

DECREASING PERMEABILITY OF GYPSEOUS SOILS BY BENTONITE⁺

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Abstract

Soils containing gypsum as a cementing agent are affected considerably when subjected to change in water content. Flow through gypseous soil causes serious damage to the foundation built on such soils. This behavior of this soil exhibited significant changes upon addition of water, especially when the process was accompanied by a continuous flow of water. The addition of relatively small amount of bentonite (3-20%) can improve the performance of granular gypseous soils providing allow permeability and an enhanced mechanical stability. A laboratory investigation of leaching-collapse test behavior of compacted mixtures of soil-bentonite had been undertaken. The study showed that the value of permeability and solubility for treated gypseous soil with bentonite improved by (9-30%) than untreated samples for two different densities.

Key Words : bentonite , gypseous soils, collapse soil , permeability

المستخلص

تتعرض الترب التي تحوي على الجبس والذي يعمل كمادة رابطة الى مشاكل معينة عندما تتعرض الى تغيير في نسب المحتوى المائي لها. يسبب الجريان خلال الترب الجبسية مشاكل خطيرة على أساسات الأبنية الواقعة عليها. ان هذا التصرف لهذه الترب يبدو واضحا عندما تتعرض الى تغير في محتوى الماء وخصوصا عندما تتعرض الى جريان ماء مستمر. إن إضافة نسب معينة من مادة البنتونايت (3-20%) من وزن التربة يساهم في تحسين اداء هذه الترب وخصوصا فيما يتعلق بالنفاذية ومن ثم استقرارية هذه الترب. لقد تم اجراء فحص (الغسل - الانهيارية) على مجموعة من النماذج التربة والمضاف اليها نسب من البنتونايت، فلقد اظهرت هذه الدراسة تحسن النفاذية والذوبان للنماذج المعالجة بنسبة (9-30%) من النماذج الغير معالجة بالبنتونايت ولكثافتين مختلفتين.

Introduction

Gypseous soils are found in arid and semi-arid areas on gypsiferous rocks and sediments of different origin, where rainfall is insufficient to leach the gypsum out of the soil mantle. They usually occur in the same regions as calcareous soils but are much less widespread. For being of marginal interest to agricultural use, they were given little attention in the past until it was realized that they have potential for both rain fed and irrigated agriculture [1].

Following construction period, numbers of problems were observed in many structures found on such gypseous soils, such as cracks, differential settlement, tilting, and

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collapse. These problems were generated due to the lack of engineering experience with gypseous soils. The remedies suggested for the defaults generated by the presence of gypseous soils depend on the type of structure and the type of the encountered defects by the gypseous soils. However, the remedies are always focused towards decreasing or eliminating the effect of water on the gypseous soils to ensure the safety and stability of the structures. The world remedial experience extended in a number of proposals basically based on providing sufficient and adequate barriers for the foundation from different sources of water. Recently some additives were also proposed to be incorporated with gypseous soil, such as oil products. Additives like cement, lime, sodium silicate, dehydrate calcium chloride and bentonites were proposed. Bentonite is one of the most unusual and versatile industrial minerals in the world. The primary mineral in it is called montmorillonite, this name is derived from the discovery of this type of clay near Montmorillon in France [2]. Bentonite has to filtrate through voids and pours of mixing soil, at the presence of water, the bentonite becomes gel and binds the soil particles for several centimeters forming filter cake which independent on soil permeability. However, the more pervious the soil, the more bentonite gel penetrate. This behaviour because of its thixotropy and viscosity [3]. This paper presents an attempt to extend the use of bentonite additives technique, which originally proved its effectiveness as an improvement technique for controlling the behaviour of soft saturated soil. The proposed use is to control the permeability behavior of gypseous soils.

