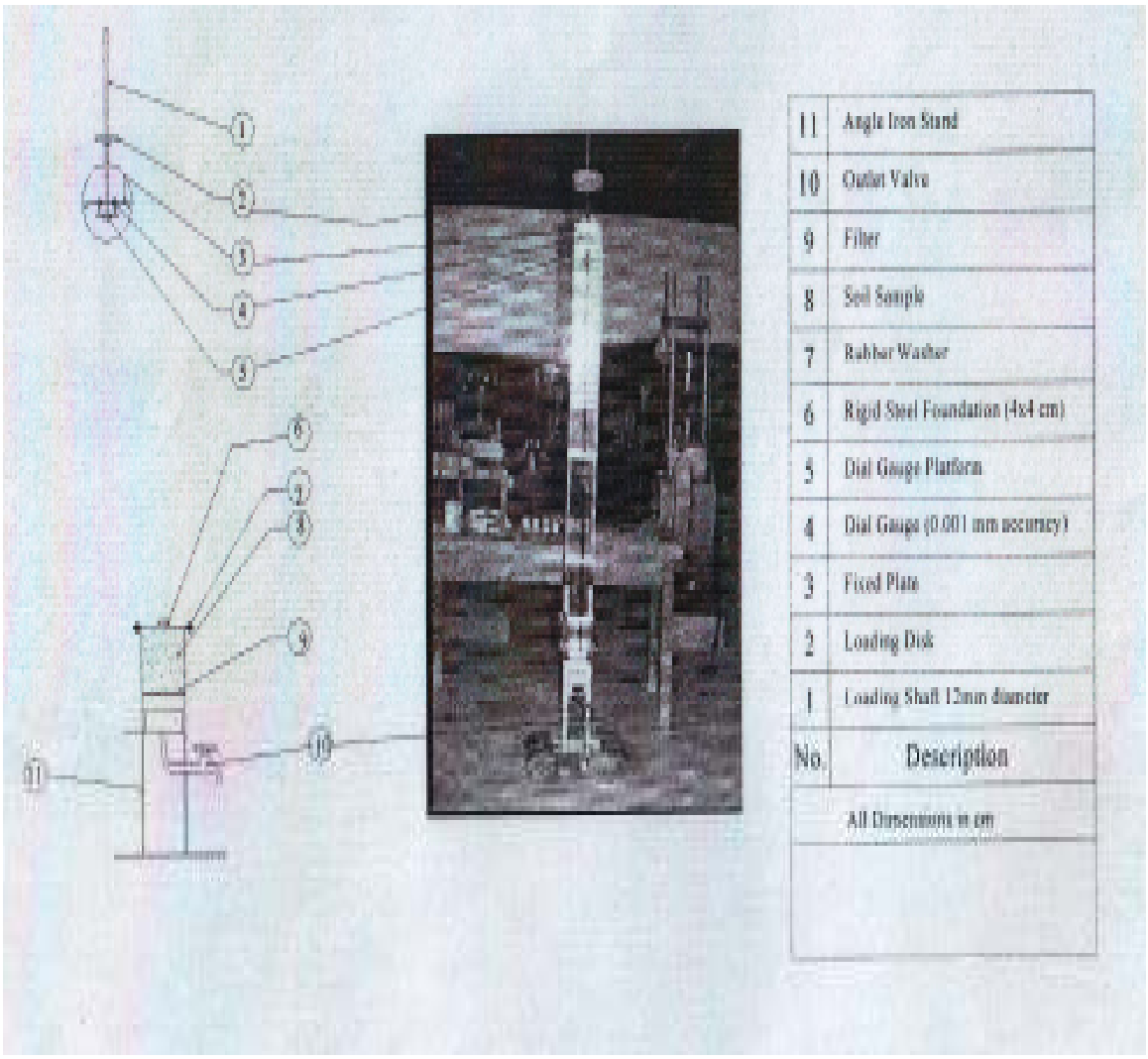
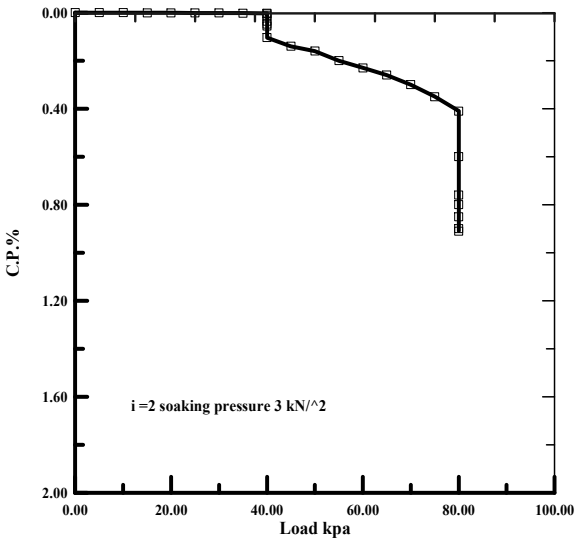
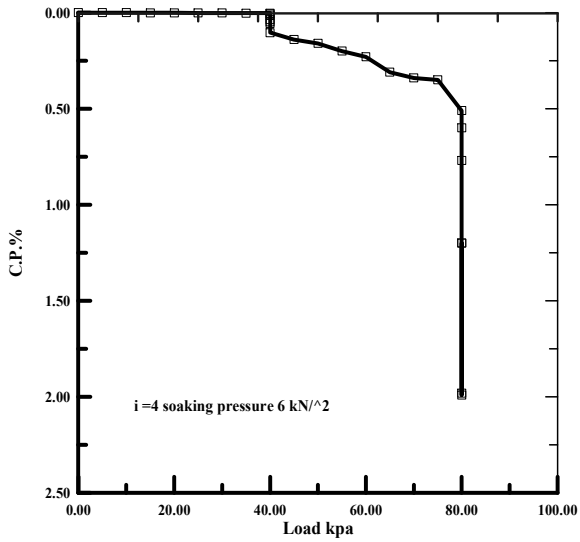
