Wasit Journal for Science & Medicine 2008 1 (2) : (133 - 1147)

The Effect of Emulsified Asphalt-Salt resistance Cement on Collapsibility of Gypseous soil

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تأثير خليط مستحلب ألاسفلت-السمنت المقاوم للأملاح على أنهارية التربة الجبسية

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الخلاصة

إن الهدف الرئيسس من هذا البحث هو معرفة تأثير إضافة مستحلب ألإسفلت والسمنت المقاوم للأملاح (هذا يعني تأثير خليط مستحلب ألإسفلت-السمنت المقاوم للأملاح) على انهيار التربة الجبسية.

إن التربة التي استخدمت في هذه الدراسة تم جلبها من مدينة سامراء (180 كم شمال مدينة بغداد) وبمحتوى جبسي قدره 69%. سلسلة من فحوص الانهيار أجريت على التربة في حالتها الطبيعية ، وبعد معالجتها بمستحلب (مستحلب ألإسفلت - نسبتين من مستحلب ألإسفلت قد استخدمت (3% ، 5%) وأربعة نسب أخرى بإضافة)السمنت المقاوم نسبتين من السمنت المقاوم للأملاح (2% ، 4%) مرة لنسبة المستحلب ألأولى ومرة أخرى لنسبة المستحلب ألثانية.

نتائج فحوص ألانهيار بينت أن انهيار عينات التربة التي تم معالجتها تتناقص بزيادة نسب مستحلب ألإسفلت المستخدم والسمنت المقاوم ، وأن نتائج أفضل تم الحصول عليها عند معالجة العينات بخليط ألإسفلت -السمنت المقاوم وكذلك نتائج فحوص ألانهيار بينت في معظمها سلوكا مشابها بزيادة نسب مستحلب ألإسفلت والسمنت المقاوم وخليطهما. في النهاية بقي أن نذكر أن العينات التي عولجت بخليط مستحلب ألإسفلت -السمنت المقاوم قد تركت قبل إجراء الفحص عليها لمدة أسبوع للسماح بالاماهة الكاملة لمركبات السمنت.

Abstract

The main aim of this research is to investigate the effect of emulsified asphalt and cement (Salt resistance) mixture (i.e. the effect of emulsified asphalt–cement mixture) on the collapsibility of gypseous soil. The soil used in this study has been brought from Samara City (About 180 Km) north of Baghdad, with gypsum content of (69%).

Series of collapse tests is performed on the soil in its natural state and after treatment by emulsified asphalt-cement mixture, Two percentages of

emulsified asphalt are employed and four percentages of salt resistance cement –emulsified asphalt mixture are used in this study.

the results of collapsibility tests show that the collapsibility of treated soil samples decreases upon increasing the percentage of emulsified asphalt. Better results were obtained when treated with emulsified asphalt –cement mixture. The results of collapse tests show almost the same behavior with increasing the percentage of emulsified asphalt and cement.

Introduction :

The gypseous soil are widely distributed in the basin of Iraq recognized as one of the unpredicted soil, which cause many problems concerning civil works because there properties change significantly upon wetting and leaching (Nashat 1990)[6].

In Iraq, great development in the areas of gypseous soils took place during the last two decades due to the need of constructing many strategic projects, i.e., hydraulic structures, industrial and civil building in these areas. When hydraulic structures are constructed in the gypseous soil, severe predicament may occur (Al-Deffaee 2001)[2].

When water seeps through cracks in hydraulic structures and all civil works, gypsum will be dissolves, thus causing a subsidence of ground level and this lead to the collapse of the structure.

Gypseous soils are unstable structure, since the gypsum acts as a binder and the soil is very hard when dry and becomes very soft of high compressibility, and losses its strength among leaching out of gypsum due to wetting, Hence it undergoes structural collapse with or without an additional increase in the stress in excess of over-burden pressure.

Because of these characteristics, the gypseous soil must be treated or stabilized by many materials and methods before construct the structures to increase the shear strength and become more resistance of water

In this study, the emulsified asphalt mixed with cement is used in stabilization of the gypseous soil. The present study includes determination of collapse potential by Oedometer collapse test.

