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Effect of Soil Nailing on Some Problematic Soils

Dr. Safa Hussain Abid Awn/ lecturer

College of Engineering/Civil Eng. Department Diyala University

Safa_alshamary@yahoo.com

Abstract:

The land scape is subjected to higher temperature during the last three decades became of "Globule warming", which became high evaporation of surface water, in addition to the increase in salt content , because of the unaffected irrigation way, of planets and the increase in the capillarity action which contribute with this process. This may led to the dissolution of salts inside soil and its appearance on the ground surface, with different depths. The NaCl salt is one of the most common salts presence in widely areas in Iraq, which has high dissolution rate in water. The problem of such soils appear when subjected to miniaturization from any source, resulting high dissolution rate of the salts in side soil skeleton, which lead to the weakening of soil, cavities may appear inside soil layer, and so it may led to failure of structures constructed on it.

This study includes the feasibility of improving the collapsibility of natural saline soil with 10% salt percent, brought from, Jurf Al-Milih region in Diyala Governorate, by mixing it with randomly distributed nail reinforcement, with three different lengths "Ln", related to width of footing "B" , (Ln/B=11%, 14.2% and 21.4%). By carrying settlement test for single model footing with time, for treated and untreated model using this technique at both dry and wetting conditions, using locally manufactured Laboratory model. This technique reduce the collapsibility of such soil, 27%.

The study includes also the effect of mixing the saline soil with some available additives: (1.5% and 3%) Lime material, (2% and 5%) of Cement material, with and without reinforcement. and investigates its effects on the collapsibility of such problematic collapsible soil. The best improvement was achieved by mixing the saline soil with (5% cement, and randomly distributed reinforcement using Ln/B=14.2%). this will reduce the collapsibility of such problematic soil, 90%.

The best treatment used in this study, is by mixing the saline soil with natural and available material which is Bentonite, with two percentages (5% and 10%) without reinforcement. and the improvement achieved by mixing saline soil with 10% Bentonite. This reduces the collapsibility to 97%, when wetting such soil with water. So it may consider the most effective treatment technique used for such soil.

Key word: ***saline soils, sabkha, treatment, soil nailing.***

تأثير التسليح بمخلفات المسامير على تصرف بعض الترب ذات المشاكل الانشائية

م.د صفاء حسين عبد عون

كلية الهندسة، قسم الهندسة المدنية/ جامعة ديالى

الخلاصة:

يتعرض سطح الارض بصوره مستمره للحرارة والتي ازدادت بشكل ملحوظ خلال العقود الثلاث الماضية، نتيجة الاحتباس الحراري مما يؤدي الى تبخر المياه السطحية للأراضي المكشوفة .إضافة الى زيادة الاملاح نتيجة لتبخر المياه للأراضي الزراعية، نتيجة عملية الري غير المدروس ولازدياد الخاصية الشعرية التي تصاحب هذه العملية ،مما يؤدي الى ذوبان الاملاح الموجودة في جوف التربة وظهورها على السطح بأعماق مختلفة ،مما يؤدي الى ظهور مشاكل التربة الانهيارية في مناطق شاسعة تتمثل في زيادة نسبة الاملاح في التربة ،ومن هذه الاملاح NaCL. وهو ملح سريع الذوبان في الماء حيث تظهر مشاكل هذه التربة عند تعرضها للترطيب من اي مصدر مما يؤدي الى ذوبان جزيئات هذه المادة التي تتخلل دقائق التربة مما يولد فجوات وتشققات وبالتالي الى اضعاف قابلية تحملها للأحمال وفشل المنشآت المقامة عليها.

تتضمن هذه الدراسه امكانية تحسين تربه طبيعيه بمحتوى ملحي 10% تم احضارها من منطقة جرف الملح في محافظة ديالى وذلك بخلطها مع بعض المخلفات من المسامير الحديديه الموزعه عشوائياً، حيث ان هذه المواد يمكن توفيرها بسهوله والاستفاده منها لغرض تسليح التربه بدل اعادة تدويرها . حيث تم استخدام ثلاث اطوال مختلفه(Ln) تم اعتمادها نسبة لعرض الاساس(B) وهي (Ln/B=11%,14.2% , 21.4%)، حيث تم اجراء فحوصات الهبوط لاساس مصغر مع الزمن، في الحالتين الجافه والرطبه، على نماذج معالجه و غير معالجه بهذه التقنيه بلستخدام موديل مختبري تم تصنيعه محلياً. واظهرت النتائج نسبة تحسين 27% على انهيارية هذه التربه.

تتضمن الدراسه ايضاً تاثير خلط التربه الملحيه ببعض المضافات وهي مادة النوره وبنسبتين مختلفتين (1.5% و 3%). و مادة الاسمنت بنسبتين (2% و 5%) مع التسليح بمخلفات المسامير الحديديه الموزعه عشوائياً، ومقارنتها بنموذج غير معالج . وكانت احسن معالجه باستخدام السمنت بنسبة 5% وخلطها مع التربة ،بالاضافة الى استخدام المخلفات الحديديه للمسامير بنسبة (Ln/B=,14.2%) . حيث تم تقليل الانهياريه لنسبة تصل الى90%. وهي نسبة جيده.

احسن المعالجات التي تم استخدامها في هذه الدراسه ، هي بخلط التربه الملحيه بمادة البينتونايت الطبيعيه والمتوفره، وبنسبتين مختلفتين (5% و 10%). حيث اظهرت النتائج التي اجريت على الموديل المختبري . ان 10% من مادة البينتونايت المخلوط بالتربه الملحيه، قلل الانهياريه بنسبه 97% ،عند ترطيب هذه التربه بالماء. والتي تعتبر المعالجة المثلى لهذا النوع من الترب.

مفلتيح لكلمات: التربة الملحية،السبخة،المعالجة بالبينتونايت،الاسمنت، النوره، تثبيت التربه.

1-Introduction:

Different types of structures have been built and number of airfield and highway network have been constructed in Iraq due to the vast development that took place during the last two decades. New patterns and forms of failure started to raise and geotechnical and structural engineers have to accept this challenge and provide safety measures and remedies. One of these problems is the presence of saline soils that covers 15% of the surface sediments soil of Iraq which containing gypsum salts between (2-20) percent, Levy, y.(1977)[1,3,4].

Saline soil covers about 30% of the world area such as Saudi Arabia ,north Africa ,Mexico ,Australia, Iraq and other countries, Abu-Taleb, M.G.and Egeli,I. (1981) [2,5].

Continental or inland sabkha or saline soil is composed from hydrated gypsum minerals $CaSO4.2H2O$, $Sio2$, calcite $CaCO3$ or $NaCL$ food salt, which covers land surface. When the water table level is raised up because of capillary action and heating of the ground and the salinity of water increase for these soils to the degree of sedimenting of these types of salts because of water evaporation so the water table plays an essential way to the presence of saline soil [2,6].

There are many factors affecting the presence of saline soil: Climatic factors. Chemical composition, geomorphological factors. And hydrological factors[7].

The construction of buildings, roads, bridges, channels, harbors and railways in such problematic collapsable soil has an always been associated with settlement associated with water infiltrates inside these soils [6].

Researchers at different institutes carried out a lengthy testing program in an attempt to understand the geotechnical properties of such problematic soils, and proposed solution for existing problems. Under these circumstances some vogue remedial proposals were, made. Some are chemical, by adding lime sodium silicate or oil product. The others are physical by compaction or soil reinforcement [8].

Mohamedzein et al (2011) [9] studied the possibility of using cement as an additive, and its effect on the shear strength of sabkha soils and. The soil used in this study is a sandy sabkha obtained from the coastal plains at Al-Auzayba, Sultanate of Oman. Cement was added in percentages of 2.5, 5, 7.5 and 10%, by dry weight of soil. The soil-stabilizer mixers were allowed to cure for 7, 14 and 28 days. Laboratory tests such as compaction, unconfined compression, consolidated undrained triaxial and durability tests were performed to measure the engineering characteristics of the stabilized material. The results showed substantial improvements in the shear strength of the sabkha--cement mixtures and the mixtures are also durable with small weight loss after 12 wetting/drying cycles. Thus, cement can be used to improve the shear strength of sabkha soils. Furthermore, the effective stress path and the tress-strain relation of the sabkha--cement mixtures follow trends similar to those of cemented calcareous soils.

Ziaie M. et al (2011)[10], investigated the feasibility of, lime as a stabilization material, and it is economic for the most geotechnical projects. And they showed that the usage of polymer is suggested only in special applications due to its rapid setting.

Bin-Shafique et al (2010)[11] , presented An experimental study, which was conducted to investigate the long-term performance of fly ash stabilized two fine-grained soil subbases. One low plasticity clay soil and one high plasticity expansive clay soil were stabilized with a Class C fly ash with fly ash contents of 0%, 5%, 10%, and 20%, and compacted statically at the maximum dry density (standard Proctor) and at the optimum moisture content of the corresponding soil to prepare ten sets of replicates from each of the combinations. He shows that, After curing all specimens for 7 days, the first set was subjected to plasticity index tests, unconfined compression tests, and vertical swell tests to estimate the improvement due to stabilization. Similar tests were also conducted on another nine sets of replicates in which six sets were subjected to 12 wet-dry cycles (three sets with tap water and the other three sets with saline water), and the other three sets were subjected to 12 freeze-thaw cycles in a laboratory controlled environment to simulate the weathering action. The effect of wet-dry cycles on stabilized soils was essentially insignificant; however, the fly ash stabilized soils lost up to 40% of the strength due to freeze-thaw cycles. He concluded that, Even after losing the strength significantly, the strength of stabilized soils was at least three times higher than that of the unstabilized soils. And the swell potential of stabilized expansive soils also increased due to freeze-thaw cycles. The vertical swell increases rapidly for first four to five cycles and then increases very slowly.

Krishnaiah and Suryanarayana (2008)[12], showed that the addition of 3% of cement, gives a considerable strength for stabilization of soils when mixing with it. Above and below this range, the strength will be less. And shows that, the silica content in cement, over 5% percent, may contribute with the strength and give fewer results.