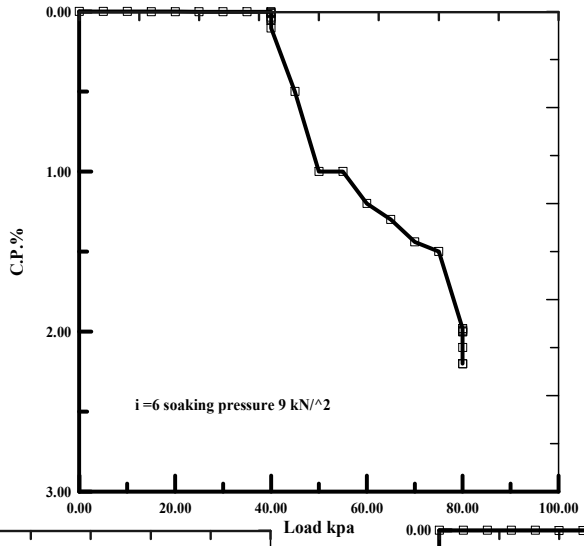
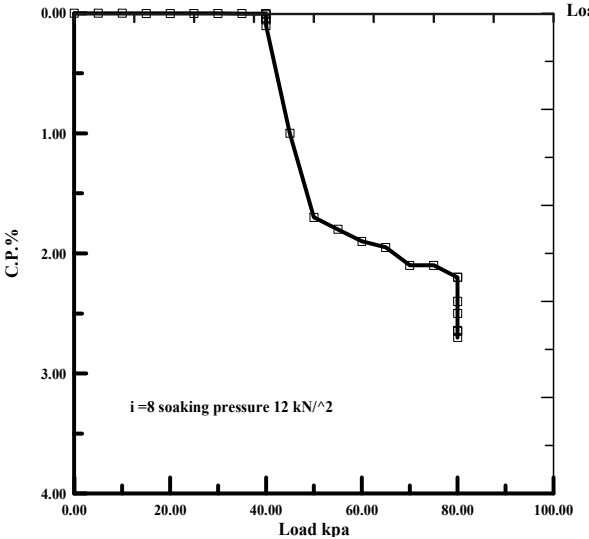


