# Effect of Adding Fine Gravel and Cement on Settlement of Sabkha Soil

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## ABSTRACT

Sabkha soil is one of the many types of collapsible soils and in turn is on of the many types of problematic soils. This soil is totally having good engineering properties when dry ,i.e ,moderately bearing capacity with low settlement .But once are wetted they loose their entire structure (collapse) and undergo very large instantaneous settlement .A laboratory model test consists of a cylindrical steel container of 270mm diameter and 300mm height, the soil is brought from Al-Khalis discrete .The density of soil is controlled by placing the required weight inside the container of known volume, to the required height .A square footing 60x60mm makes from steel is used .The stress is applied from a fixed loading system designed especially for model tests .In this study two types of treatment carried out ,the first treatment is added fine gravel only with percentages (2%,4.5%,6%) to soil which is not give good improvement .The second type of improvement is added 3% of cement with fine gravel (4.5%,6%) percentages which give good improvement, reduced the collapsibility to 84% .Also, when adding 3% of cement with 4.5% fine gravel to soil ,give good improvement, reduced the collapsibility to 90% .

**Keywords:** Sabkha soil ,collapsibility ,behavior.

## تاثير اضافة الحصى الناعم والسمنت على هبوط التربة السبخة

**الخلاصة**

تعتبر تربة السبخة هى احد انواع الترب الانهيارية وتسبب الكثير من المشاكل للمنشات المشيدة عليها اذ تمتاز بانها قوية ومتماسكة وهبوطها واطى عندما تكون جافة ولكن بمجرد وصول الماء اليها فانها تصبح ضعيفة جدا وتسبب هبوط عالى جدا .هذه الدراسة ركزت على استخدام معالجتين لهذه التربة ,الاولى هى اضافة الحصى الناعم بنسب (6%, 4.5%, 2%) واثبتت المعالجة لهذه الطريقة عدم حصول تحسين ملحوظ لهبوط التربة .اما الطريقة الاخرى فهى اضافة سمنت بنسب ( 1.5 %, 3 %, 4.5 % ) مع حصى ناعم بنسب (4.5 % , 6 % ) وقد حصل تحسن كبير في هبوط التربة حيث قلت بنسبة تتراوح بين( 62% - 90 % ).

## INTRODUCTION

Sabkha is a collapsible soil that is susceptible to large and sudden reduction in volume upon wetting. The geotechnical problems caused by Sabkhas are now well defined and although several improvement methods are playing an increasing role in foundation work of roads and highways. A potential variation in compressibility of Sabkha sediments will lead to excessive different settlements . This is ascribed to fact that Sabkha deposites, in general, are known to vary from very loose or loose to dense conditions with a relatively short distance of five to ten



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meters .As sequence, Sabkha possesses a high collapse and soil potential mainly as a result of dissolution of sodium chloride, leaching of calcium ions and soil grain adjustment.

Sabkha is an Arabic expression to describe recent coastal sediments with a high salt content and are characterized by very low bearing capacities and low SPT values(1) .

Salt flats or Sabkhas are salt bearing arid climate sediments covering vast areas of coasts of middle Eastern and North African countries .The development of this material is due to low wave energy allowing the settlement of silt and clay particles to take place and then be loosely cemented by soluble .Sabkha sediments are characterized by high void ratios and low dry densities .Accordingly ,upon wetting Sabkha soil is renowned for being highly compressible material with low bearing resistance and hence considered among the poorest of foundation material (2,3).

Saline soils are associated with many geotechnical problems ,due to presence of digenetic salts of different sizes ,shapes and compositions ;and shallow saline ground waters .Therefore ;saline soil is considered to be an inferior construction material .Because of these characteristics ,some of pavements located on saline flats have exhibited various type of deterioration in form of reveling ,cracking ,rutting and formation of landslides in recently built roads .The susceptibility of these soils to strength loss and collapse upon wetting makes their use in construction very risky and hazardous Saline soils present high rigidity and high shear strength in natural conditions ,but they change radically in front of water action triggering huge localized settlement in civil works(4,6)

Many studies are performed about geotechnical behavior of saline soil in civil projects in different countries .Saline soil posses a high collapse potential attributable primarily to dissolution of sodium chlorides ,leaching of calcium ions and soil grain adjustment(5) .