Finally, the aim of this study is to investigate the effect of emulsified asphalt-cement mixture on the collapsibility of gypseous soil to be come more resistance of water.

Collapse Mechanism:

The definition of collapse is can be considered as a reduction in volume of fill material or natural soil deposit due to water seeps with no change in applied stress, this can be attributed as inundation. Inundation may be caused by

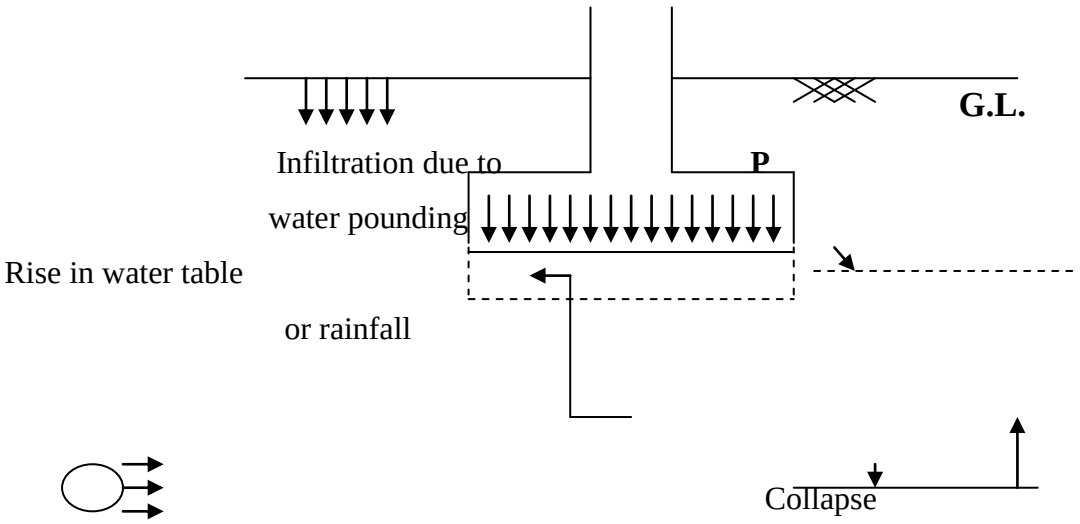
downward infiltration of surface water, rising ground water level, bursting of underground water supply line (Sonils.et.al.) [9], see figure(1).

According to Dudley(1970)[4], Pereira and Fredlund(2000)[8],the following factors produce collapse in soil :

1- An open, Partially unstable, unsaturated fabric;
2- A high enough net total stress that will case the structure to be metastable.
3- A bonding or cementing agent that stabilized the soil in the unsaturated condition which is reduced on addition of water causing the inter aggregate or inter granular contacts to fail in shear, resulting in a reduction in total volume of the soil mass.

Wetting induced collapse has occurred in compacted fills such as earth dams, highway embankments, and filled canyons. Embankment of compacted soils experience wetting induced collapse settlement, primarily due to loss of soil suction upon wetting problems associated with collapse settlement in compacted fills include damage to structures and foundations, slope failure with in fills. damage to pavement, and sub-grade placed on highway embankment, piping, seepage losses and failure in earth dams.

Potential for collapse in a fill can be controlled during the placement and compaction process (Schwartz 1991 ; Lawton et. al. 1992; Pereira and Fredlund 2000)[7].



mechanism

Infiltration due to Ground water table

broken water pipe

Fig.(1): Occurrence of collapse phenomenon.

Collapse potential in soil :

The collapse potential (C.P.) expressed in percentage is defined as :

$$C.P.= \frac{\Delta e}{1 + e} \times 100\ \%$$

Where :

Δe = change in void ratio in an oedometer test on saturation at a given stress

e = void ratio of the oedometer test specimen at the given stress before inundation.

Jennings and Knight (1975)[5] have suggested criteria to assess the severity of the problem associated with collapse, based on values of collapse potential according to table (1).

Table (1): Collapse potential and severity of collapse (after Jenning and Knight 1975)[5].

Collapse potential (CP) %	Severity of collapse
0-1	No problem
1-5	Moderate Trouble
5-10	Trouble
10-20	Severe Trouble
>20	Very Severe Trouble

Liquid Asphalt :

Cationic medium setting emulsified asphalt manufactured at oil of south company in Al-Basrah City. It consist of asphalt cement (63%), water (36.5%) and an emulsified agent (0.5%), type "Denoram-S". Properties of the liquid asphalt are given in Table(2).

