The Characteristics of Collapsing Soil in Marshes Area

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Abstract

The soils of the marshes in the south of Iraq are considered as soft soil, which is usually a silty clay and clayey silt. In this study, compressibility and shear strength characteristics are studied for three soils used in this work, were brought from three different areas (Alchebaish, Alhalfaiya and Almejar Alkabeer) near marshes and taken at depth ranging from (1-1.5) m below ground level after excavating the upper soil strata. All fundamental tests were performed on these soils.

Laboratory tests results showed that these soils have high collapsibility and that shear strength parameters of c and ϕ) decrease when soaked in water but the main decrease was in (c) value. Also the study includes the influence of the initial void ratio and the water content on the modules of the collapsibility. The value of collapse Potential seems to depend mainly on the natural water content and initial void ratio. The collapse potential increases with the increase of void ratio and decreases with increase of water content.

دراسة الخصائص الإنـهيارية لتربة الأهوار

الخلاصة

تعتبر تربة الأهوار في جنوب العراق من الترب الضعيفة والتي تتكون عادة من طين غريني أو غرين طيني . وفي هذه الدراسة تم دراسة خصائص الانضغاط والانهيارية ومقاومة القص لثلاث ترب تم جلبها من مناطق (الجبايش ،الحلفاية، المجر الكبير) وقد أجريت كافة الفحوص الأولية على تلك الترب .

وقد بينت نتائج الفحوص المختبرية إن هذه الترب تعتبر ذات إنهيارية عالية وان دارسة القص(**c**، **ϕ**) تقل عند الغمر في الماء، ولكن النقصان الرئيسي كان في قيمة (**c**) وقد شملت الدراسة أيضاً تأثير نسبة الفراغات والمحتوى المائي على معامل الانهيار ،إذ تم التوصل إلى أن قيم معامل الانهيار تعتمد بشكل رئيسي على محتوى الرطوبة الطبيعي ونسبة الفراغات الابتدائية إذ تزداد مع زيادة نسبة الفراغات وتقل مع زيادة المحتوى الرطوبي .

Introduction

The prediction of the behavior of soil under structure is an essential part of any design problem. The behavior of loaded soil depends on many factors. The settlement is one of the major factors which is usually considered by the foundation engineer (Affendi and Faisal 1994). Some soils show a rather unusually type of settlement in which large and immediate settlement take place on wetting of soil and this settlement is known as a collapsing settleme Thecollapsing settlement usually occurs in loose soil with open structure. The underestimation of collapsing settlement or failing in identifying the collapsing behavior of the soil may lead to badly cracked structure or even to structure failure (Arora, 1992). The collapsing soil has been recognized in a large parts of marshes area, but studies of the collapsing properties in this area are limited.

Testing program

Classification tests were performed first including physical and chemical tests. The physical tests included specific gravity, Atterberg limits, and dry density .The chemical tests carried out on the samples include total soluble salts, PH value, gypsum content, organic content and total sulphate content. The results are shown in table (1) and table (2). The engineering tests conducted were collapsibility and shear strength test. (Head 1986).

Table (1): Physical properties of the soils used

Properties	CS*	HS*	AS*
Wn (%)	22	32	24
γd (kN/m^3)	12.34	13.11	12.54
L.L(%)	33	60	42
P.L(%)	21	35	28
P.I	12	25	14
Gs	2.52	2.61	2.54
Clay (%)	77	82	21
Silt (%)	14	16	53
Sand (%)	9	2	26

*** Symbols for Testing Soils.**

Table (2): Chemical properties of the soils used

Property	CS	HS	AS	Standared
T.S.S (%)	32	41	23	Earth manual E8
SO3 (%)	7.5	9.32	5.88	Bs (1377-1975)
PH	7.3	7.5	7	Bs (1377-1975)
G.C(%)	15.75	20	12.35	Improvement soil-saline and Al-Kali soil
O.C%	8.66	9.32	6.6	Bs (1377-1975)

Compressibility Characteristics:
Collapsible soils:

A collapsible soil is defined as any saturated soil that goes through a radical rearrangement of particles and great loss of volume upon wetting with or without additional loading (Lambe, 1967).