This study shines the lights about the effect of adding fine gravel and Portland cement on behavior of Sabkha soil during soaking and leaching process.

## EXPERIMENTAL WORK

### Soil Used

The soil used in this study was brought from Al-Khalis discrete at 1m depth of handmade borehole .Natural moisture content for the soil was 10% ,grain size analysis is conducted on soil before and after washing as shown in fig.(3) .Classification test was made for the soil include liquid limit and plastic limit which values are 20%,15% respectively .Therefore; the soil is SC-SM type.

## LABORATORY MODEL PREPARATION

A cylinder with 27 cm diameter and 30cm height made from thick steel material was prepared ,the soil was oven ,pulverized and sieved through sieve No.4 .The soil was placed in the cylindrical container with density 17.5 kN/m3 mixed with initial water content 4%,the soil was mixed thoroughly with different percent of fine gravel (2%,4.5%,6%) .The fine gravel sizes is between(5-1.18)mm and sulphate content (SO3%) is 0.1% .Also ,the soil mixed with ordinary cement portlad (1.5%,3%,4.5%) and fine gravel (4.5%,6%) .The chemical and physical properties of cement are shown in table 1 A model with no treatment was made for making a comparison with treated one with fine and cement addition .The soil density was controlled by dividing it three layers ;each individually compacted to recoded level until reaching the last layer ,the soil surface was leveled with aid of sharp instrument . a square footing 6x6 cm made from steel ,was placed at the center of the model ,over last bed of the soil.

## LOADING FRAME AND SETTLEMENT CONTROL

The system of loading frame chosen for all laboratory model tests was fixed loadings, to ensure continuous and long term loading application and easy stress controlling and loading additions during test .The model consists of vertical steel shaft of square section (1.2 m length ,1x1 cm cross section) connected as shown in fig.(2) .

The settlement was measured using 0.01mm sensitive dial gauge ,fixed out of the model with the aid of magnetic holder .The loading frame and settlement control was designed especially for these tests type on model samples to investigate settlement during soaking and leaching of Sabkha soil with water .

The settlement was recorded with time for model tests at dry state ,this state takes about one day which represents the immediate settlement .At soaking stage (takes one day) ,the water was opened and starting wetting the soil in the model from top to bottom .The leaching process takes 5 days in which the small openings at bottom of container permitted to drained.

## RESULTS AND DISCUSSION

The sequence of each test is carried out as follows : the load is applied (35 kPa.) on soil through 6x6 cm footing model and time zero stated .The flow chart of experimental work is shown in fig.(3) .

Tests results are shown separately in fig.(4,5,6,7,8,9) while fig.(10) shows data accumulation which are piled in one drawing .This curve is the most important and can be realized immediately that collapse settlement is thus by far is reduced by fine gravel and cement addition .The settlement for case of no addition is continued and does not stop until leveled off at measured quantity of 15.75 mm, that is S/B ratio of 0.26 ,that is a very large settlement and author believe that there is no such domestic building or installation that can withstand such a numerical value .This type of settlement is collapse (instantaneous) and not long term one like consolidation settlement .If settlement takes place suddenly the structure would not have turn to adjust the stresses induced or distributed .The results of addition fine gravel only to soil are shown in fig.(5,6,7),we noticed that S/B are extremely the same as the soil with no addition ,therefore; there is no significant improvement when adding fine gravel percentages (2%,4.5%,6%) .