Experimental Works

The selected site was near "Sodium Sulphate Factory" 29km north-west of Samara city at a distance of about 100km north of Baghdad. The soil was taken from 0.5-1.0m depth with gypsum content approximately equal to 66.4%, which represents high content of gypsum. The laboratory models were carried out inside a steel container with dimensions of (600_L*600_W*500_T) mm, see plate (1). Square steel base with plate dimension of (100_L*100_W*10_T) mm were designed and manufactured as a footing, 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 major experimental work consists of conducting laboratory model test for bentonite mixed with gypseous soil bed. The tests were directed to investigate the efficiency of bentonite as a technique to improve the engineering performance of gypseous soil upon wetting. Thus a series of model tests with different bentonite percentage with soil materials were performed.

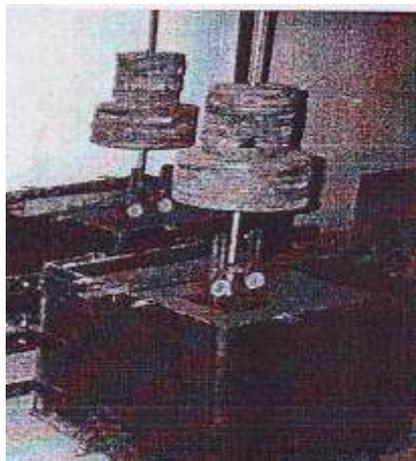


Plate.(1) Leaching- Collapse test

Testing Procedure

Two densities were selected initially for model tests, the first represents the field density and the second represents the maximum density (obtained by standard Procter test). After the completion of the curing, the test was carried out as follows:

- 1-The sample was transferred to the setup .The loading frame was placed at its position, so that the center of footing coincides with the center of sample.
- 2-Load was applied through the upper base plate in the form of load increments.
- 3-Each load increment was left until the deformation reading seizes. The maximum applied stresses for the models were 80 kPa.
- 4-After the deformation of the footing reached its final stage, the lower drain was opened and more water was added in the top to control the water level samples of water were taken at specific time period to identify the value of TSS and SO_3 .
- 5-The same procedure was repeated for the soil samples treated with bentonite (3-20%)

Analysis and Discussion

Figure 1 show the curves of coefficient of permeability versus time for the soil used, at dry unit weight densities of 12 and 15 kN/m^3 and for applied stress of 80 kPa.

From the figures, it can be observed that the permeability of both types of soil studied is high at beginning of leaching stage, fluctuates for some times in a descending order then reaches a steady state condition. The high permeability because of enlargement of voids, and the cause of low permeability due to the collapse of soil structure under the influence of applied pressures [4].