According to (ASTMD 5333, 2003) collapse is defined as the decrease in height of confined soil following wetting at a constant applied vertical stress as shown in table (3). A collapsible soil may withstand relatively large applied vertical stress with small settlement while at low water content, but this soil will exhibit settlement after wetting with no additional increase in stress. Large applied vertical stress is not necessary for collapse. Table (4) shows some values of collapse potential to describe the degree of severity of problem.

Table (3) Classification of Collapse Index (Ie) According to (ASTMD 5333, 2003)

Degree of Specimen Collapse	Collapse Index (Ie)%
None	0
Slight	0.1 -2.0
Moderate	2.1-6.0
Moderately severe	6.1-10
Severe	>10

Table (4): The Severity of Collapse Potential, After Jennings and Knight (1975)

Severity of Problem	**P (%)**
No Problem	0-1
Moderately Trouble	1-5
Trouble	5-10
Severe Trouble	10-20
Very Severe Trouble	>20

Jennings and Knight (1975), suggested a laboratory test know as (double odometer test) to evaluate the collapse potential. They conducted odometer test on two identical specimens one of them tested in its natural water content while the other tested after saturation the difference between the two compression curves represent the collapse potential of the soil at any given stress level.

The sample at natural water content is placed in the oedometer and loaded progressively until the pressure reach (200 kPa). At the end of the loading stage the sample is flooded with water and left for (24) hrs, during this time the volume change is recorded. The samples will then be loaded to a specific pressure. The collapse potential is define as:

$$CP = \frac{\Delta e}{1+e} \times 100 \qquad \text{.... (1)}$$

Δe: Change in void ratio upon wetting.
e: Initial void ratio.

Collapse Test:

The results of collapse tests are shown in figure (1). The results show typical relationships between the collapse potential and time. It can be seen that (CP) curve starts by rapid increase in strain and time.

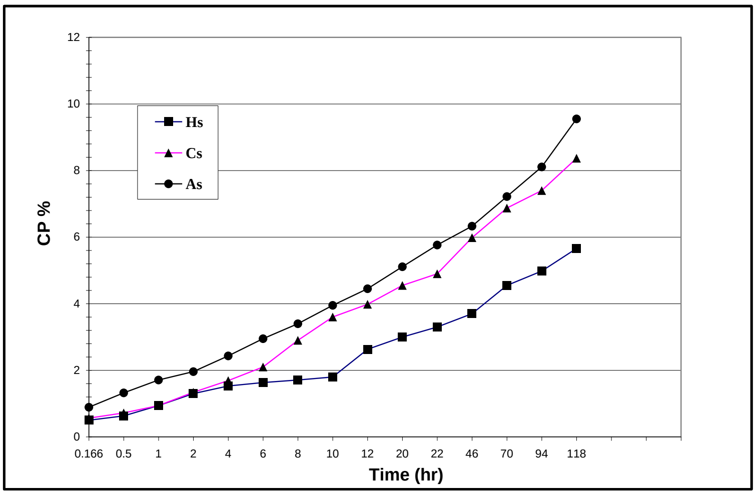


Figure (1): Results of Collapse Potential-Time Relationship of Soils

Double Oedometer Test:

Figure (2) shows relationships between the collapse potential and effective stress for the three soils. It can be seen that (CP) increases progressively with increasing the applied stress.

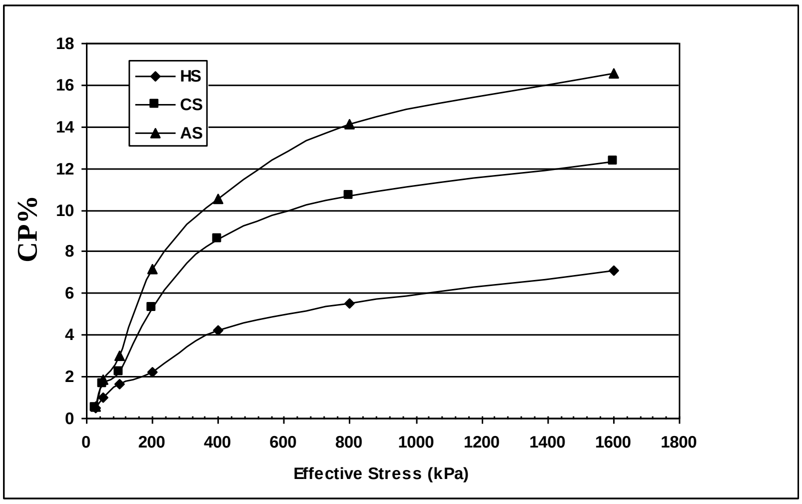


Figure (2): Results of Double Oedometer Test of Soils.