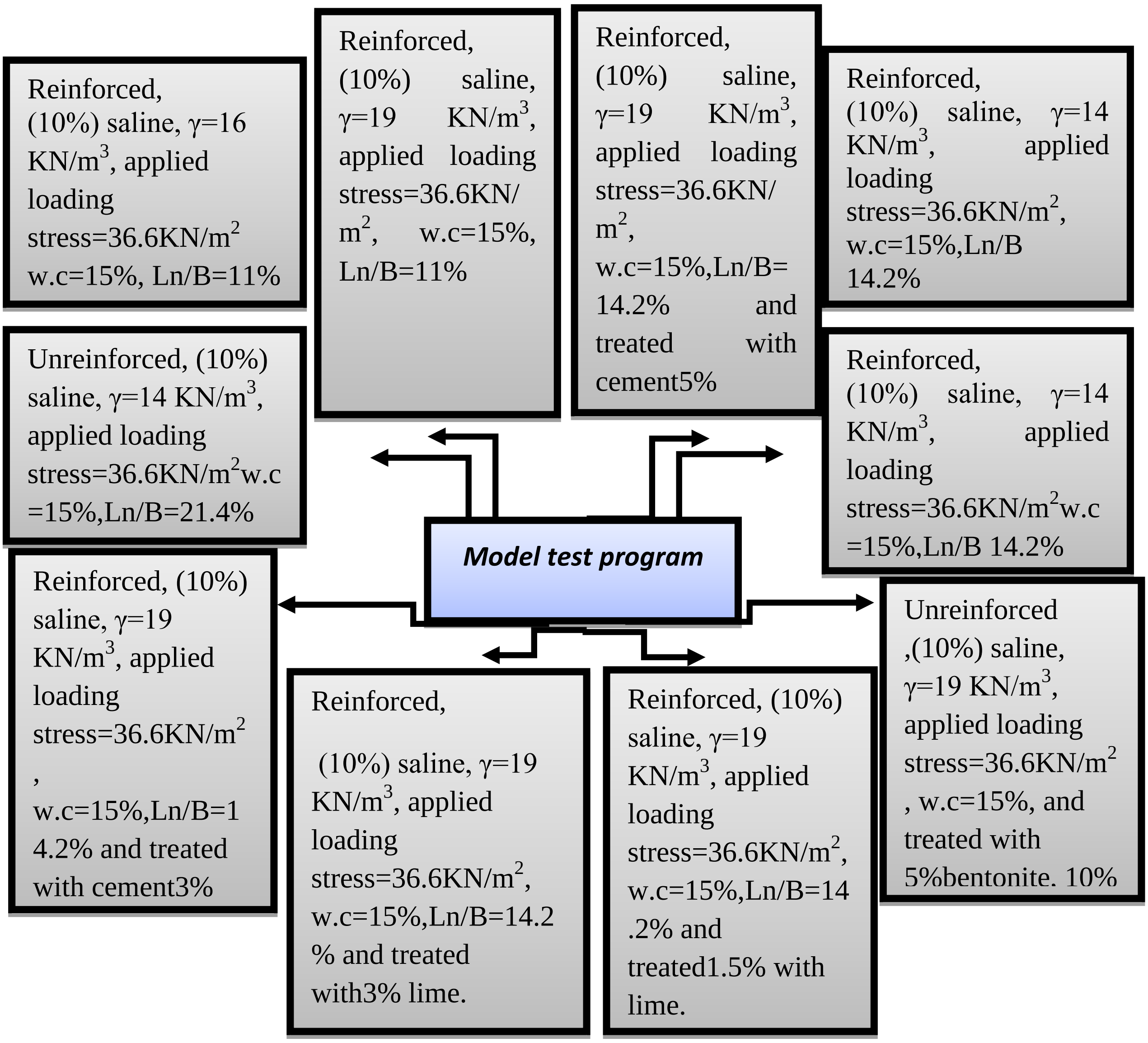
The present work is based on monitoring the behavior of moderate scale laboratory model footings constructed on natural saline problematic soil. Some models were supported on unreinforced soil and the others on soil reinforced with randomly distributed steel nails reinforcement with different lengths (Ln) related to width of footing(B) (LN/B= 11%,14.2%and21.4%). The idea behind such material is to improve the collapsibility generated from wetting saline soil with water, which causes high dissolution of salt particles inside soil skeleton. The author believe that reinforcing such problematic soil with randomly distributed nail reinforcement, with the addition of some additives, may compensates the reduction in volume change upon wetting of such problematic soil and. So reducing structural damages causes from the collapse problem of such soil. The effect of three additives (cement, lime and Bentonite) with different percentages, with and without reinforcement, and its effect on the collapsibility of saline soil, were investigated thoroughly during this experimental study.

2-Purpose of study:

The main objective of this study is to investigate the feasibility of using three patterns of randomly distributed nails reinforces and its effect on the collapse behavior of natural saline soil. The study covers the effect of length of reinforcement on the compressibility of collapsible problematic soils during dry and wetting test, and the effect of three additives, Bentonite, Cement and Lime with different percentages on the collapsibility of such soil, with and without randomly distributed nail reinforcement. To arrive to such conclusions, more than 12 laboratory models, were conducted and monitored under same conditions (W.C=1.5%, soil density=14KN/m3 ,σ=36.6KN/m3, salinity content for soil=10%.

3-Experimental work:

The experimental work consists of performing laboratory model tests; to investigate the feasibility of using random distribution nail reinforcement with three additives: Bentonite, Cement and Lime with different percentages and its effect on the collapsibility of natural saline soil. The results of reinforced models were compared with unreinforced model. In order to show the improvement of such technique. The work includes also, the effect of chemical additives with and without reinforcement, on the collapsibility of natural saline soil, by mixing it with different percentages of three available additives (Bentonite, lime and cement). The testing program is shown in **figure (1).**



Fig(1): Testing program flowchart

3-1 Soil used.

The soil used was natural one, brought from a region near Jurf Al-Milih region, in Diyala governorate in which this region famous of highly salt content. The ground surface in this region is widely covers with natural NaCl salts, which is used as cooking salt.

The samples of soil was extruded from the ground surface at 1m depth, it is sandy soil with (10%) salt content. The soil was oven dried, pulverized placed at the oven at 50°C for 24 hours. The soil was sieved through sieve no.4 to separate large soil practically. The grain size distribution was preformed according to ASTM 422-79 the natural soil was wet sieved through NO. 200 (0.075mm) sieve, then the sample was oven dried at (65-75°C), then sieve analysis was carried out by a set of sieves. Since the soil is sandy, there is no liquid or plastic limit in sand. And it is classified as (SP), poorly graded sand. As shown in figure **(2).** The moisture content was determined at dry temperature of (65-75°C) to prevent any loss of crystal water above this temperature, Nashat and Al-Mufty 2000[13].

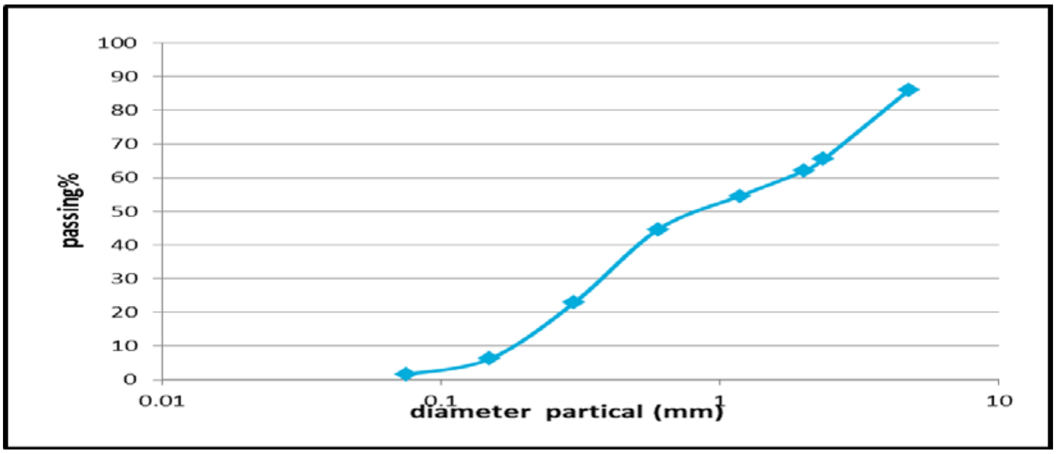


Fig (2) grain size distribution curve for soil used.

3-1-1 Compaction test:

This test was performed according to BS 137775 NO.12 and 13 Head 1980[16], to find the moisture-density relation of the soil under the specification of proctor compaction test, the apparatus and energy. The soil was oven dried at (40-50°C) and sieved on (20mm) sieve before the tests were conducted as shown in **table (1)** and **figure (3)**

Table (1) results of compaction test for the saline soil used in the study.

γ wet(KN/m^3)	W.C (%)	γ dry (KN/m^3)
14	15%	12.2

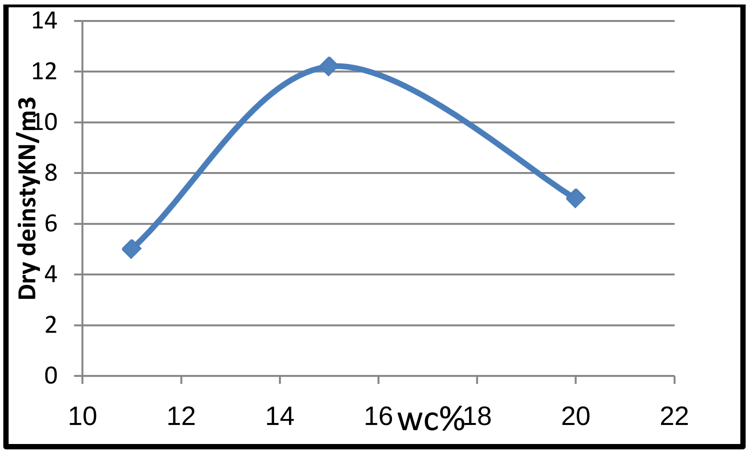


Fig (3) compaction test for soil used.

3-2 Soil reinforcement used in the study:

Stainless steel nails, with different lengths as reinforcement materials to stabilize the coolapsible saline soil during wetting with water. The length of reinforcement "Ln" was taken relative to footing width"B". Three different (Ln/B) of randomly distributed nail reinforcement, (LN/B= 11%,14.2%and21.4%), was chosen to show the efficiency of this technique on the collapsibility problem of such highly content saline soil.