Table(2): Properties of Liquid Asphalt

Properties	values
Residue by evaporation (%)	63
Cement mining	1.2
Kinematics viscosity at 25 C (C.stoke)	45
Test on residual from distillation a-Penetration at 25C (100gm/Sec.) b-Ductility at 25C (5cm/min) c-Solubility in Tetrachloride (%)	 130 137 100
Storage stability 24 hrs.	0.8
Settlement,5 days, mm	3.2

Experimental work :

The experimental work are divided to Physical and chemical tests.

1- **physical tests:** its contained:

a- Unit weight and water content :

These tests have been conducted according to ASTM (D2927-71) and (D2216-80)[1] standards respectively. Water content in all tests is determined using oven drying at (45 C) not to let the crystallization water of gypsum be lost. This would not affect water content value, as the soil has not significant clay fraction.

b- specific gravity

The specific gravity of the soil determined according to BS-13377 : 1976, test No.(6)[3], But "Kerosene" is used instead of water due to the dissolving action of water in gypsum.

c- **Grain size distribution**

The grain size distribution of the investigation soil was determined by sieving analysis which was conducted according to ASTM D422-72[1] but with dry sieving, The grain size distribution test show that the soil can be classified as sand poorly graded with silt (SP-SM) as shown in curves of the soil in figure 2.

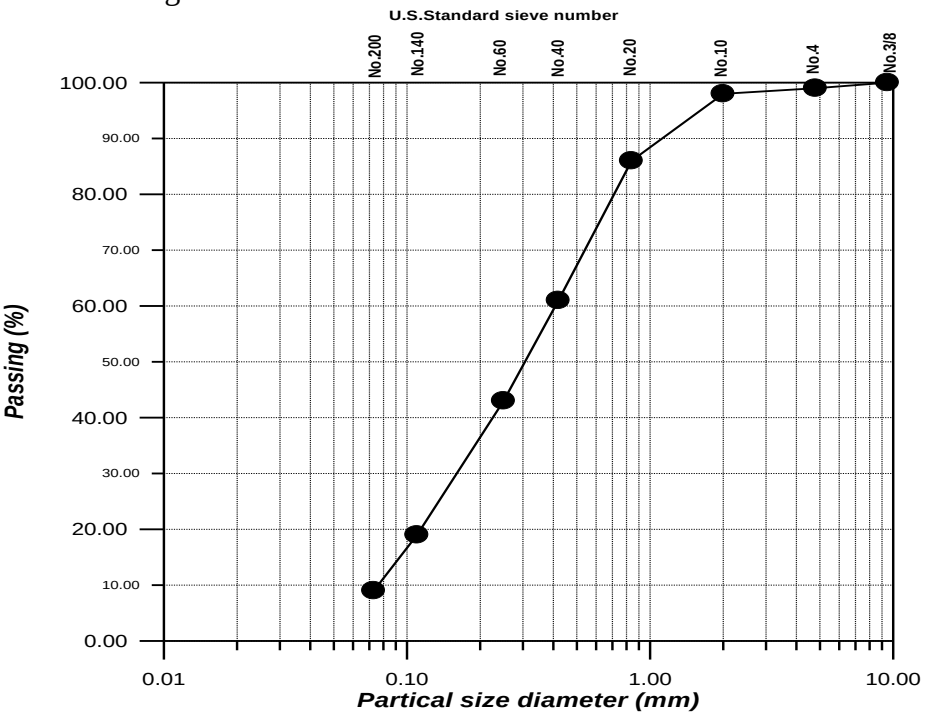


Fig.(2) : Grain size distribution

d-Atterberg limits :

The liquid limit was carried out according to BS-1377-76, test No.(2),A[(3)], using the cone penetrometer method. The plastic limit is determined in accordance with BS-1377-76, test No.(3).

The liquid limit and plastic limit are carried out on natural soil, on passing sieve No.(40). The drying temperature in all tests is maintained at ($45C^{o}$) because of the significant amount of gypsum percent. The results of consistency tests are summarized in table (2). Finally, the table (3) below show the index properties for the natural soil.