From table (5) it can be seen that the collapse potential obtained from double oedometer test at stress of (200) kPa is relatively greater than that obtained from the collapse test. This is due to adding the water to the specimens at the start of test .

Table (5) Summary of the Variation of Collapse Potential between the CT and DOT

Soil Type		HS	CS	AS
CP%	CT	2.2	3.78	4.33
	DOT	2.26	3.78	7.2

Effect of Initial Void Ratio on the Collapse Potential:

The relation between the initial void ratio on the collapse potential and the relative collapse potential is presented in figures (3),(4) and (5) , for the water content between (12, 18 and 24) % and under stress (50,100 and 200) KPa . in general the collapse potential increases with increasing the initial void ratio.

Effect of natural water content on the collapse potential

Figures (6),(7) and (8) shows the relation between the natural water content and the collapse potential under stress (50,100 and 200) KPa and for different initial void ratio, when natural water content increase in general collapse potential decrease .

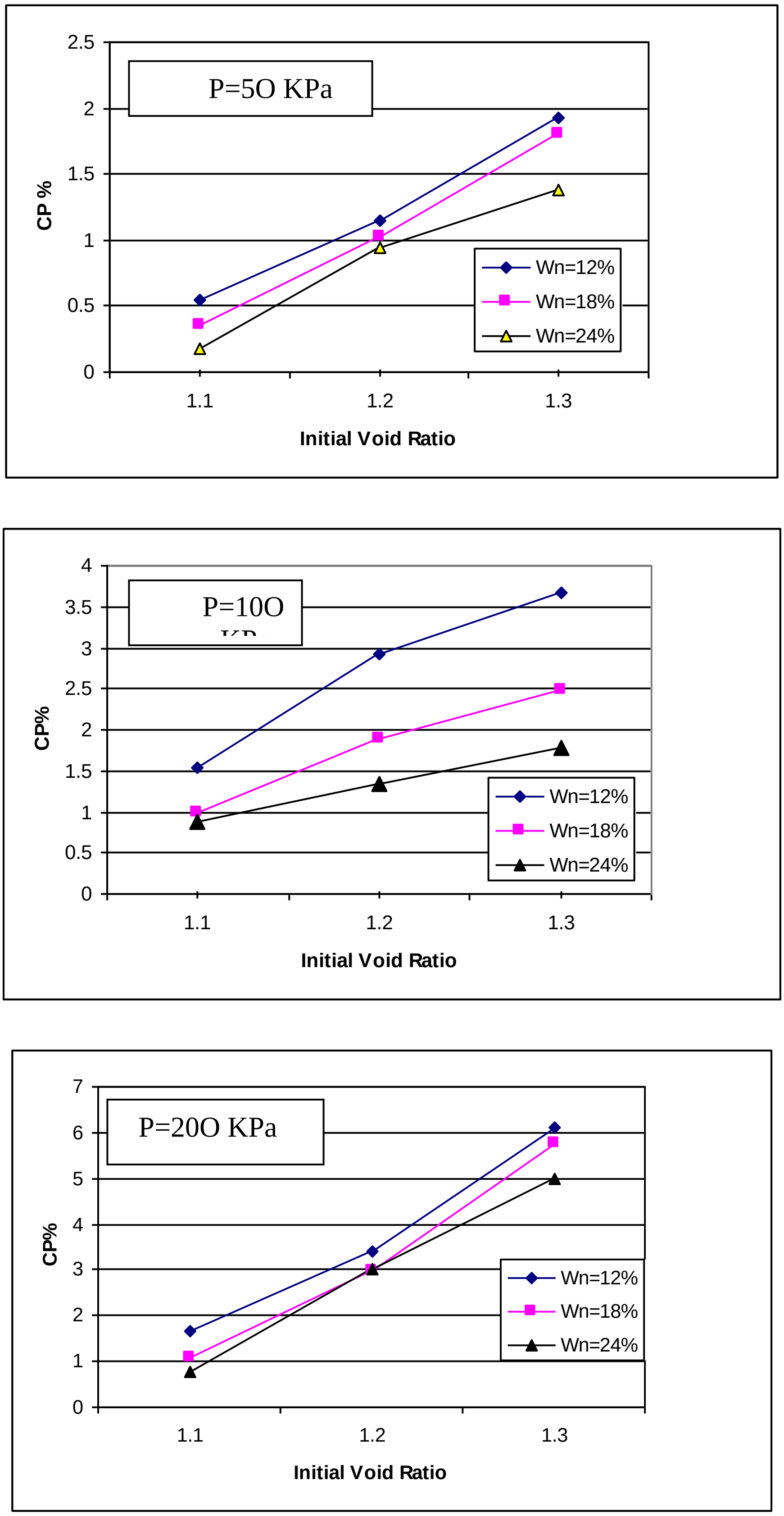


Figure (3) Relationship between the initial void ratio and the collapse potential for Alhalfaiya soil.