3-3 Chemical additives used in the study:

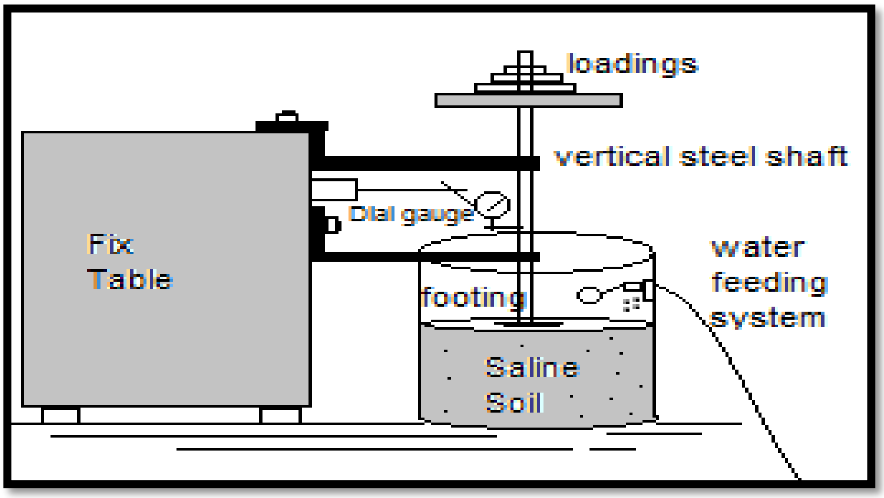
Three additives were used to improve the collapsibility of saline soil,(Bentonite, Cement and Lime).

Bentonite is pure natural and available material. One of its properties is that, when wetted with water, its volume expands about 15times[14], compared to natural size. It is expected that, using this un-expansive material may work as a balance agent to minimize the collapse of the saline soil upon wetting with water, so it may prevent the damages for structures constructed on. Cement or lime, are common materials used to stabilize soils and very effective to stabilize gypseous soils. it works as a cementing agent between soil particles when mixed with soils. The best and most economic percent is 3%[15]. In this study the author investigate the effect of these materials with and without reinforcement, on the saline soil.

3-4 Model Preparation and test criterion:

The laboratory model consists of thick plastic cylindrical container with (265mm diameter and 340mm height). The natural saline soil was divided in to three parts in the plastic container each part of soil was compacted to the required height. To ensure good compaction homogeneous layer with soil density =14 kN/m^3. This process continued with the second and third soil parts. After compaction of the last soil layer the soils surface is leveled with as steel knife edge. The rectangular footing (4.8cm*6.5cm) made of stainless steel was placed at the center of soil sample.

16 Model were prepared for testing. The laboratory model consist includes also the loading control system, which consist of vertical steel shaft of high stiffness, welded to upper and lower thick plates this shaft designed to applying vertical concentrated load to the footing. The shaft is held to a fix heavy table to ensure dis overturning of the loading system. A plate was welded at the lower portion. To place the dial gage for settlement measuring, with time. The dial gage was held by a magnetic field holder, stuck to the steel table. All the instruments and manufacturing steps for the steel control system for stress are shown in **figure (4)** and **(5).**



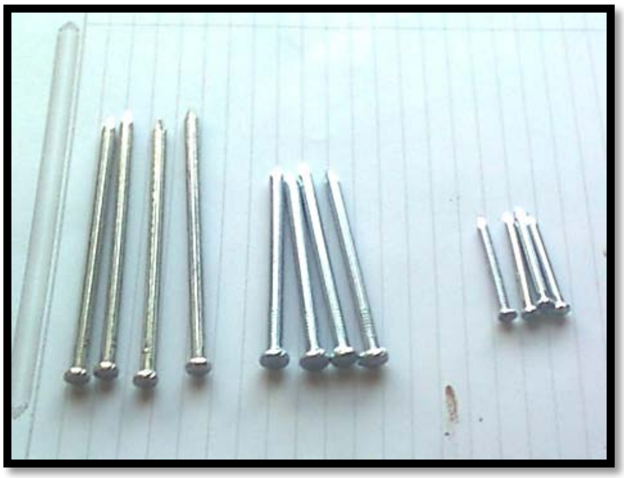
Fig(4): diagram of loading frame and model preparation steps

Fig (5) : A picture for the manufactured laboratory model and the fix loading system, used in the study.

For all tests the soil density used is 14 kN/m^3. The applied axial stress used was reached to 35kPa. This level of stress was chosen because, above this value, sudden collapse of footing occurred at water soaking test for the soil at the condition of 10% salinity, because of high dissolution rate of salts inside soil, which result to weakening the soil holding footing, and so failure of structure occur.   The settlement of footing was recorded with time for all improved or unimproved samples.

3-4-1 Preparation of Reinforced soil Model.

The first model was prepared without the addition of nail reinforced for comparison. The other reinforced soil models was prepared by mixing the natural saline soil with 5% by weight of stainless steel nails as reinforcement to stabilize such collapsible soil. The first model is reinforced with (Ln/B=11%) reinforced the second in reinforced with (Ln/B=14.2%), the third was reinforced with (Ln/B=21.4%), the nail length (Ln) was related to footing width (B), to simulate the model scale to the real one. The reinforcement used in this study is shown in **figure (6).**



Fig(6): Steel (nail) reinforcement with different lengths related to footing width (Ln/B=11%,14.2%,21.4%) used to stabilize saline soil.

4-Results and Discussion:

4-1 Introduction

Saline or Sabkha is one of problematic soil. It is not less dangerous than Gypseous soil. The solubility of natural (NaCL) Salt is more than the solubility of other salts.

In this study, the behavior of such collapsible soil was investigated at dry and wet condition. The footing is stable and not suffering any serious settlement as can be seen from **Fig (7)** especially at the first (1400min). At the first moment of wetting soil, the problem of collapse appears because of highly dissolution of salt inside the soil, and the bond between particles weaken and the effective stress will decrease. This process causes a reduction in the bearing capacity of soil and the sample was failed as can be seen in **Fig (7)**. The value S/B% at the end of test reached (76%). when simulating the model to the real case for footing with (2m) depth. The collapse settlement results from this soil. Reaches (150mm) which may causing severe damages for building constructing on it.

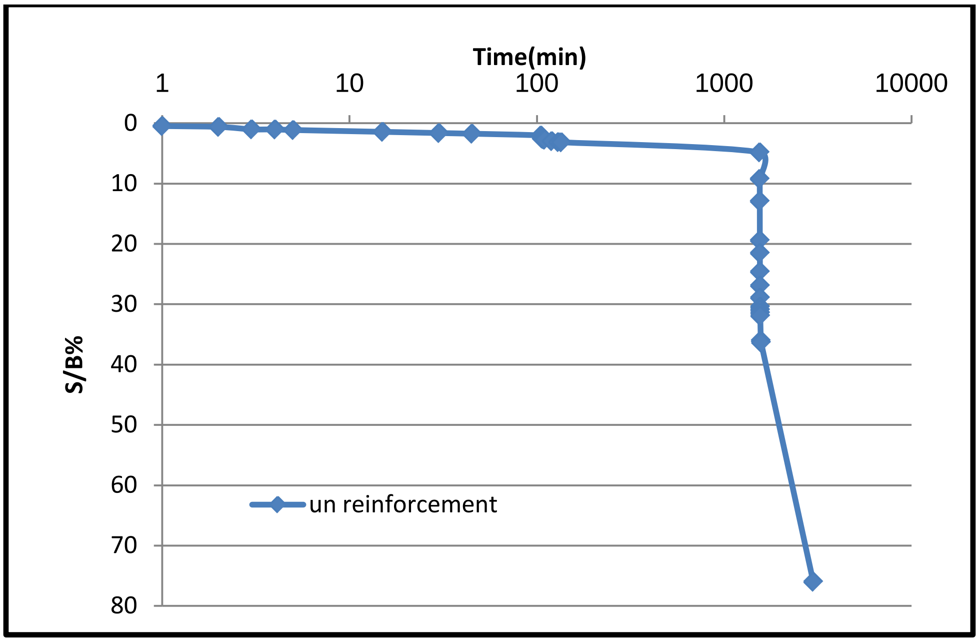


Fig (7) Time-S/B relation for unreinforced model with10% Saline soil, applied stress=36.6KN/m^3),γ=14KN/m^3 w.c=15%

The need was appears to improve such soil. Since large Iraqi areas were covered by such problematic soils, since the salinity in some north regions of Iraq, reaches more than 10% and this considers as serious problem.

In this study the anther tries to reduce S/B% to a reasonable values. Which make the structure constructing on this soil, safe. The model of saline soil with (10%) salinity and soil density (14KN/m^3) with axially loaded rectangular footing was chosen for comparison with other models tested at the same conditions. The indication of improvement is the reduction of S/B% (settlement of footing /footing width).

4-2 Improvement of Saline Soil by randomly distributed nail reinforcement:

Figures (8),(9), (10) shows the relation between S/B% with time for reinforced saline soil with 10% salinity with relative density =14KN/m^3 for soil subjected to axially loaded by rectangular footing with different Ln/B nail reinforced, compared with unreinforced model (7) tested at the same conditions. The Ln/B% (length of nail /width of footing)*100 was chosen as a simulation of the model test, related to the natural case in the silt to investigate the feasibility of nail reinforcement as a physical improvement, and compared it with the unreinforced model.

The value of S/B% is reduced from 76% for unreinforced model to 68% for reinforced model with Ln/B=11%. So the S/B% value reduces to 10%. While the reduction in S/B% is (20%) for the reinforced saline soil model with Ln/B=14.2%.