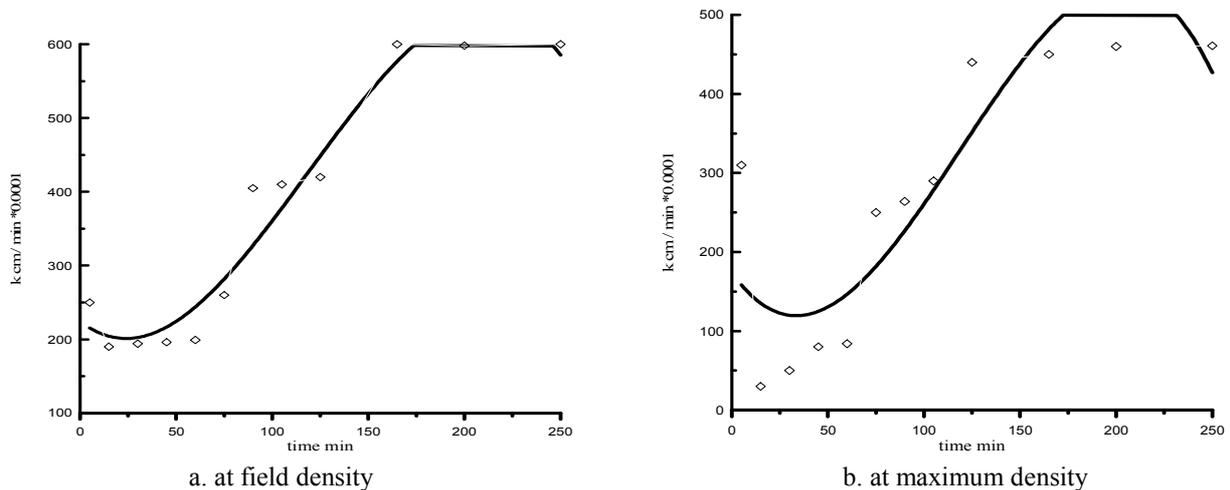


Fig. (1) Effect of compacted densities on the Coefficient of Permeability with time

Figures 2 and 3 illustrate the relationship between permeability and the quantity of bentonite added to several representative soil samples. Varying the quantity of bentonite between 3 and 20 percent typically changes permeability by an order of magnitude. The permeability is dependent on both the soil gradation and the quantity of bentonite used. Both factors are important. The presence of permeable soil, bentonite has a tendency to filtrate

through the voids of the surrounding mixing soil, bentonite becomes gel and binds the surrounding soil for several centimeters through it. The soil becomes impervious to solid particles and water. This is because of gelatin layer, a film more and more impervious named "cake" [5]. The general trend of the results obtained from the two figures demonstrates that the coefficient of permeability for samples prepared at field density is always higher than of maximum density. Figure 4 show final dissolve salts versus coefficient of permeability . It can be observed that the values of dissolve salts at the beginning of leaching process are high, and then 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 decrease with time and because of presence of bentonite, the amount of T.D.S will decrease subsequently. It is observed that the ratio of the coefficient of permeability before adding bentonite to the same coefficient for the soil mixed with bentonite k_b increases with increasing bentonite percent from 1.1, 1.24, 1.35, 1.48 and 1.5 for (3%, 5%, 10%, 15% and 20%) bentonite . It can be seen that the ratio $k/k_{b\%}$ for the two different unit weights are very close and the behavior of the bentonite on this sample are same for the two different densities.