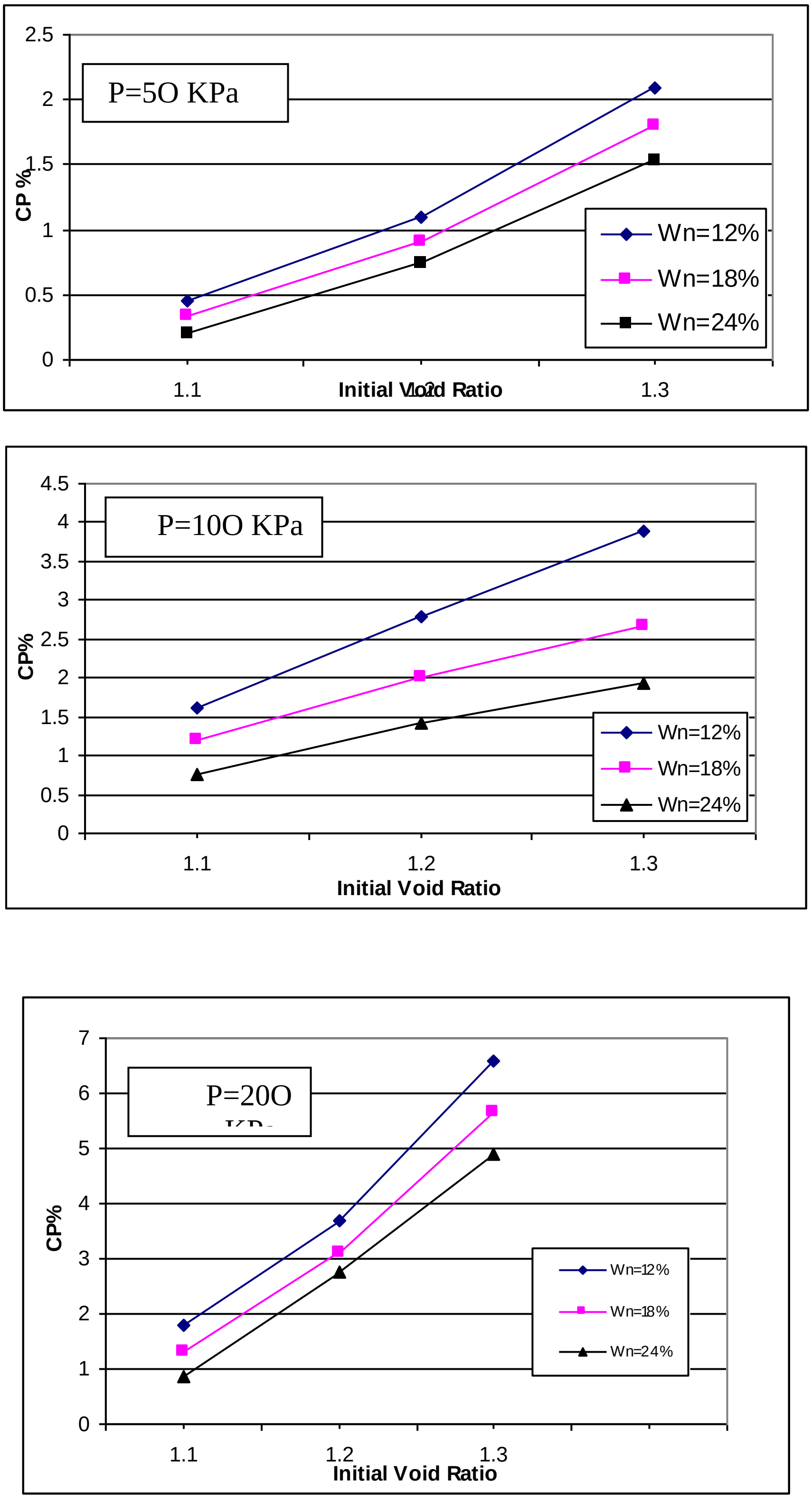


Figure (4) Relationship between the initial void ratio and the collapse potential for Alchebaish soil.