Just adding 3%percent of Portland cement with (4.5%,6%) fine gravel to soil reduces settlement to 84% the value for no treated Sabkha soil (S/B=0.04,S/B=0.02) .These curves have almost similar trend of behavior .Also, when adding another percents of Portland cement (1.5%,4.5%) with 4.5% fine gravel to soil reduces settlement to 62%,90% respectively the value of no treated Sabkha soil (S/B=0.10,S/B=0.22) as shown in fig.(11,12) .

It must be mentioned here, that the recorded settlement belong to soaking is more than the leaching, that the recorded settlement belong to soaking is more than the leaching .As compare with gypseous soil ,It is noticed that the Sabkha soil has collapsibility more than the gypseous soil ,this is because the chloride salt is dissolved faster than the calcium sulphate salt .

It is noticed that the increase in addition of fine gravel percent with cement to soil increased the improvement to half which may be due to connect of particles with it .

## CONCLUSIONS

The following points are drawn from this study :

1.It is dangerous to use Sabkha soil in any engineering construction or to build on unless they receive some sort of treatment .

2.In using percentages (2%,4.5%,6%)of fine gravel with Sabkha soil ,there is no significant improvement .

3.In using 3% of cement and fine gravel percentages (4.5%,6%) with Sabkha soil, the collapse settlement is reduced by 84%.

4.The bearing stress used in laboratory models is about 35 kPa., this may be represent the average and actual bearing stress in most domestic buildings .High stresses will of course cause higher settlement collapse .

5.The settlement obtained during soaking Sabkha soil (treated and untreated ) is more than that from leaching process .

6. When increase of fine gravel percent with 3% cement , reduced the settlement of Sabkha soil (S/B=0.02) .

7.In using percentages (1.5%,4.5%) of Portland cement and 4.5% of fine gravel with Sabkha soil ,the collapse settlement reduces 62%,90% respectively .

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**Table (1) Chemical and physical properties of cement.**

| $C_3A$ % | Initial setting time (min.) | Final setting time (hour) | Fineness |
|---|---|---|---|
| 2.6 | 171 | 3.46 | 330 |