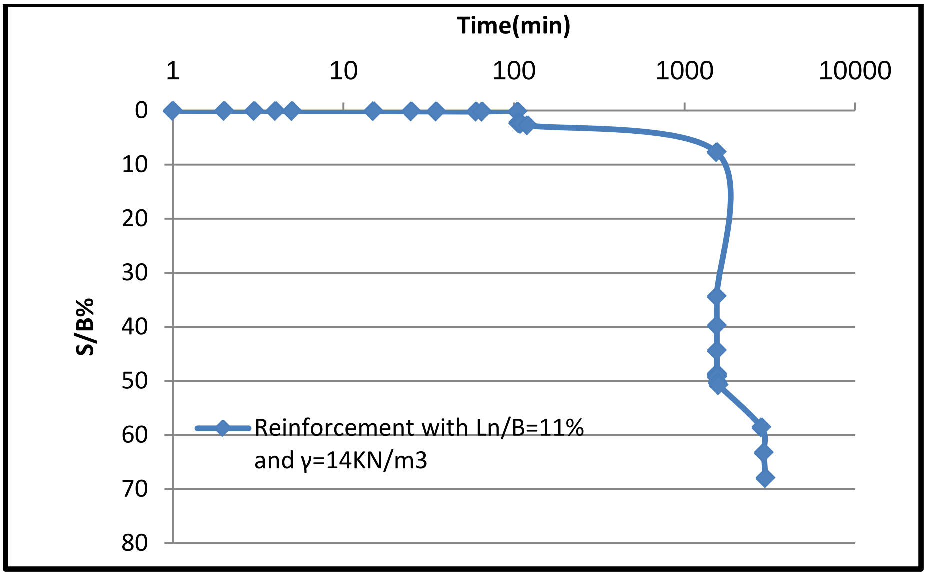


Fig (8) Time-S/B relation for reinforced model. With 10% Saline soil applied stress=36.6KN/m^3) Ln/B=11%,γ=14KN/m^3'w.c=15%

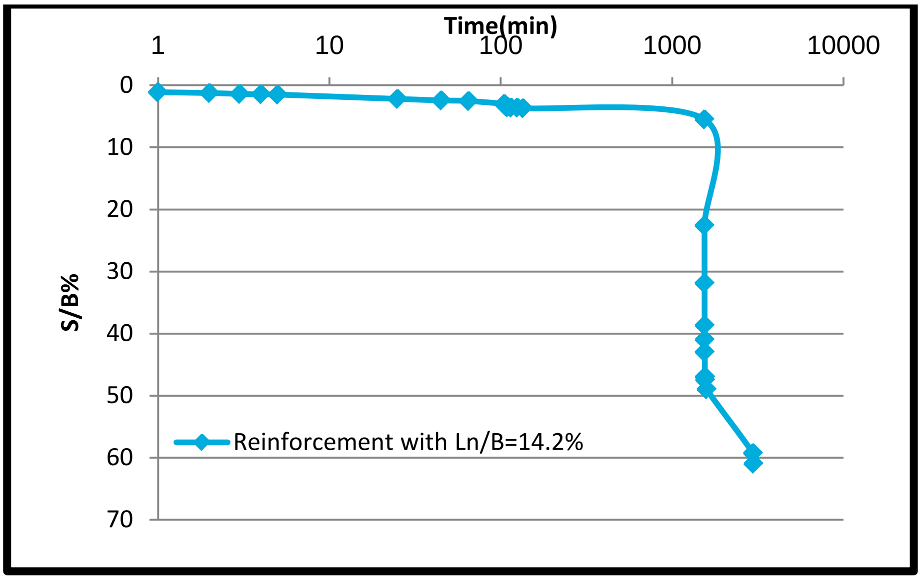


Fig (9) Time-S/B relation for reinforced model.With10% Saline soil applied stress=36.6KN/m^3),γ=14KN/m^3 Ln/B=14.2% and w.c=15%

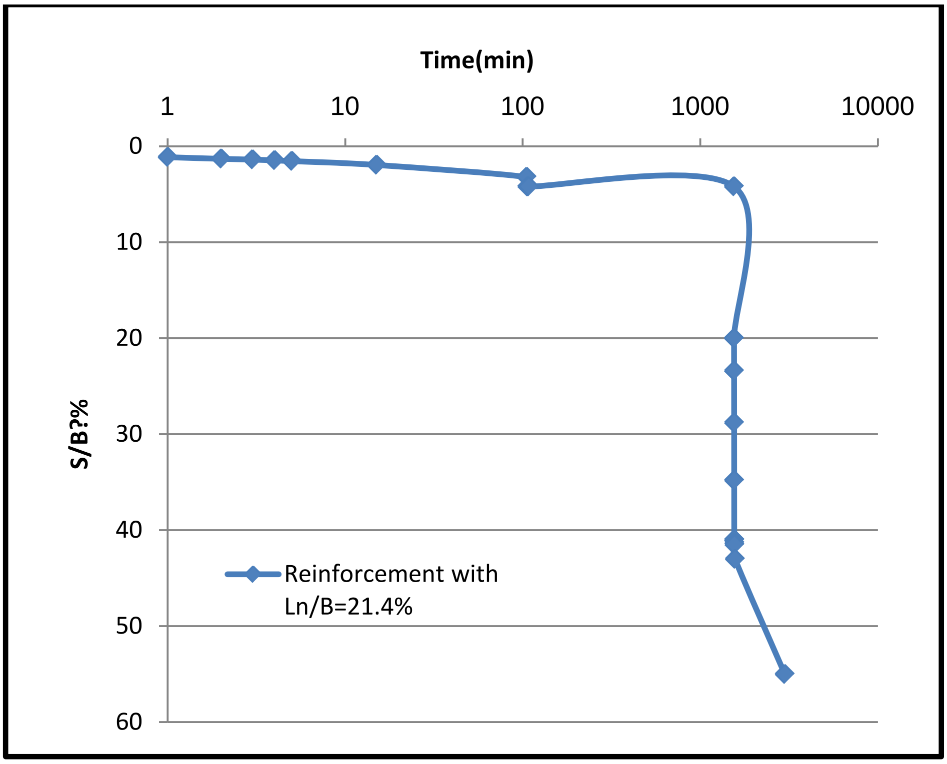


Fig (10) Time-S/B relation for reinforced model. With 10% Saline soil applied stress=36.6KN/m^3) Ln/B=21.4%, γ=14KN/m^3, w.c=15%

The best improvement using the Neil reinforcement was obtained when reinforcing saline soil with Ln/B=21.4% which reduce the S/B% value (27%) as shown in **figure (10).**

Table (2) shows the effect of soil reinforcement using different lengths of steel Neil, on the collapsibility of saline soil.

Table (2): effect of randomly distributed nail reinforcement on the reduction percent in S/B% value

improvement	***Ln/B=0***	***Ln/B=11%***	***Ln/B=14.2%***	***Ln/B=21.4%***
Reduction in S/B%	0	10%	20%	27%

A monograph in **figure(11)** shows the improvement percent in saline soil gained at the end of wetting saline soil model sample, using different Ln/B% randomly distrusted nail reinforced, with keeping all variables (10%salinty, γ=14KN/m^3 and vertical stress=36.6 KN/m^2), during testing of models.

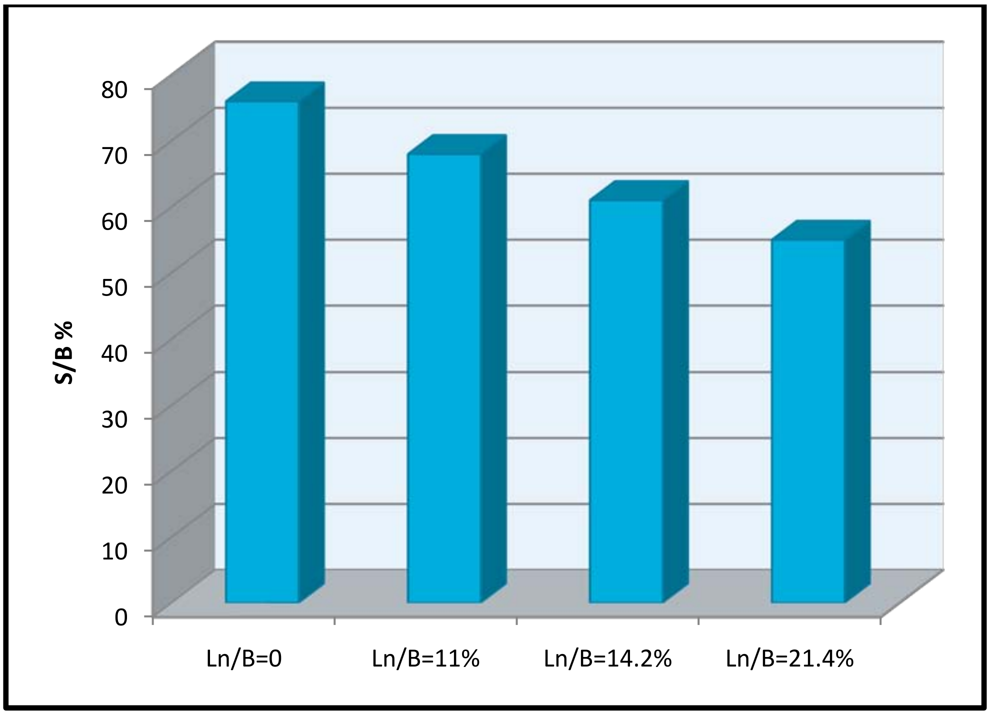


Fig (11) Improve of saline soil by randomly distribution nails reinforcement

The results of all laboratory model reinforced with different randomly distributed nail reinforced Ln/B= (11%, 14.2% and 21.4%) with an unreinforced as a referred are shown in **fig (12).**