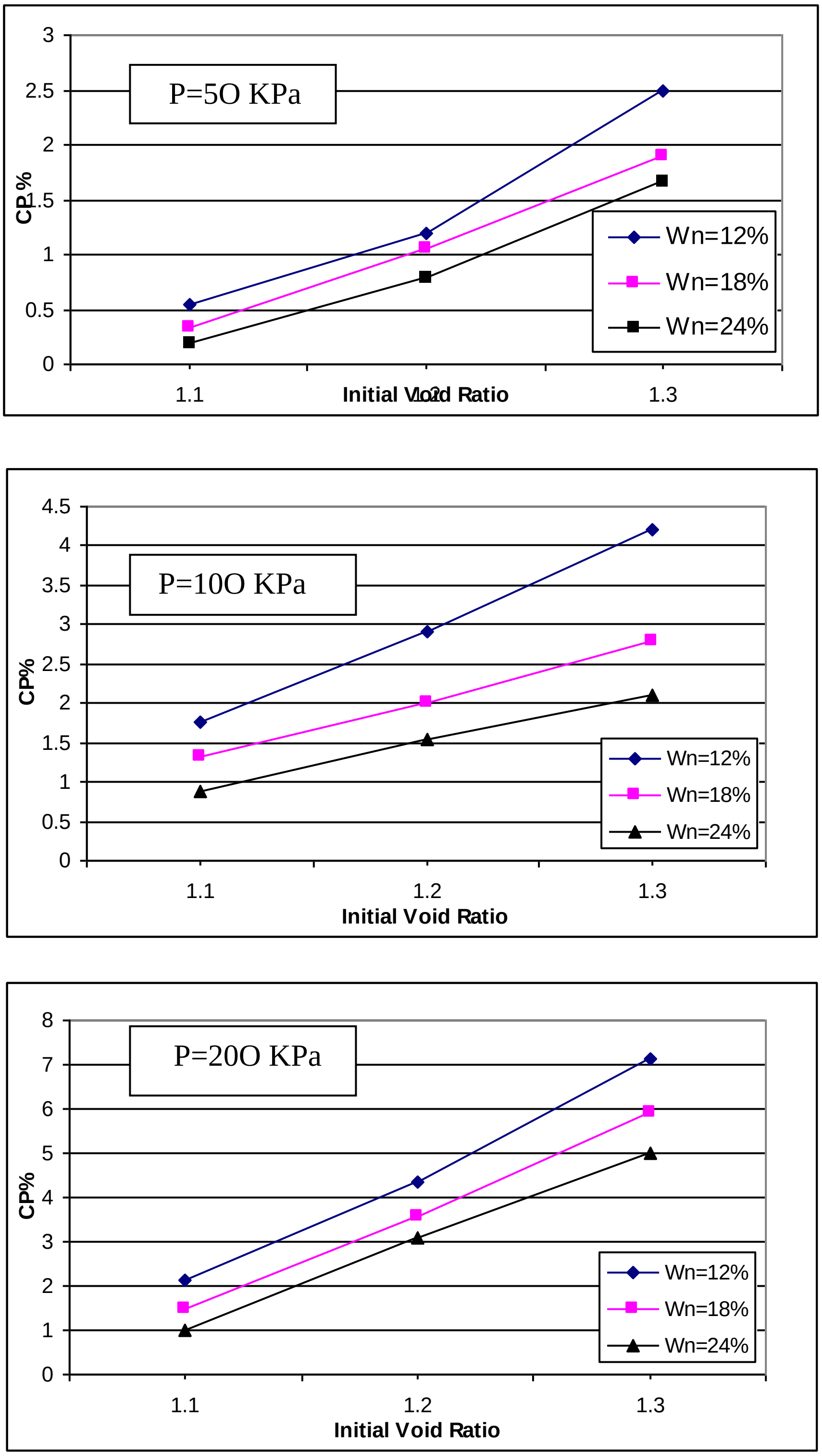


Figure (5) Relationship between the initial void ratio and the collapse potential for Almejar Alkabeer soil.