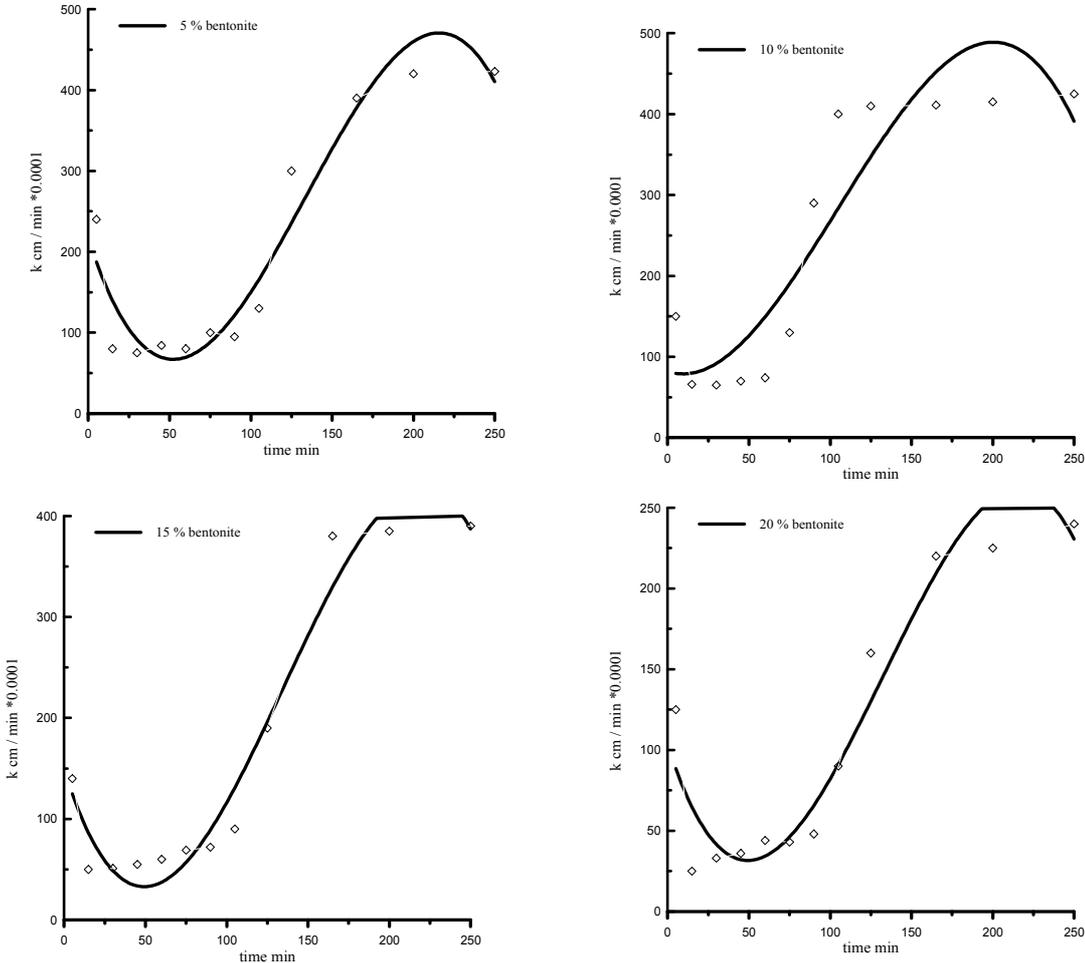


Fig. (2) Effect of bentonite % on K for samples compacted at field density.