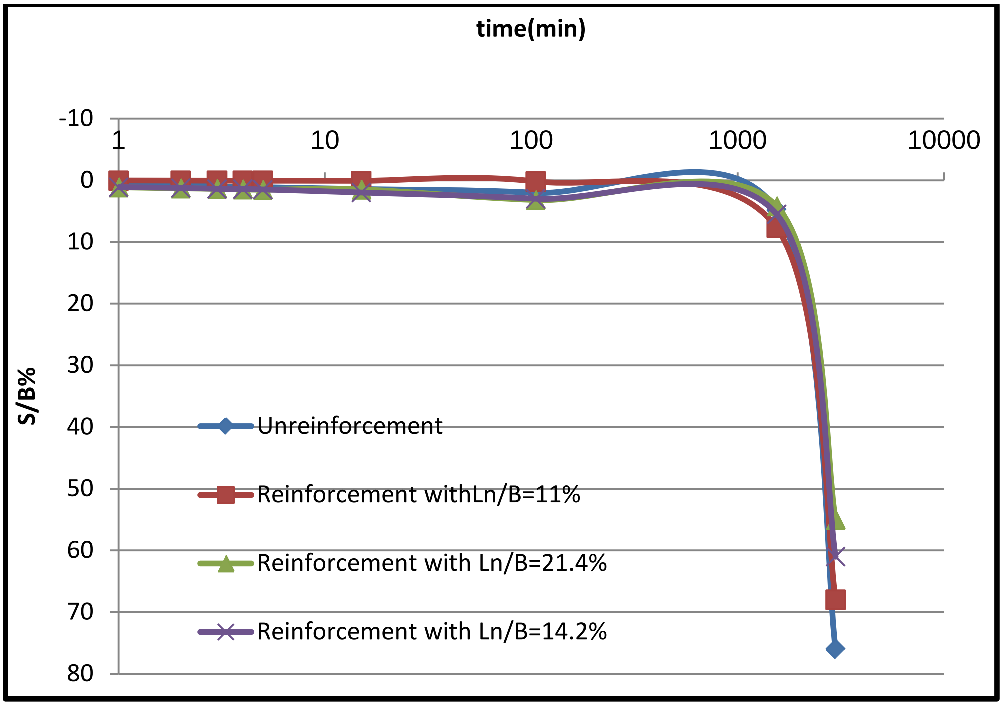


Fig (12) Treatment of saline soil by physical treatment (Ln/B=11%, 14.2% and 21.4%), γ=14KN/m^3, w.c=15%and stress=36.6KN/m^3

4-3 Improvement of saline soil by randomly distributed nail reinforcement, with compaction:

Fig(8),(13),(14) shows time-settlment relationship, of three laboratory models tests treated by one type of randomly distributed nail reinforced, and compacted to different densities (γ=14KN/m^3,γ=16KN/m^3,γ=19KN/m^3). The reinforced models are compared with the unreinforced model, **fig (7)** as a reference.

The results of laboratory model tests shows a pronounce effect of compaction of saline soil, with reinforced, in reducing the collapsibility of saline soil when subjecting to water. When saline soil is compacted; the soil particles would fill the air voids between the saline particles and increase the effective stress. When the soil mass subjected to wetting from any source and compacted. The water fluctuation or infiltration through soil particles, may be reduces because of soil compaction since there is less air voids, and as we compact the saline soil more, the air voids will be less. In addition to that, the steel nail reinforcement may work as a bond and bridge between soil particles and will increase frictional resistance between soil particles, more for compacted saline soil specimen. **Fig (15**) shows the results of laboratory model tests for saline soil improved by randomly distributed nail reinforced (Ln/B=11%) with compaction. at soil densities (γ=14KN/m^3, γ=16KN/m^3, γ=19KN/m^3).

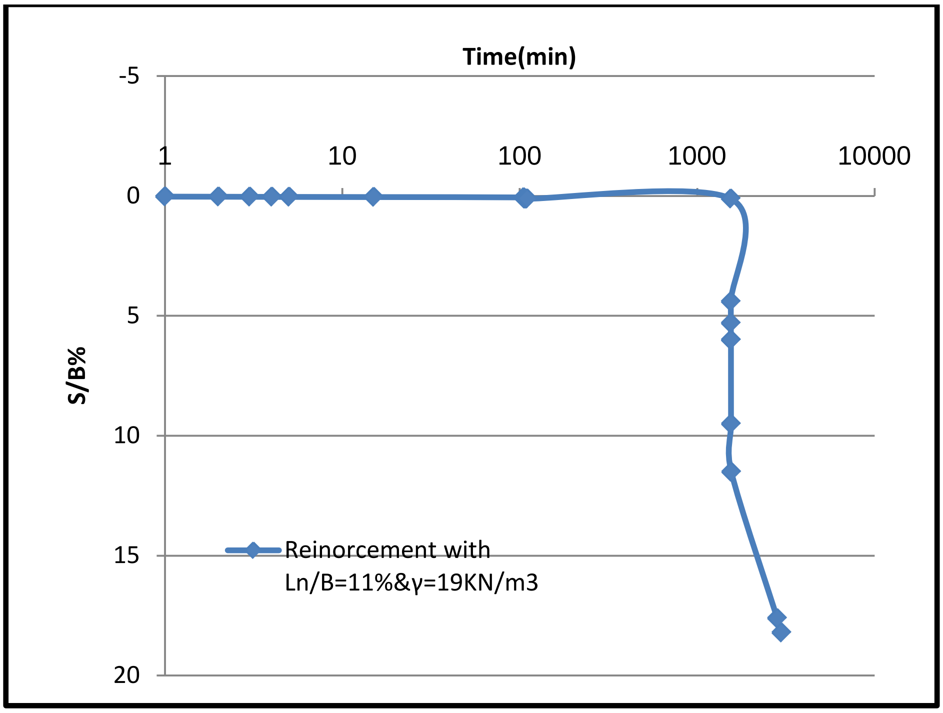


Fig (13) Time-S/B relation for reinforced model. With 10% Saline soil applied stress=36.6KN/m^3&γ=19KN/m^3

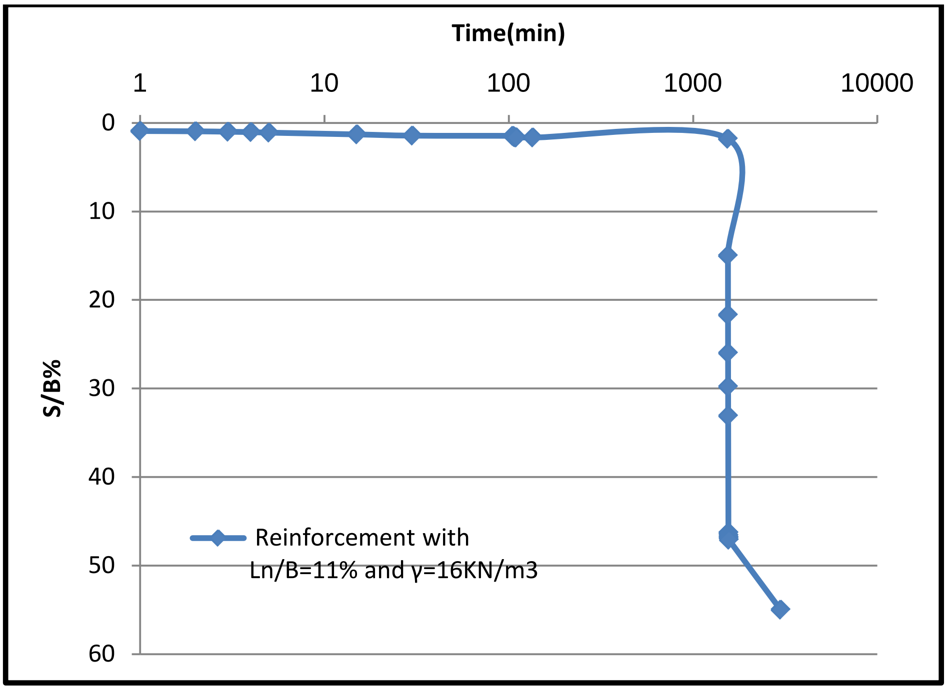


Fig (14) Time-S/B relation for reinforced model. 10% Saline soil applied stress=36.6KN/m^3) Ln/B=11%, γ=16KN/m^3 w.c=15%

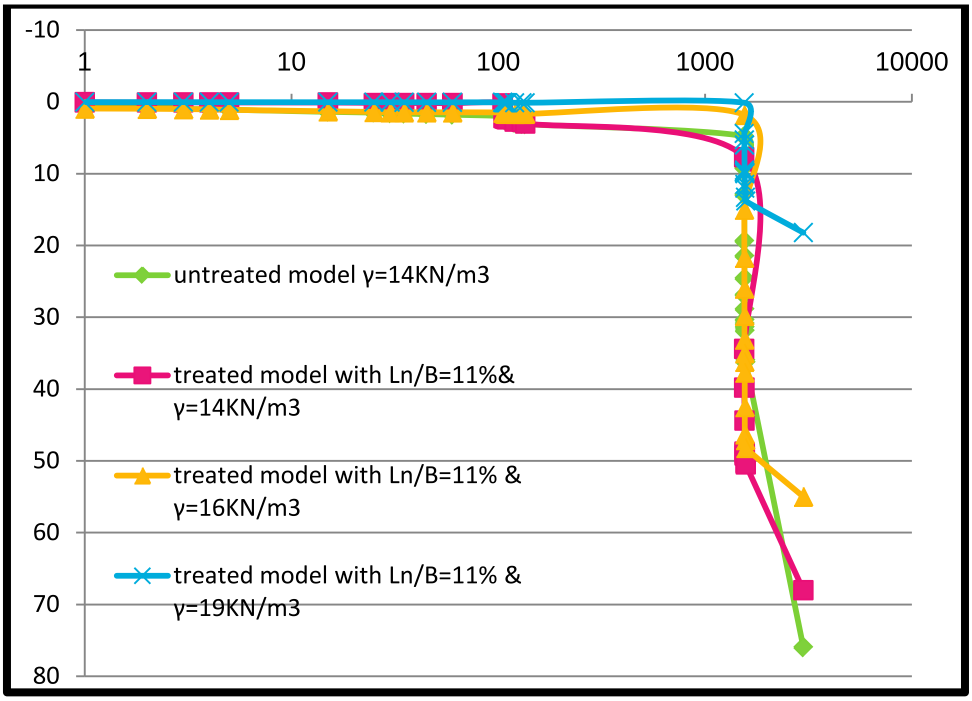


Fig (15) Treatment of saline soil with different density by physical treatment (Ln/B=11%) , compacted with different soil densities 14, 16 and 19 kN/m3.

Figure (15) shows the effect of reinforcement of saline soil with compaction on the collapse behavior of saline soil upon feeding this soil with water. The use of (Ln/B=11%) of nail reinforcement, with compacting saline soil to 14kN/m^3 , reduced the S/B% value to

(10%), compared with the unreinforced model. While the reduction percent in S/B% value, for the model compacted to 16kN/m^3 and 19kN/m^3, are (28%), and (75%) respectively. using the same reinforcement type.