Fig (1) Model Assembly









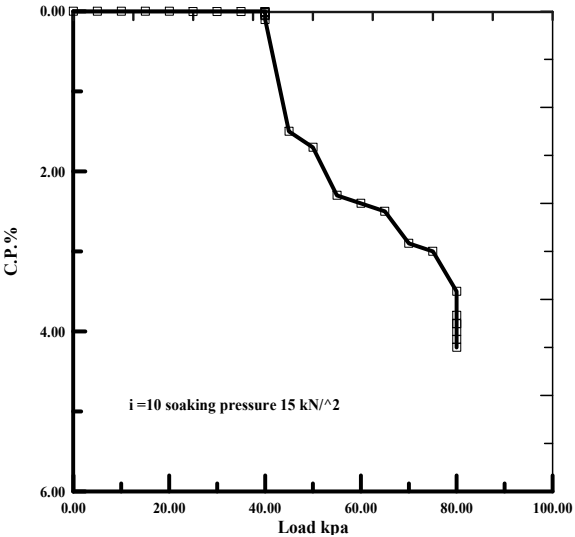
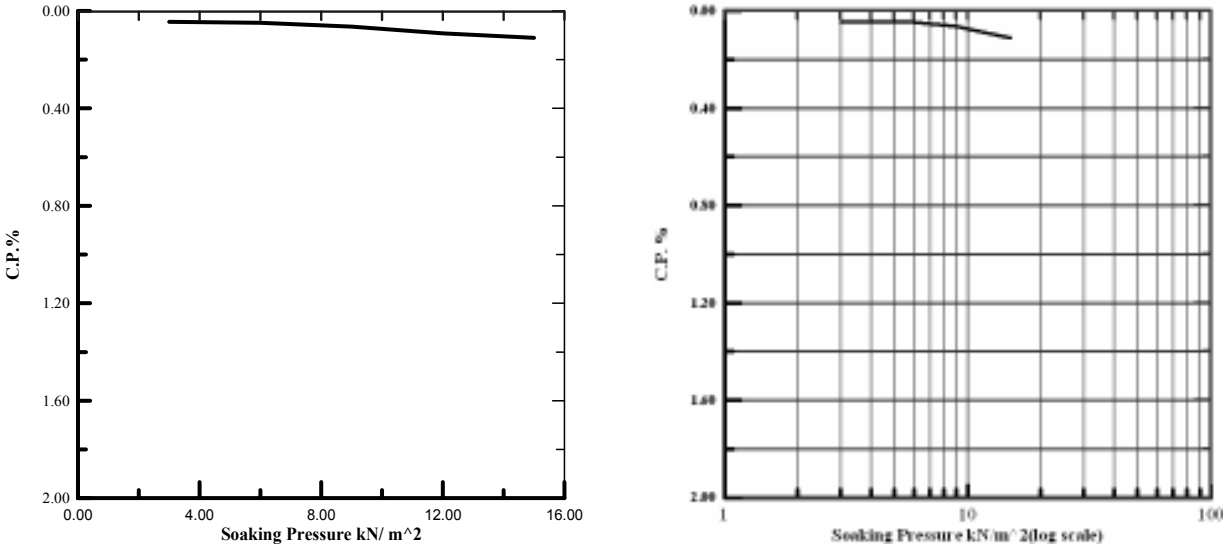
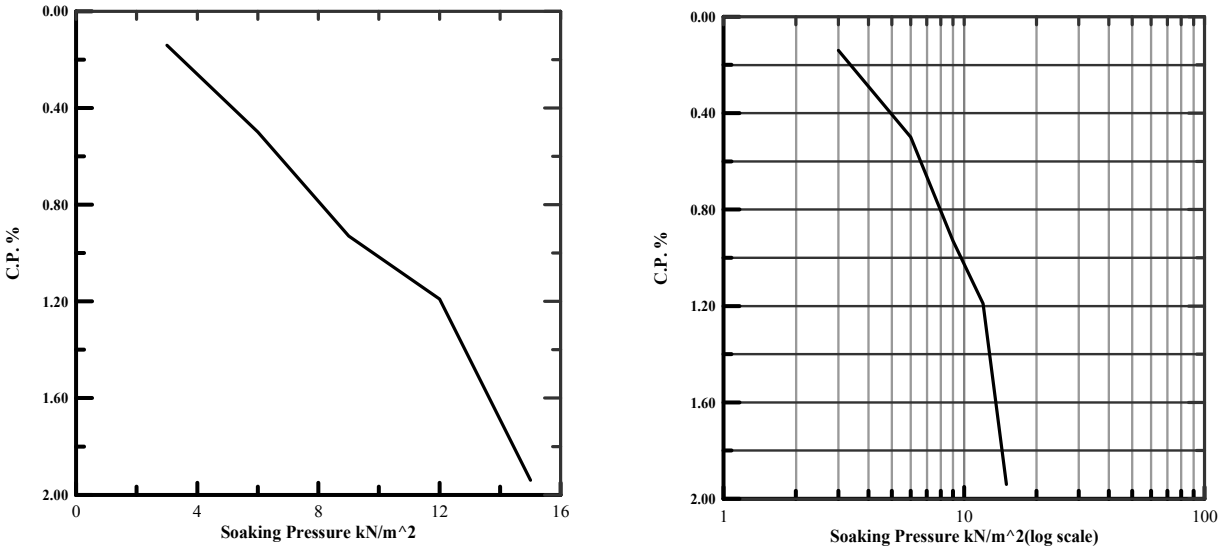