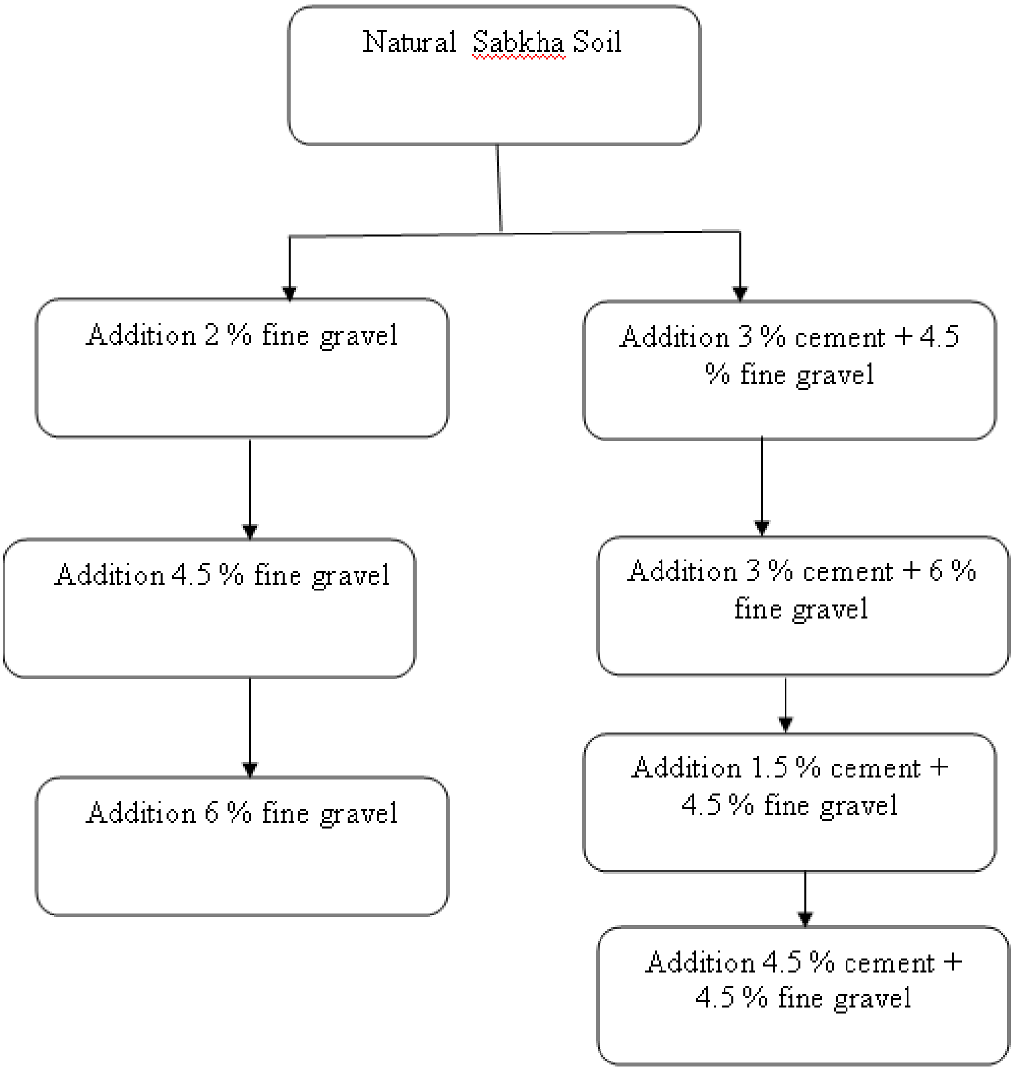


**Figure (1): Flow chart program of experimental work**

**Figure (2): Laboratory model preparation and equipments for soaking and leaching Sabkha soil.**

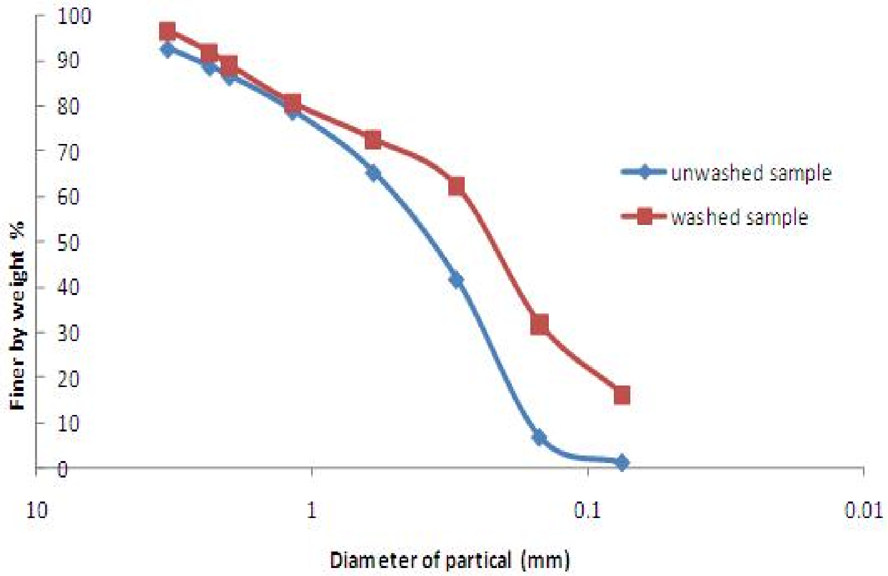


**Figure (3):Grain size distribution of Sabkha soil.**

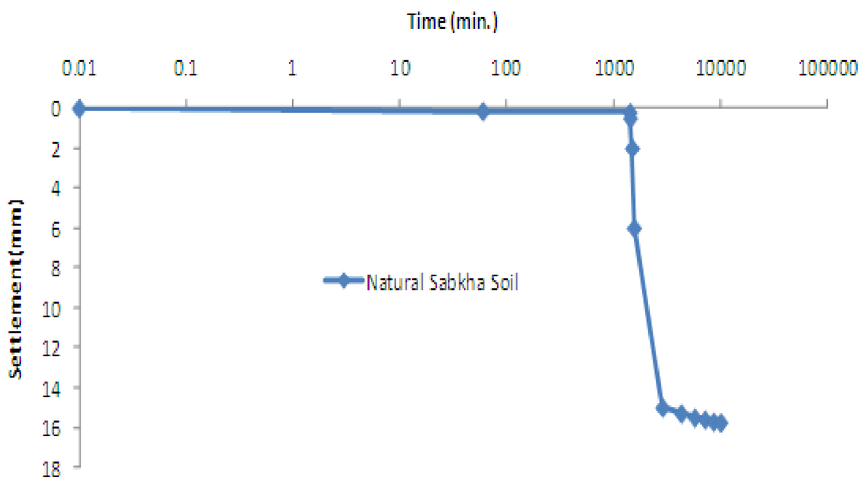