Table (3): Index properties for the natural soil.

Site	Values
Depth (m)	(0.5-1)
Specific gravity (Gs)	2.37
Gypsum content (%)	69
Atterberg limits Liquid limit (%) Plastic limit (%) Plastic index (%)	 33.5 N.P. N.P.
Standard compaction properties Maximum dry density (KN/m^3) Optimum moister content (%)	 14.3 13.5
Passing sieve No.200	9.3
According to USCS classification	SP-SM

Mechanical tests:

The test those conducted on all specimen is single collapse test, this test was suggested by Knight (1973)[5], three groups of specimens were tested, the first group includes the specimen of soil before treatment. Disturb specimens were used and compacted in consolidometer device at natural water content then tested, While the second group includes specimens treated by emulsified asphalt while the third group contains specimens treated by emulsified asphalt–salt resistance cement mixture as well as soil in its natural state.

For each group, and for each test, the specimens is loaded progressively until (200 Kpa) is reached, then it is left until equilibrium is maintained under this load, then flooded with water and left for (24 hrs). For the second group, the specimens were left for 7 days before loads to permit of cement components to get an enough time for hydration.

Results of collapsibility tests:

Three groups of tested specimen have been used to predict the behavior of collapsibility of soil at its natural state and after addition the emulsified asphalt and salt resistance cement mixture in different percentages. First group contained specimens of soil in its natural state without any treatment, the collapse test shows that the collapse potential is reached to (10.1) as shown in figure.(3). The collapsibility is classified as sever trouble according to Table (1). Summary of the data for collapse tests are given in table(4).

Table 4 : Results of collapse test

Type of binder	*Results of specimens treated by emulsified asphalt*			*Results of specimens treated by emulsified asphalt-salt resistance cement mixture*			
% of binder	0	3	5	3+ 2 % cement	3+4% cement	5+2% cement	5+4% cement
C.P. (%)	10.1	3.6	1.5	1.2	0.9	1.1	0.8

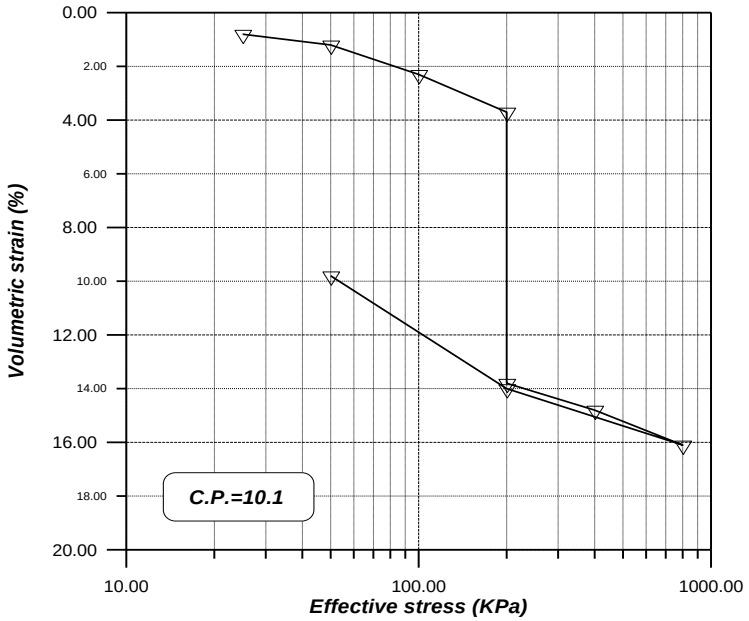


Fig.(3): Single collapse test for untreated specimen

From figure.(3), it can be noticed that instantaneous and significant settlement take place upon flooding in water.

The change in volume upon flooding in water pointed out that the soil is collapsible. When water is added to the soil sample under constant stress destruction of the particles binder due to dissolution of gypsum particles and new reorientation of particles will take place resulting in an instantaneous settlement. According to the value of collapse potential shown in table (1), the soil may be classified as "sever trouble" (Jenning and Knight, 1975)[5].