Figure (16) shows a monograph for the untreated and treated saline soil models by (Ln/B=11%) randomly distributed nail reinforced compacted with three limits (γ=14KN/m^3, γ=16KN/m^3, γ=19KN/m^3).

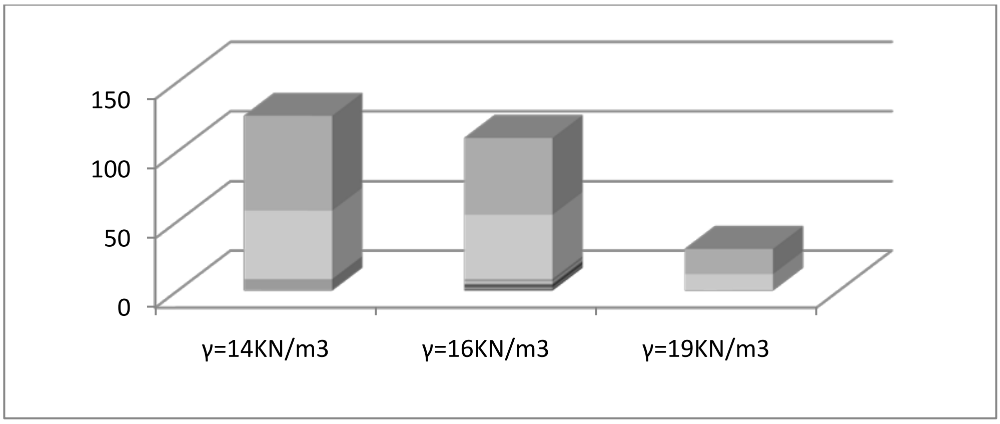


Fig (16): Monograph of the effect of compaction of saline soil and reinforcement with (Ln/B=11%)

4-4 Treatment of Saline Soil by Chemical additives:

Figures (17) to **(20)** shows the time-S/B% relation for treated saline soil with different chemical additives. The author was chosen (3) available additives (lime, cement and bentonite). The results of treated models are compared with the untreated one.

Figures (19) and **(20)** shows the effect of cement addition with two percentages (3%) and (5%), on S/B% value. The reduction percent in S/B% gained after mixing saline soil with chemical additives using Ln/B=11% of nail reinforcement, are (71%) and (93%) respectively, for models tested on the same conditions (γ=14KN/m^3, 10% salinity, σv= 36.6KN/m^3) and during wetting soil with water.

It can be recognize from **figures (17)** and **(18),** that, the addition of (3% lime) to saline soil as a stabilizer, would increase the S/B% to 82%, compared to the untreated one which gives, S/B%=76% and this lime percent weaken the soil. On the other hand, the model treated with (1.5%) lime, the (S/B % value decreased to 70%), which gave a reduction percent in S/B% value of (8%), compared with the untreated one. Which is Neil compared with other treatment techniques used in this study.

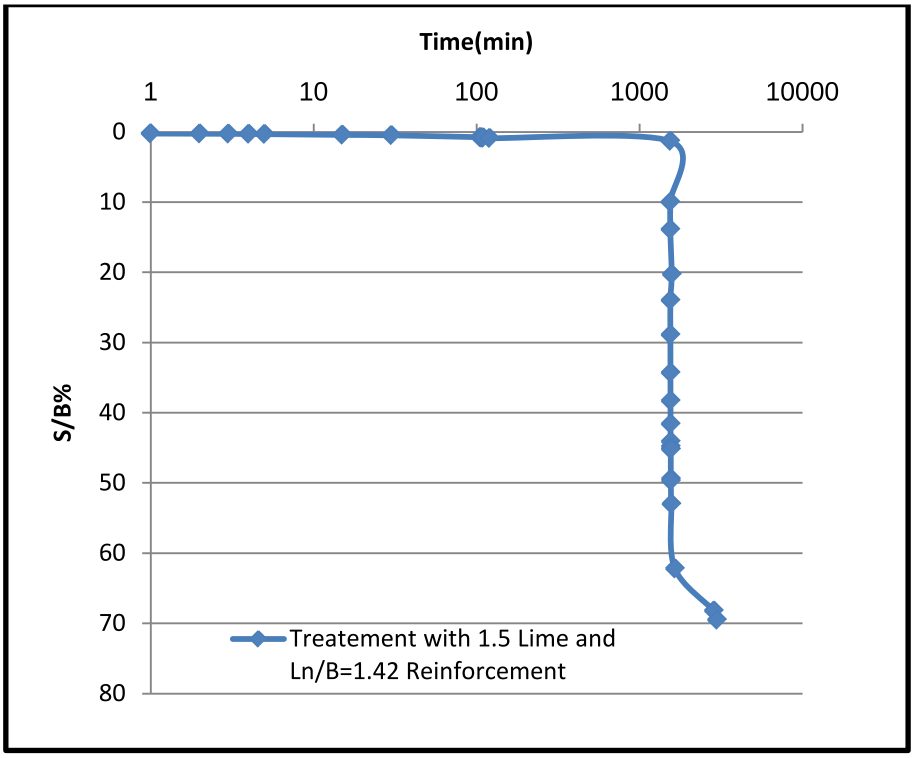


Fig (17) Time-S/B relation for reinforced model. Saline soil 10%, applied stress=36.6KN/m^3) Ln/B=14.2%, γ=14KN/ (lime 15%) and w.c= 15%

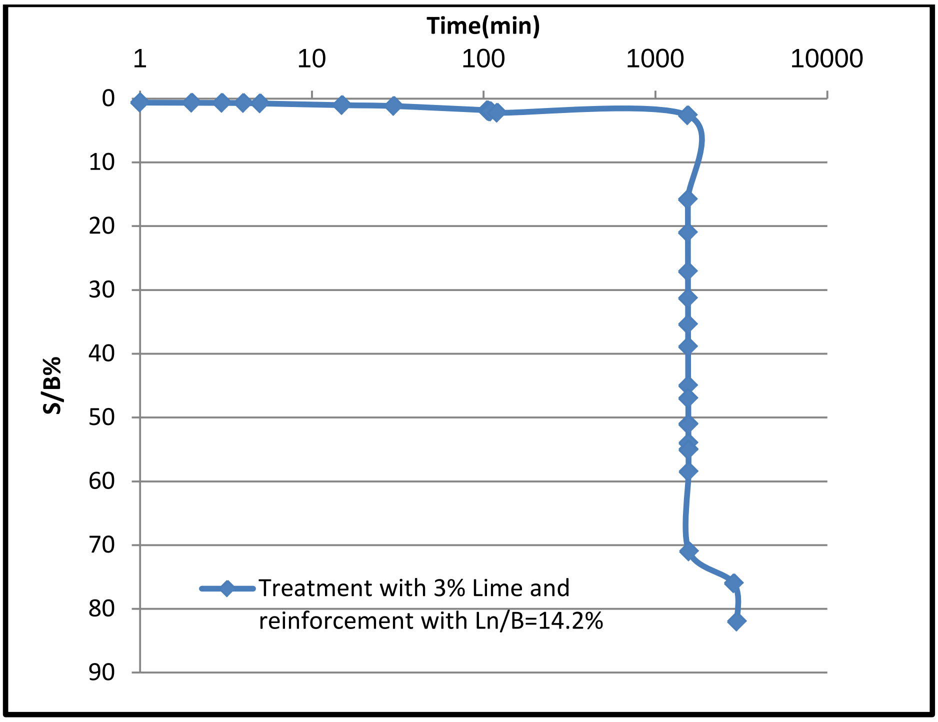


Fig (18) time-S/B relation for reinforced model. With 10% Saline soil, applied stress=36.6KN/m^3) Ln/B=14.2%, γ=14KN/m^3 (lime3%) and w.c=15%

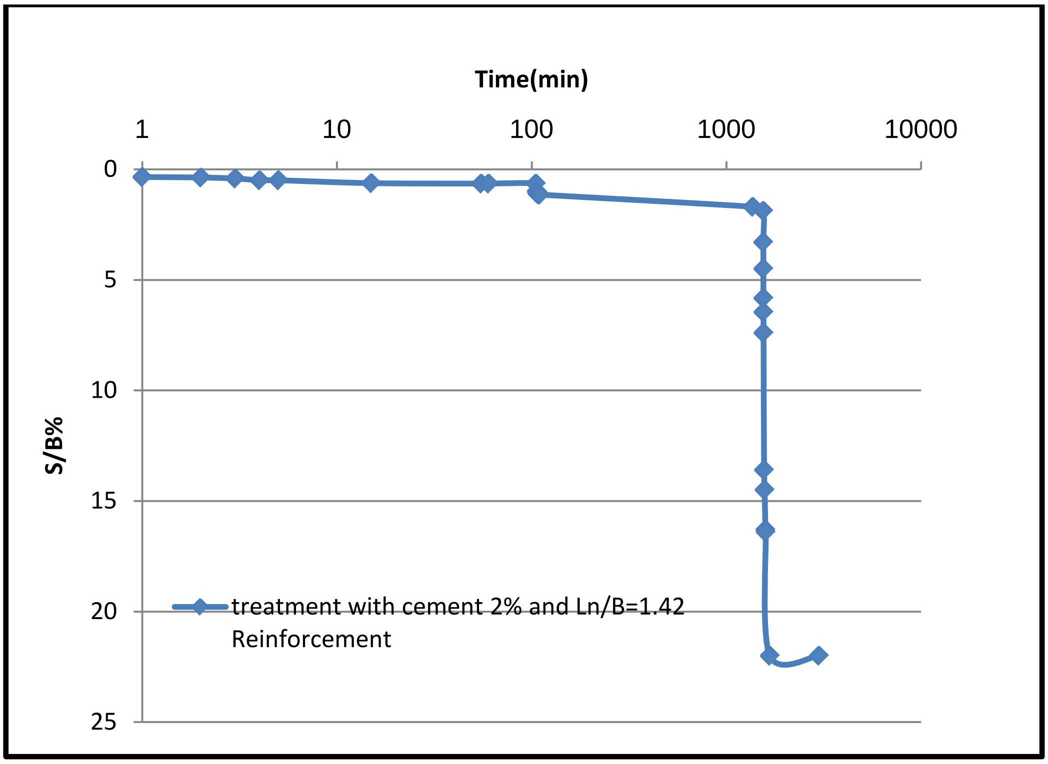


Fig (19) Time-S/B relation for reinforced model. Saline soil 10%, applied stress=36.6KN/m^3) Ln/B=14.2%, γ=14KN/m^3 (cement2%) and w.c=15%