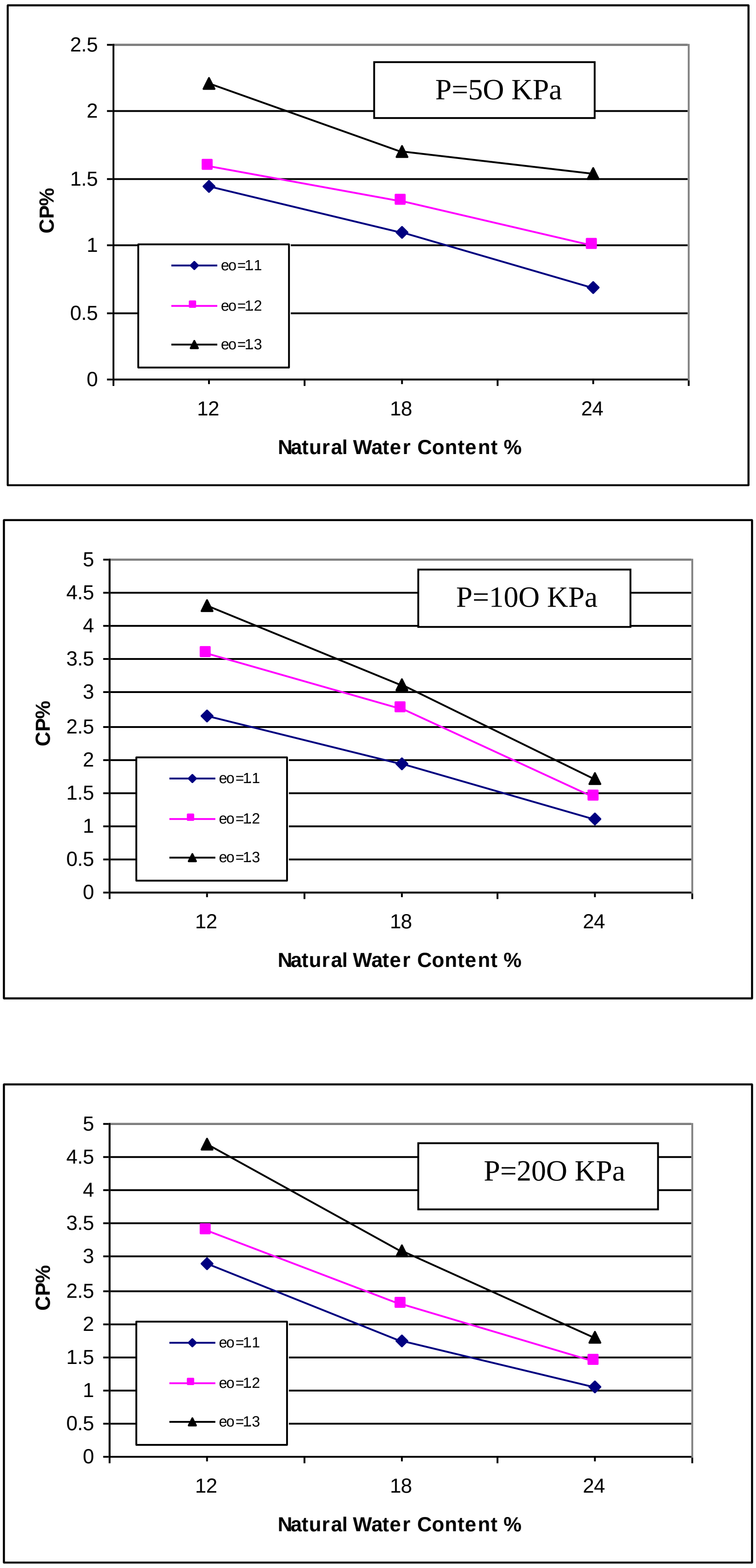


Figure (6) Relationship between the natural water content and the collapse potential for Alhalfaiya soil.