The second group of specimens included specimens treated by emulsified asphalt in two percentages , 3% and 5% respectively. For the first percentage, the collapse potential is reduced to (3.6%), while in the second , the collapse potential is reduced to (1.5%), as shown in figure (4) and figure (5) respectively.

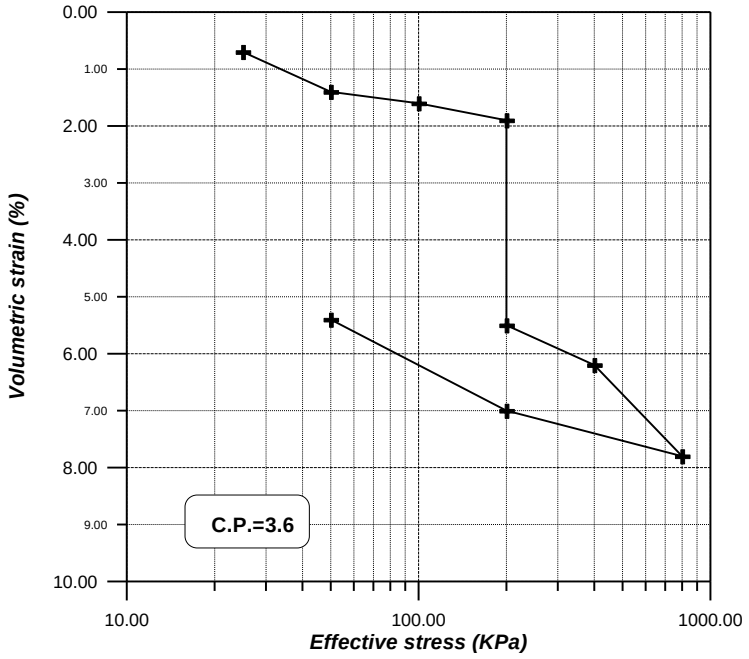


Fig.(4): Single collapse test on specimen treated by 3% emulsified asphalt

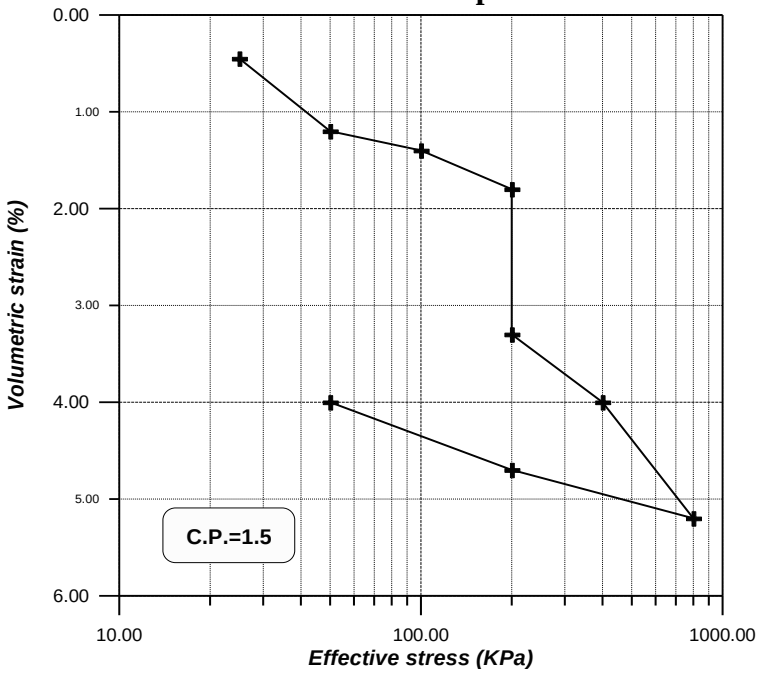


Fig.(5): Single collapse test on specimen treated by

5% emulsified asphalt

In both test, this behavior can be attributed to cementation agent of emulsified asphalt plug the voids between soil particles.

In the third group four specimens are treated by mixture of cement (salt resistance) and emulsified asphalt in.

In the first specimens, treated carried out by adding (3%) from emulsified asphalt added to it (2%) of cement (salt resistance), the collapse potential is reduced to (1.2%) as shown in figure (6).