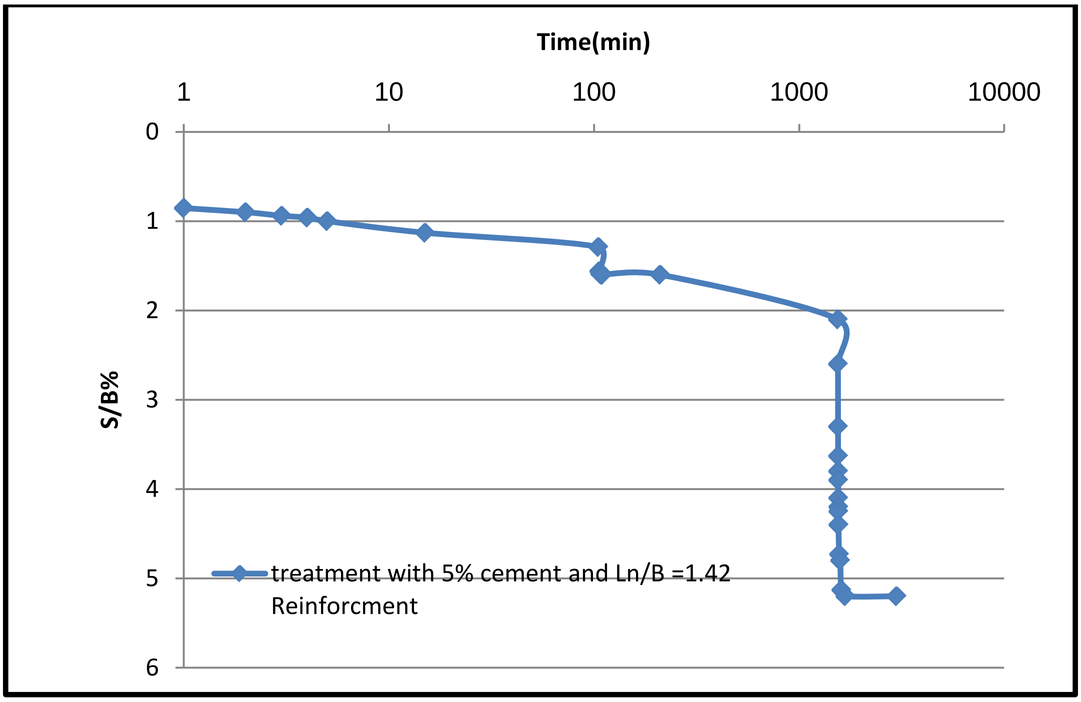


Fig (20) Time-S/B relation for reinforced model.10% Saline soil applied stress=36.6KN/m^3) Ln/B=14.2%,γ=14KN/m^3 (cement5%) and w.c=15%

Fig (21) shows the effect of chemical additives (cement, lime) with Nail reinforcement, on collapsibility of saline soil with keeping all test conditions (γ=14KN/m^3, 10% salinity ,vertical stress =36.6KN/m^2) the same for all models test.

Fig (22) shows a monograph illustrate the improvement of saline soil by two chemical additives (cement, lime).

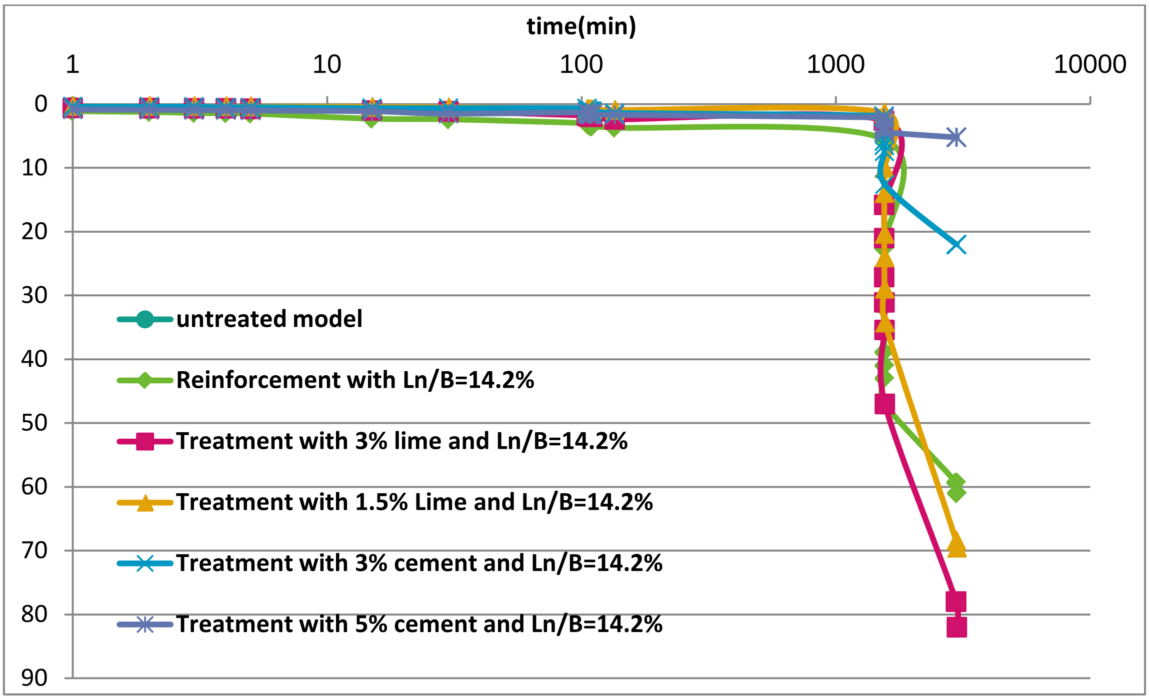


Fig (21) Treatment saline soil by chemical and physical treatment, (γ=14KN/m^3, w.c=15% and Ln/B=14.2%)

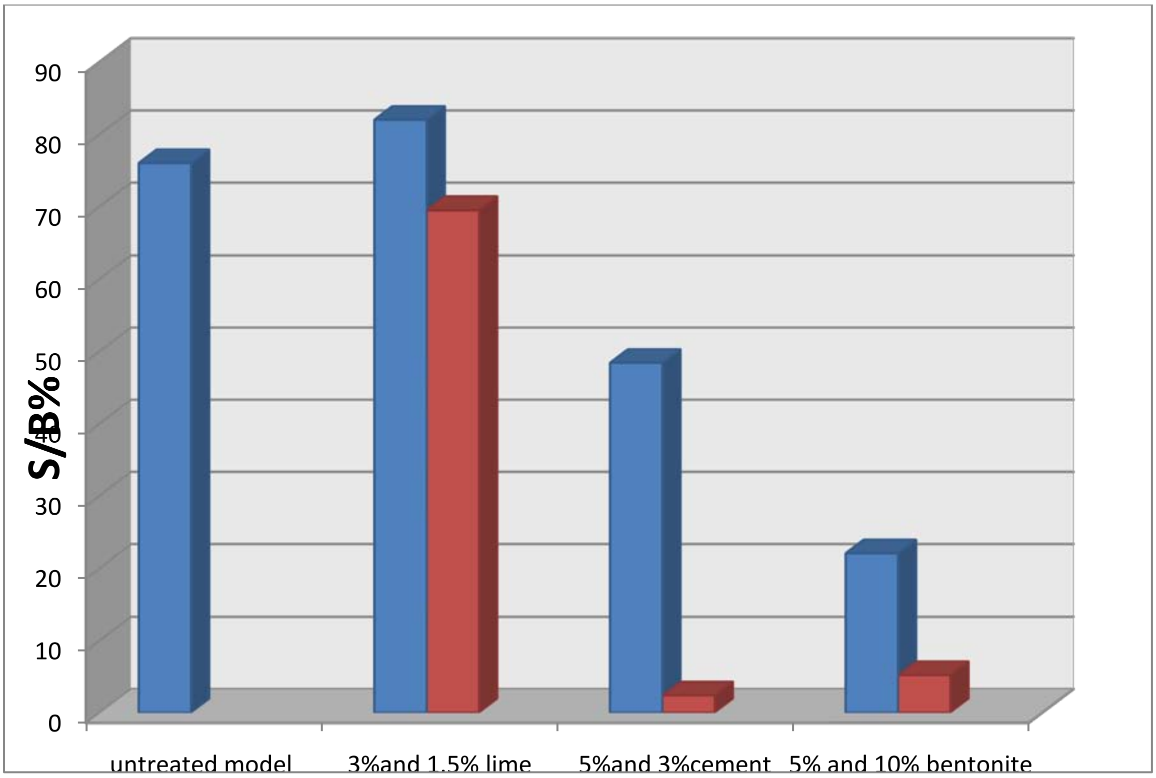


Fig (22): Effect of chemical additives with reinforced on collapsibility of saline soil (γ=14KN/m^3,10% salinity and stress effect=36.6KN/m^2

4-4-1 Effect of Bentonite on the Collapsibility of Saline Soil:

Fig (23) shows time-S/B% relation. For treated saline soil with (5%) and (10%) Bentonite and compared with the untreated saline soil model.

Bentonite swells when water fluctuates through its particles because of the Montmorilonite minerals which formes this soil. It became problematic when wetted with water because of swelling. On the other hand saline soil becomes collapsible when subjected to wetting from any source. This behavior of two soil shine the lights for a new method to improve the collapse behavior of saline soil by mixing it with different percentages of reverse, swelling soil (bentonite) ,it is widely used for soil exploration.

The reduction in S/B% is the indication of improvement of saline soil model. From **fig (23)** we can see that the value of S/B% for treated saline soil with (5%) and (10%) bentonite is reduced to (35%) and (97%), respectively, compared with the untreated model. This additive material may consideres as the most economic and practical material to improve such collapsible soil.

Fig (24) shows a monograph which illustrates the effect of Bentonite to reduce S/B% value, compared with other treated and untreated saline soil for models tested at the same conditions.