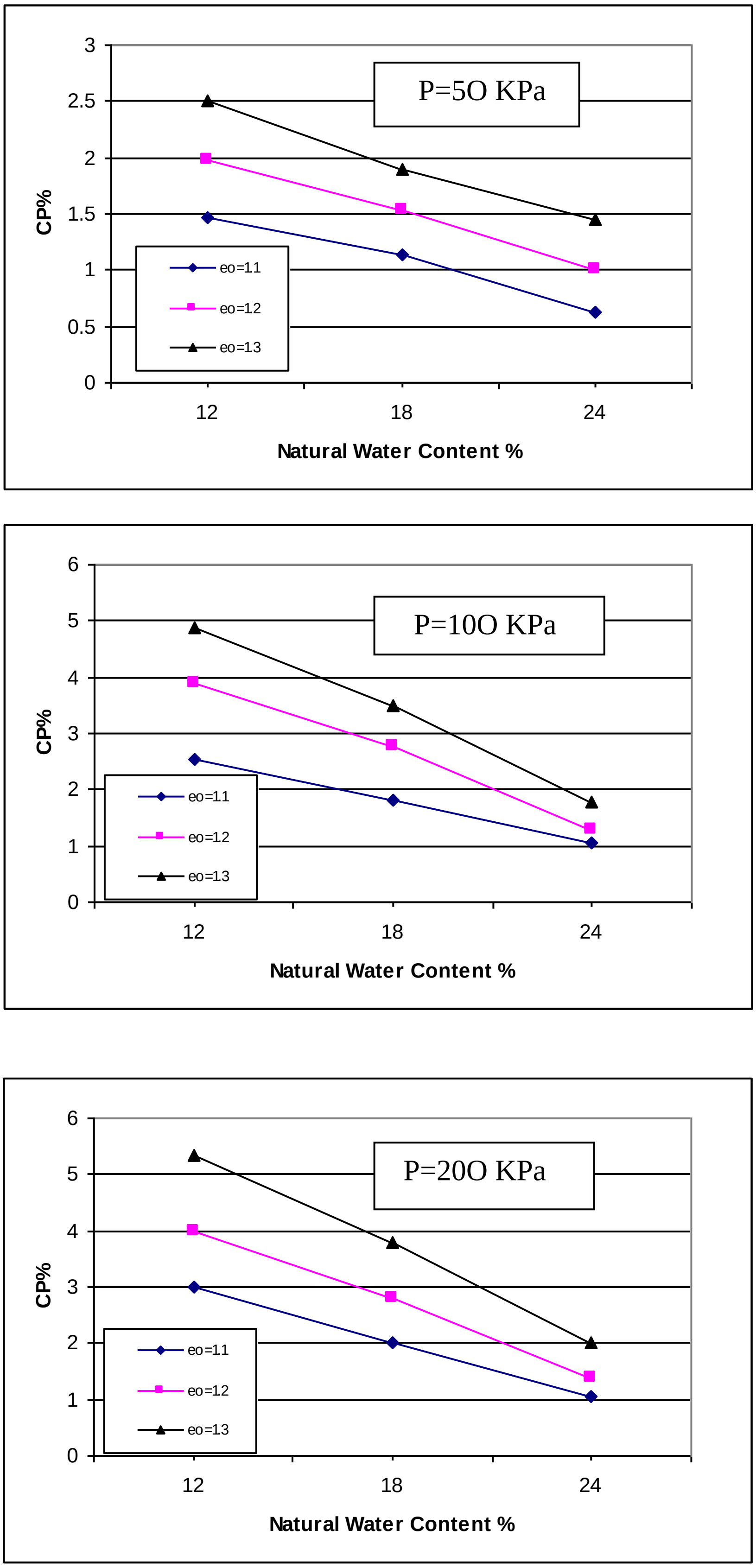


Figure (7) Relationship between the natural water content and the collapse potential for Alchebaish soil.