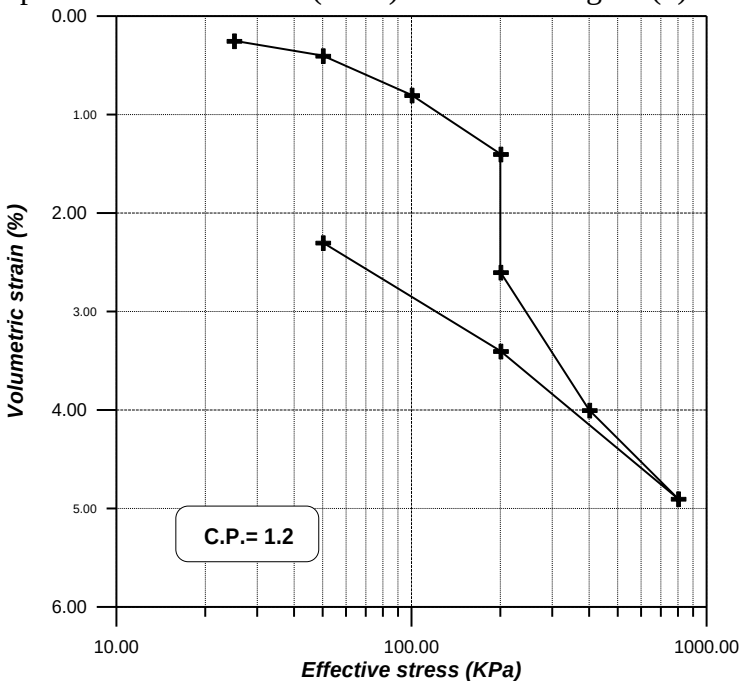


Fig.(6): single collapse test on specimen treated with 3% emulsified asphalt mixed with 2% salt resistance cement

The second specimen treated with (3%) of emulsified asphalt added to it (4%) cement (salt resistance),the collapse potential is reduced is to (0.9%) as shown in figure(7).

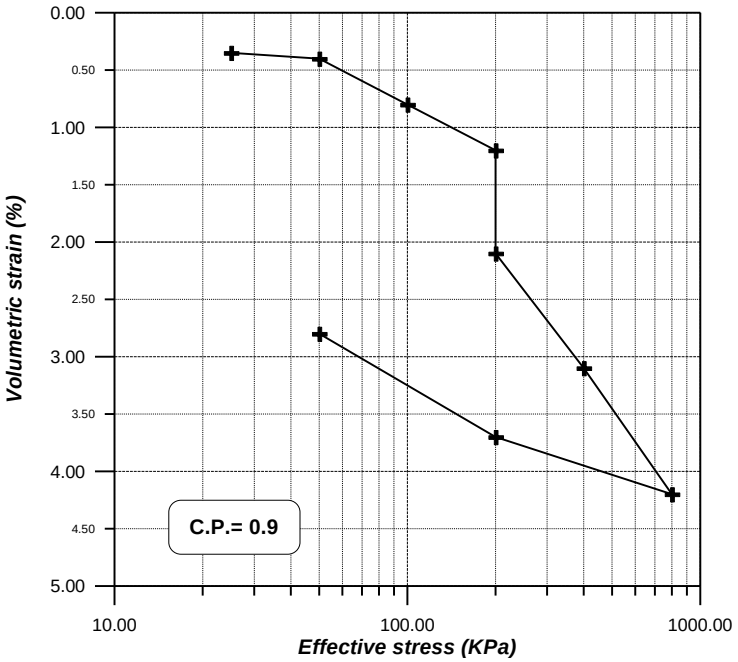


Fig.(7): Single collapse test on specimen treated with 3% emulsified asphalt mixed with 4% salt resistance cement

The third specimen treated with (5%) of emulsified asphalt added to it (2%) of cement (salt resistance), in this specimen, the collapse potential is reduced to (1.1%) as shown in figure(8).