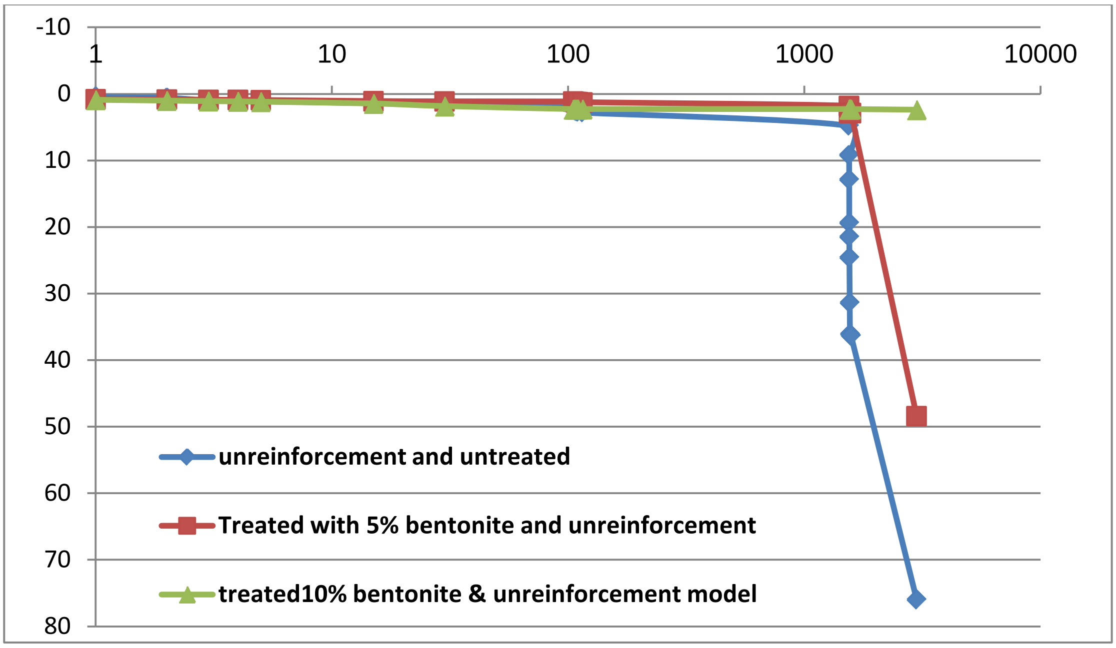


Fig (23) Three different percentage 5%and10% bentonite with stress=36.6KN/m^3),γ=14KN/m^3 and w.c=15%

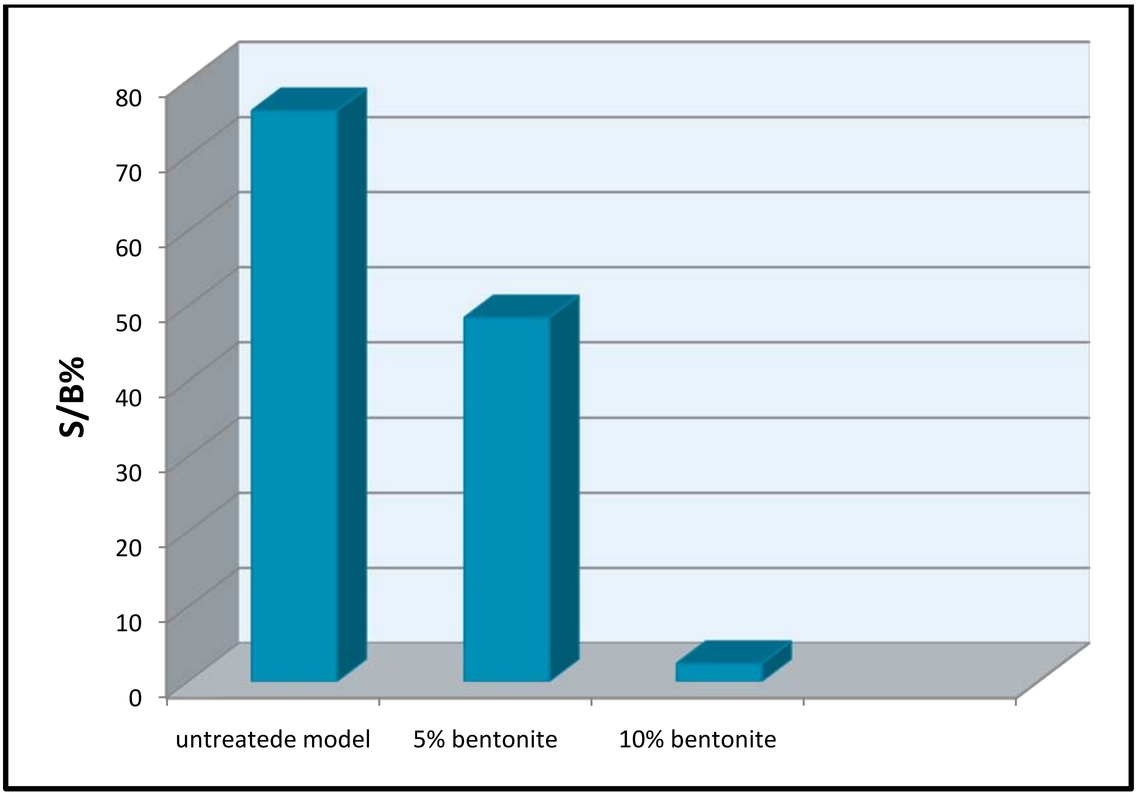


Fig (24) monograph shows the improvement of saline soil by bentonite (γ=14KN/m^3, 10% Salinity and vertical stress=36.6KN/m^2.

5-CONCLUTION:

- Saline Soil is one of problematic soil causes damages to structures constructed on it, when this soil subjected to from any source.
- Wide area of Iraq contains (NaCL) or (CaSo4.2H2O) or CaCO3 salts. Which is considered highly collapsible soils
- Addition of lime to saline soil to more than (2%) will increase the collapsibility and the soil became more problematic. The best percent is (1.5%) and reduce the collapsibility little percent (8%) .Which is consider not practical when compared with other used additives.
- Cement dust mix is an effective improvement additive for Saline soil, and (5%) cement percent mixed with such collapsible soil would reduce the collapsibility to (90%) compared with the untreated model.
- Bentonite is highly availability material. Which make it an economical material to improve collapsibility.specially, it has an incredible effect on reducing the collapsibility of saline soil. and (10%) mixture of this additive with saline soil, would reduce the collapsibility (97%).

6-RECOMMENDATION

- From the results of all models test it is advice to use cement dust as an efficient method to improve saline soil with compaction. and full scale model may need, to support the results of this study.
- Recognizing the effect of other reinforced materials(geogrid, geotextile, or mesh reinforcement), and its effect on the collapsibility of saline soil.
- The need was appears for series of laboratory odometer test for the mixing proportions of bentonite as a new improved material mixing with saline soil with different variable, soil density initial moisture content, and recognize a table or chart for the best mix proportion of this new additives to the saline soil.
- Studying the effect of leaching on the compressibility of saline soil treated with the additives used in this study. And the durability of the reinforcement material(neil).

References:

1-Levy, Y. (1977)" The Origin and Evolution of Brine in Coastal Sabkhas, Northern Sin" Journal of Sedimentary Petrology,Vol 47 :pp 451-462.

2-Abu-Taleb, M.G. and Egeli, I. (1981)" Some Geotechnical Problems in the Eastern Province of Saudi Arabia", Proceedings,Symosium on Geotechnical Problems inSaudi Arabia, Riyadh, Saudi Arabia, 2 : 799-811.

5-James, A.N. and Little, A. L. (1994) " Geotechnical Aspects of Sabkha at Jubail, Saudi Arabia" The Quarterly Journal of Engineering Geology, 27: 83-121.

3-Johnson,H.S., Kamil ,M.R, Pierson , G.O. and Ramsay , J.B. (1978)" Sabkhas of Eastern Saudi Arabia" in Al-Sayyari, S.S. and Zolt, J.G. (Ed.), Quarterly period in Saudi Arabia, Springer, Berlin, 84-93.

4-Al-Amoudi, O.S.B., Abduljauwad, S.N., El-Naggar, Z.R. and Rasheeduzzafar (1992)." Response of Sabkha to Laboratory Tests: A Case Study" Engineering Geology, 33:111-125.

6-Abduljauwad, S.N. and Al-Amoudi, O.S.B. (1995)." Geotechnical Behaviour of Saline Sabkha Soils" Geotechnique, 45(3): 425-445.

7-Ghazali, F.M, Fatani , M.N. and Khan , A.M. (1985)" Geotechnical Properties Of Sabkha Soils of Jeddah , Saudi Arabia" , Proceedings of the Second Saudi Engineers conference , Dhahran, Saudi Arabia, 1:286-307.

8-Abduljauwad, S. N. , Bayomy, F., Al-Shaikh, A. M. and Al-Amoudi, O.S.B. " Influence of Geotextiles on Performance of Saline Sebkha Soils" , Journal Geotechnical Engineering.

9-Mohamedzein et al (2011) "Cement stabilization of sabkha soil from Al-Jazeera Saltanat Oman", Geological Engineering ISSN, Vol 29, pp 999-1008.

10-Ziaie M et al (2011) "Improvement of volume change characteristics of saline clayey soils", Journal of applied science, Vol 11, pp. 76-85.

11-Bin-Shafique et al (2010)"The long-term performance of two fly ash stabilized fine-grained soil subbase", Resource, Conservation and Recycling Journal, Vol 54, pp. 666-672.

12-Krishnaiah S. and Suryanarayana P. (2008), " Effect of Clay on Soil Cement Blocks", the 12th International Conference of Internationa Association for Computer Methodes and Advanced in Geomechanics (IACMAG), 1-6 October , 2008, Goa, India.

14-Ene E. et al (2009),"Some basic geotechnical of expansive soil modified using pyrocastic dust", Engineering Geology Journal, Vol 107, pp 61-65.

15-Al-Hadithy, D. K. (2001), "Compressibility of saline soils treated with Cement", M.Sc Theses, Building and Construction Department, University of Technology.

16-Head K.H 1980, Manual of soil laboratory testing, Vol 1, 2 and 3Pentech Press, London.