**Figure (4): Time settlement curve for natural Sabkha soil (stress =35 kPa,γ=17.5 kN/m$^3$)**

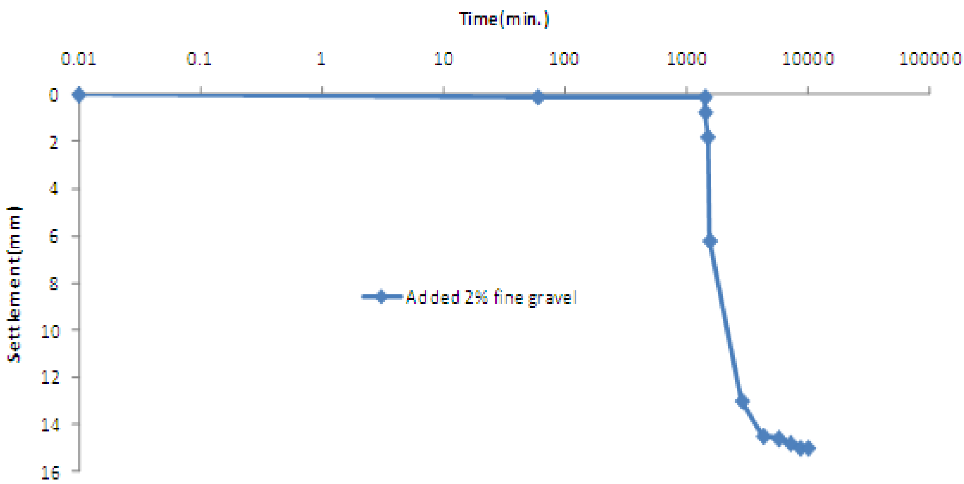


**Figure (5): Time settlement curve for natural Sabkha soil with 2% fine gravel (stress =35 kPa,γ=17.5 kN/m$^3$)**

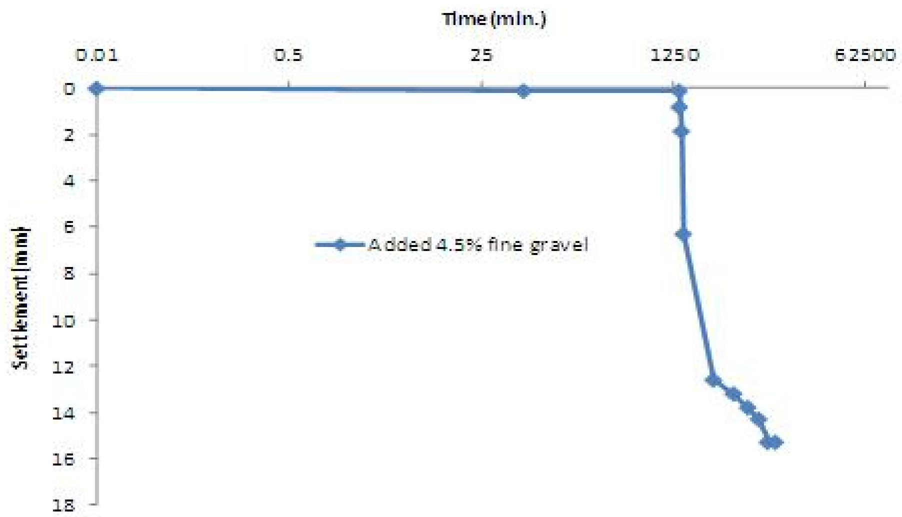