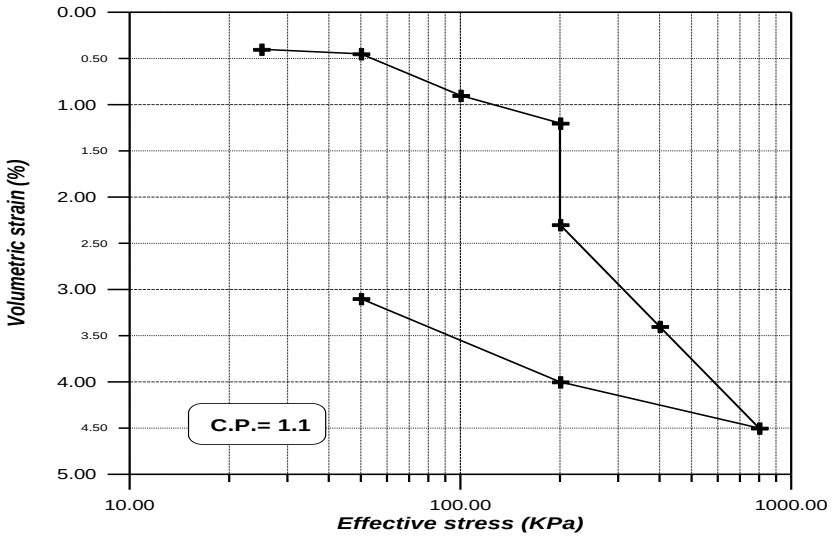


Fig.(8): Single collapse test on specimen treated with 5% emulsified asphalt mixed with 2% salt resistance cement

For the last specimen, specimen treated with mixture of (5%) emulsified asphalt and (4%) cement (salt resistance), the collapse potential reached to (0.8%) as shown in figure(9).

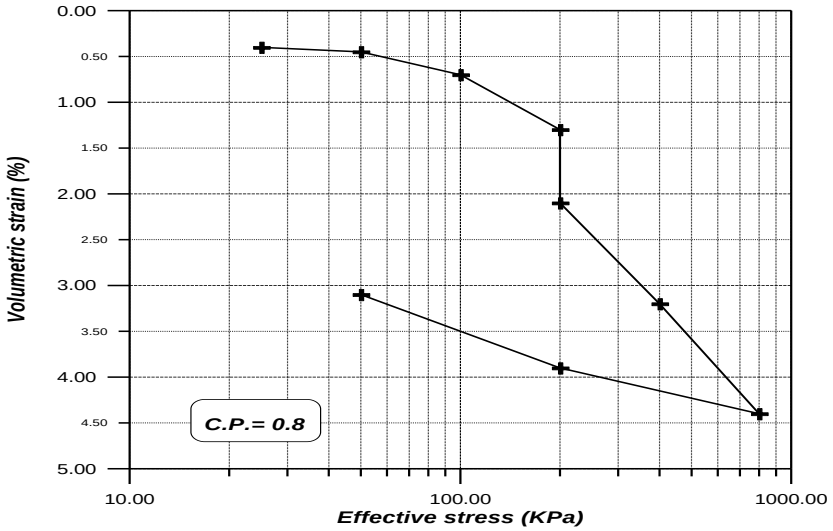


Fig.(9):Single collapse test on specimen treated with 5% emulsified asphalt mixed with 4% salt resistance cement

The collapse potential is reduced from 10.1 in natural case for the soil to (0.8) in specimen treated by mixture of (5% emulsified asphalt + 4% salt resistance cement), the behavior can be attributed to cementation agent of emulsified asphalt as well as cement plug the voids between soil particles and worked as a water proofing.

Conclusion:

As a result of the testing program conducted on soil samples taken from Samara City with gypsum content (69%), the following conclusions could be drawn.

1- Large decreases in collapse potential reached to 8.6% when the sample treated by emulsified asphalt due to water proofing action for emulsified asphalt.
2- Cementation agent for salt resistance cement and water proofing action for emulsified asphalt makes gypseous soil more resistance of water.
3- it is found that the value of collapse potential of the tested soil (untreated) locate between (10%-20%) which is referred that the soil considered collapsible. In addition, the collapse potential as a very high is located less than (1) after treating with different binders which means that the soil collapsibility may be not affect as a problem.
4- The increases of the ratio of binder gives excellent results until (3% emulsified asphalt+4% salt resistance cement),Then become without any benefit and may be gives negative results due to the sliding of particles on catch other surrounded by the binder.

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Recived ……..……. (27/5/2008)
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