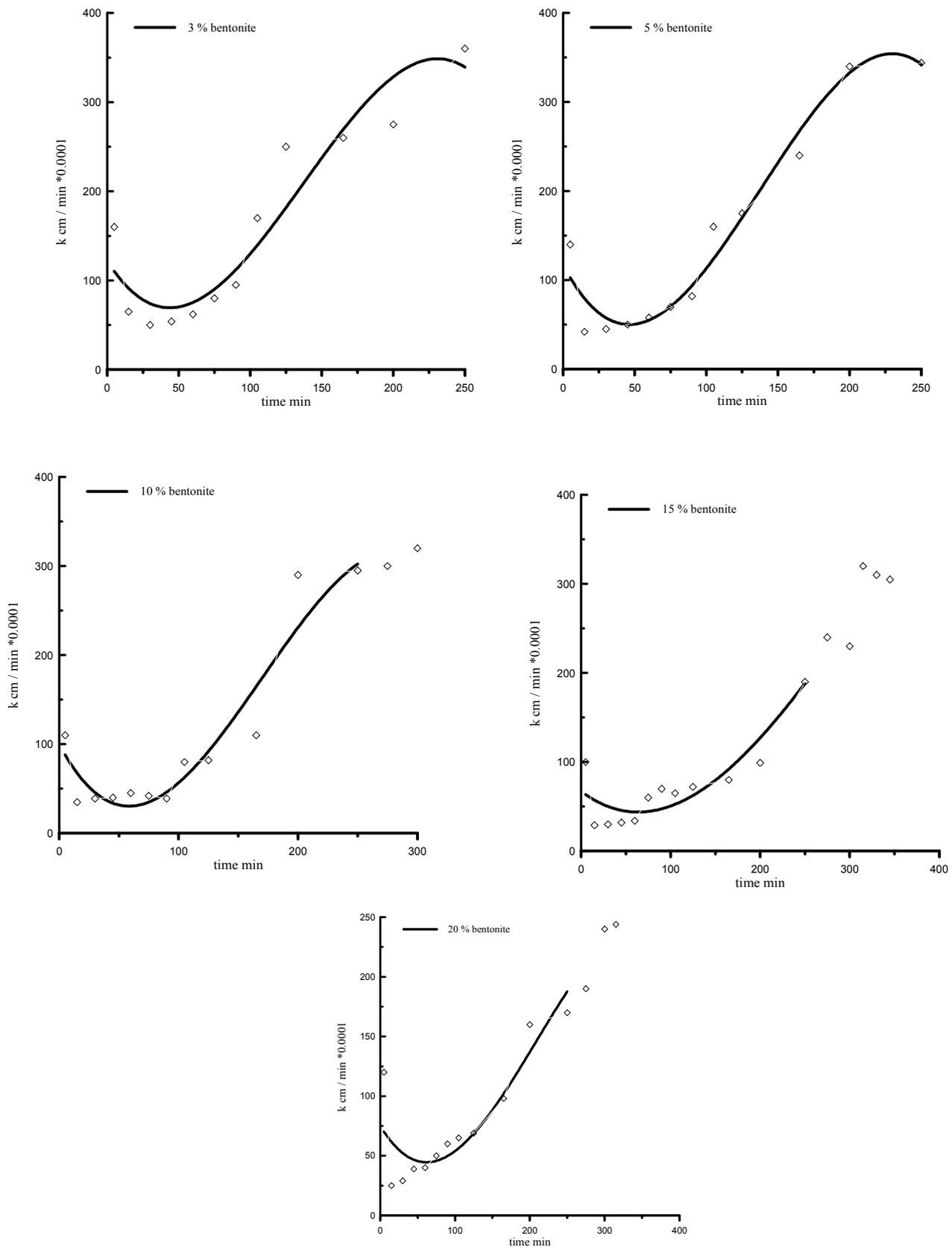


Fig. (3) Effect of bentonite % on K for samples compacted at maximum density.

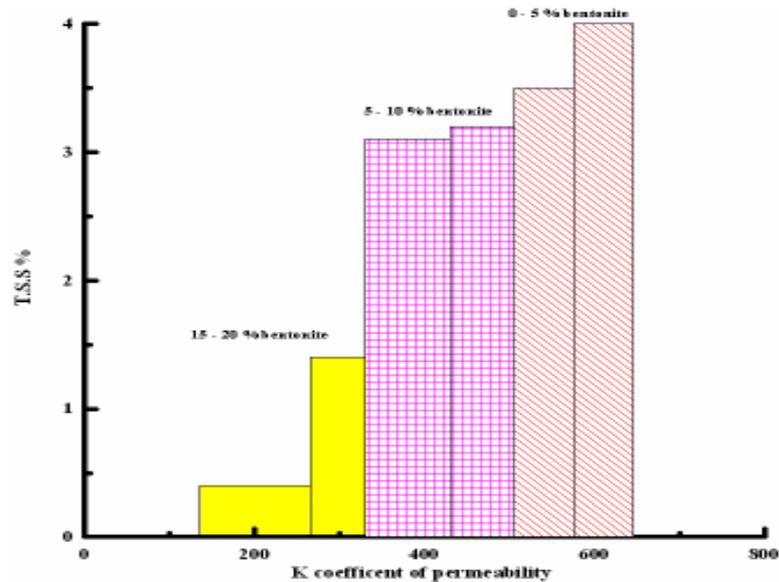


Fig. (4) Cumulative T.S.S vs K for samples at field density

Conclusions

Based on the experimental work of this study the following main conclusions are drawn.

The investigated gypseous soil compacted at maximum density exhibited a reduction in coefficient of permeability as compared with soil compacted at field density while the influence of adding bentonite for samples compacted at these densities exhibited the same reduction in coefficient of permeability, therefore No reliable value of coefficient permeability can be used confidently in design, because the permeability value changes radically through time.

The properties of filter cake formed on any granular soil are essentially independent of the soil permeability. However, the more pervious the soil, the more penetrate of filter cake. It is necessary to investigating the effect of particle size and gradation of backfill material at its relationship with formation of filter cake. The permeability is a function of both the filter cake that forms and the permeability of the soil mixed with bentonite.

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