**Figure (6): Time settlement curve for natural Sabkha soil with 4.5% fine gravel (stress =35 kPa,γ=17.5 kN/m$^3$)**

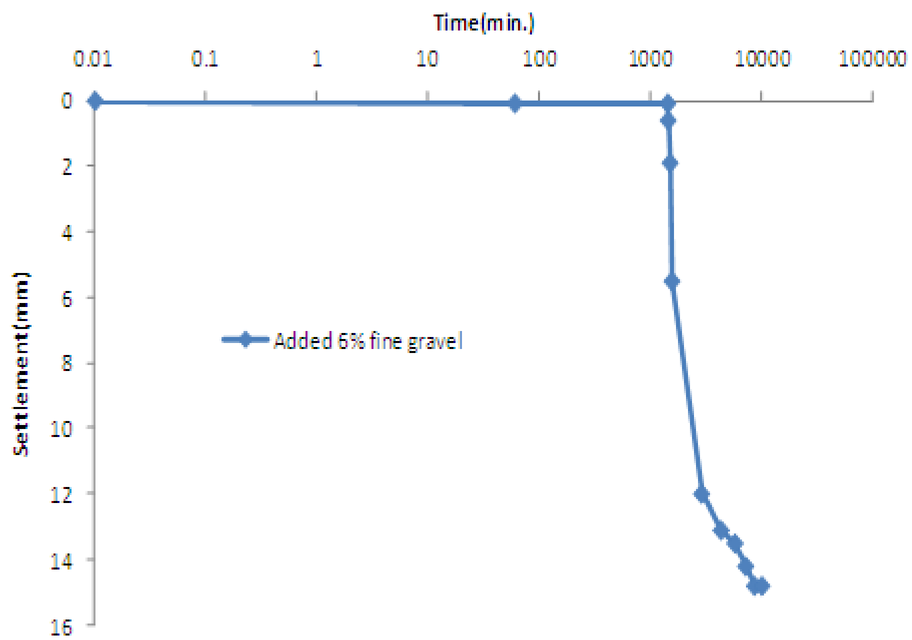


**Figure (7): Time settlement curve for natural Sabkha soil with 6% fine gravel (stress =35 kPa,γ=17.5 kN/m$^3$)**

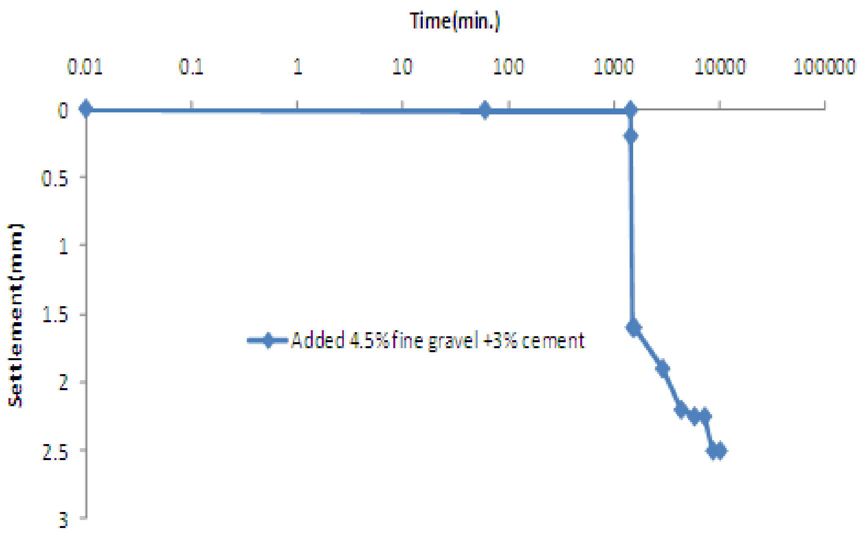