Fig (2) Collapse Curves for all tested model



a- At 40 kpa



b- At 80 kpa

Fig (3) Typical Variation of Collapse Potential with Stress level

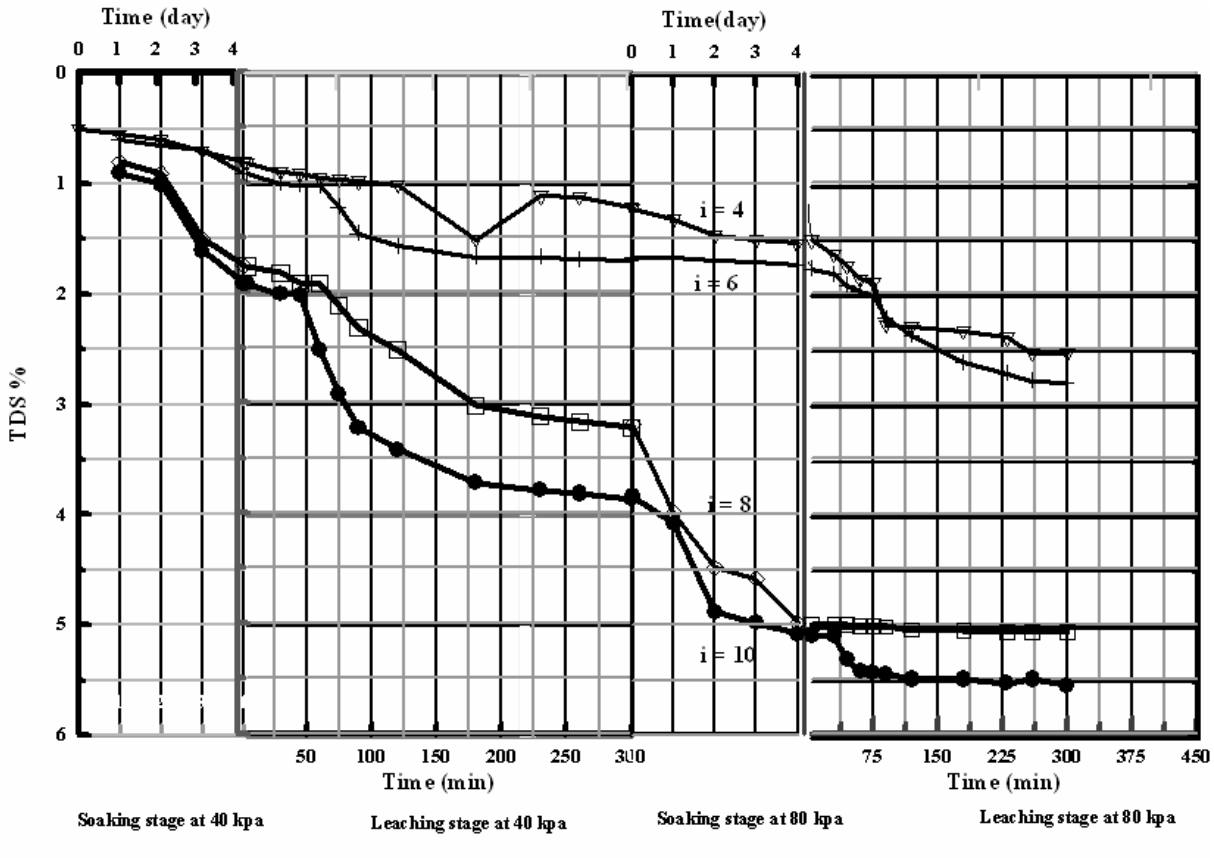


Fig (4) Cumulative TDS vs. Time for tested Samples

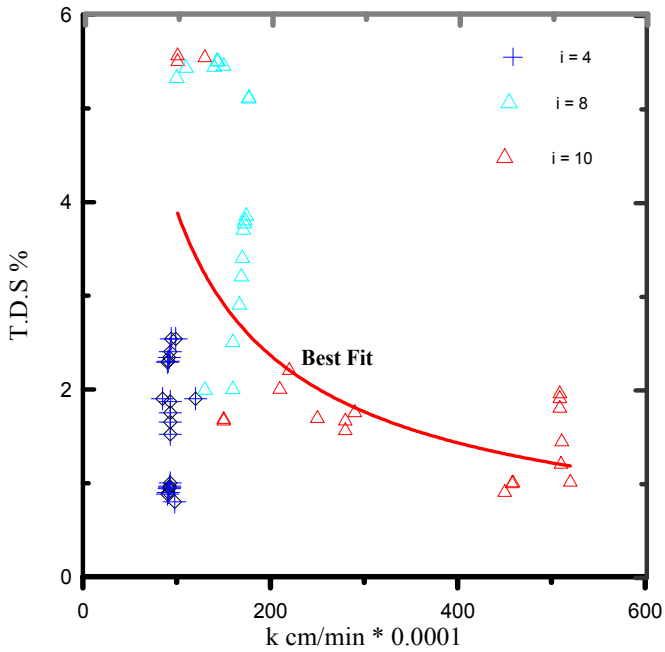


Fig (5) Cumulative TDS vs. K for tested Samples

Conclusion:

The main conclusions obtained from the experimental work of this study are.

1- Since percent loss in gypsum content was small, after 5 days of continuous static leaching , thus it is concluded that instantaneous collapse of gypseous soils, as water is added, is not due to the dissolution (removal) of gypsum but is due to the softening and breaking of bonds between soil particles which is provided by gypsum.

2- Soaking only is not effective , if it is required to improve the gypseous soil for engineering purposes, because gypsum can not be removed easily. If the content of the soil at saturation exceeds the liquid limit , the soil will collapse if it gets saturated. The main goal should be keeping water out of these soils (keep them dry). Design should include sloping the ground surface away from the structure, using foundation, extending down spouts at least 10 feet away from foundations, making sure water cannot pond close to structure, being aware of automatic sprinkler systems ,etc, on big projects, the ground can be made to collapse prior to construction by the addition of pounded water, followed by preloading to take out additional settlement.

3- The collapsibility due to leaching is always higher then that due to soaking , in the first time wetting cycle. One the contrary , the collapse ratio becomes higher in the soaking period as compared to the leaching in the second rewetting cycles.

4- The volume of water in soaking chamfer should be sufficient to provide a complete dissolution of gypsum in gypseous soil sample. For small or limited soaking water volumes it is recommended to change the water continuously to ensure the complete dissolution of gypsum. For this purpose , it is necessary to estimate the quantity of water to be changed to provide pure water during soaking period.

5- If the water content of the soil at saturation exceeds the liquid limit, the soil will collapse if it gets saturated.

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