**Figure (8): Time settlement curve for natural Sabkha soil with 4.5% fine gravel +3% cement (stress =35 kPa,γ=17.5 kN/m$^3$)**

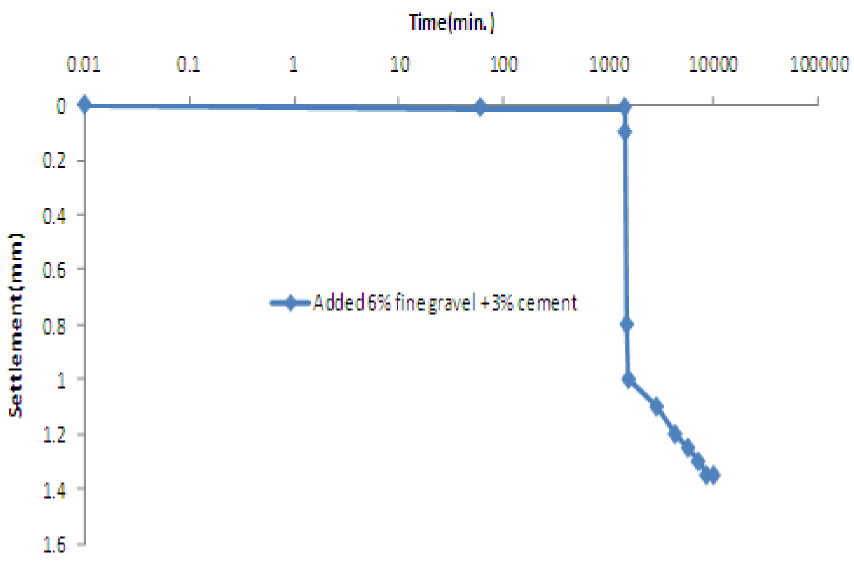


**Figure (9): Time settlement curve for natural Sabkha soil with 6 % fine gravel +3% cement (stress =35 kPa,γ=17.5 kN/m$^3$)**

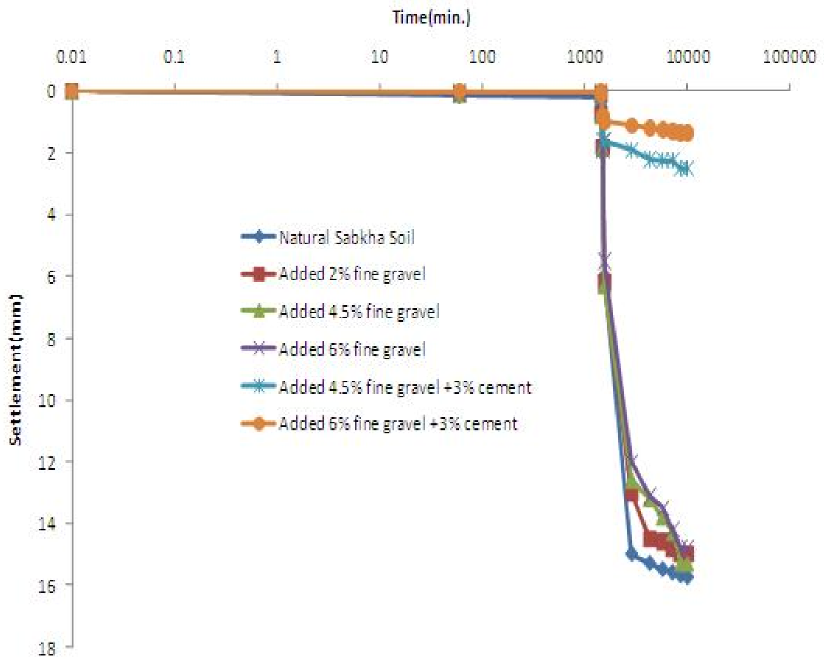


**Figure (10): Time settlement curve for all cases (stress =35 kPa, γ =17.5 kN/m³).**

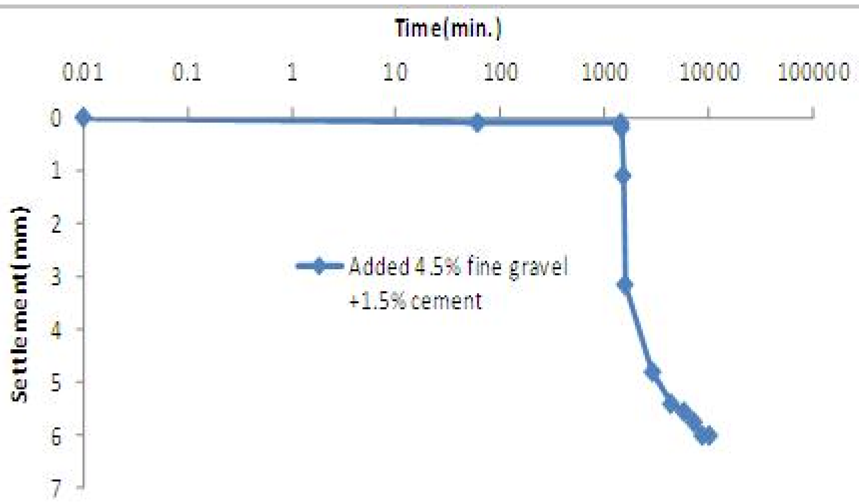


**Figure (11): Time settlement curve for natural Sabkha soil with 4.5 % fine gravel +1.5 % cement (stress =35 kPa,γ=17.5 kN/m³)**

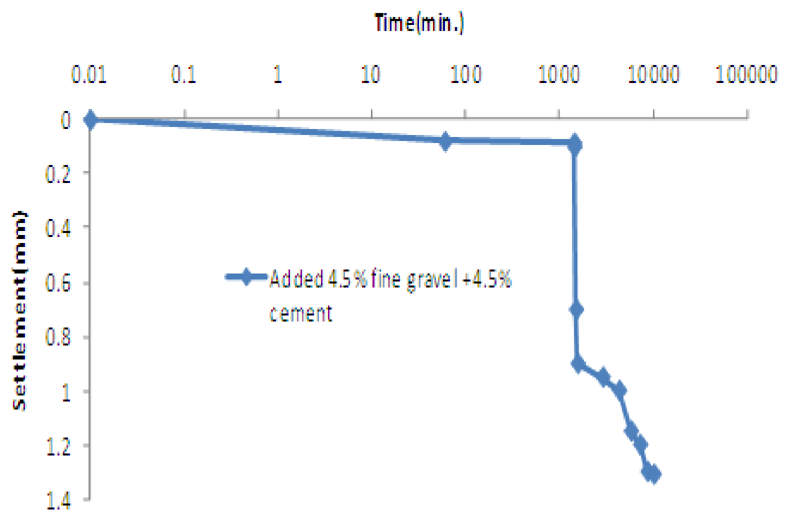


**Figure (12): Time settlement curve for natural Sabkha soil with 4.5 % fine gravel +4.5 % cement (stress =35 kPa,$\gamma$=17.5 kN/$m^3$)**