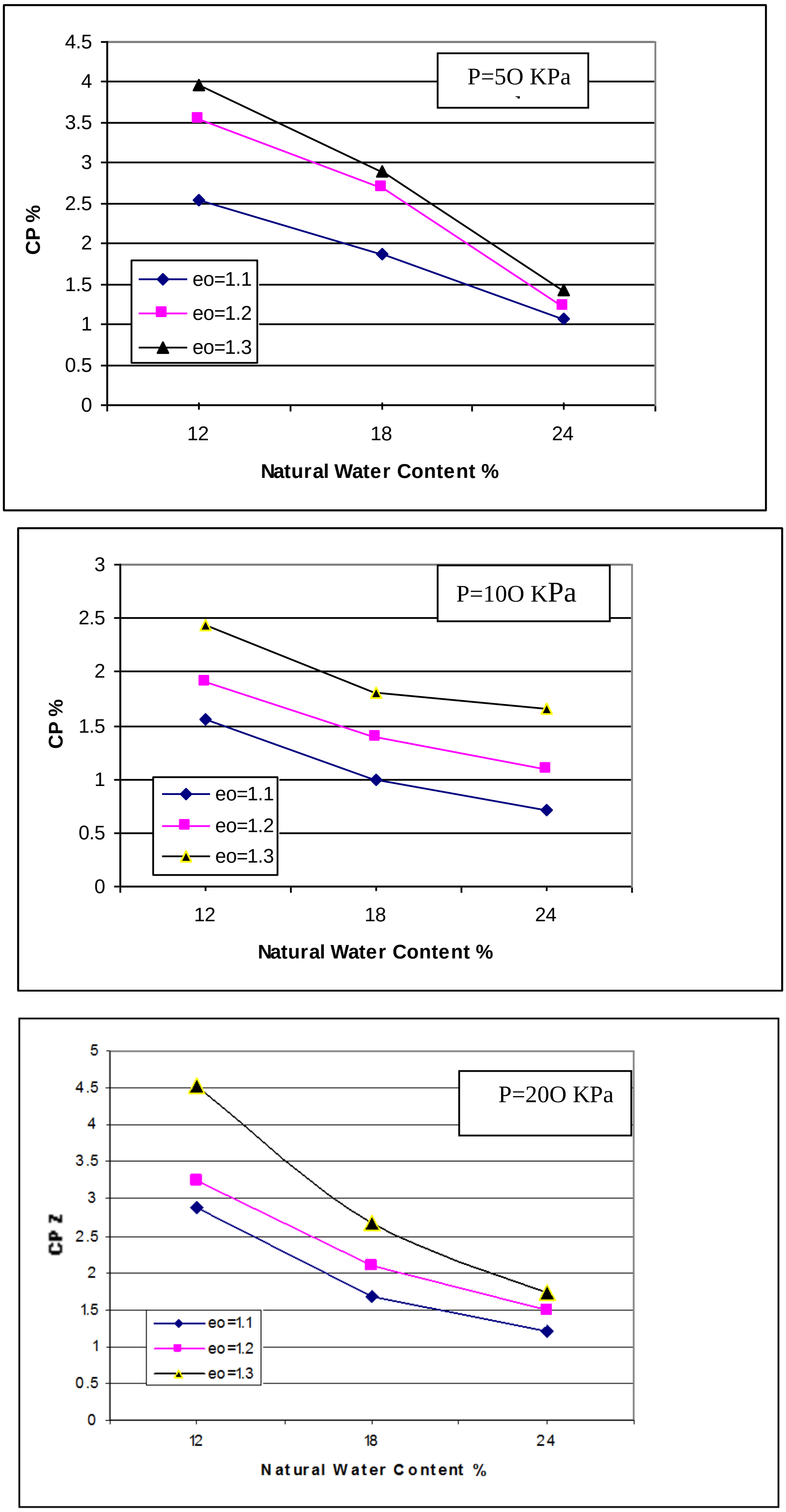


Figure (8) Relationship between the natural water content and the collapse potential for Almejar Alkabeer soil.

Shear Strength Tests:

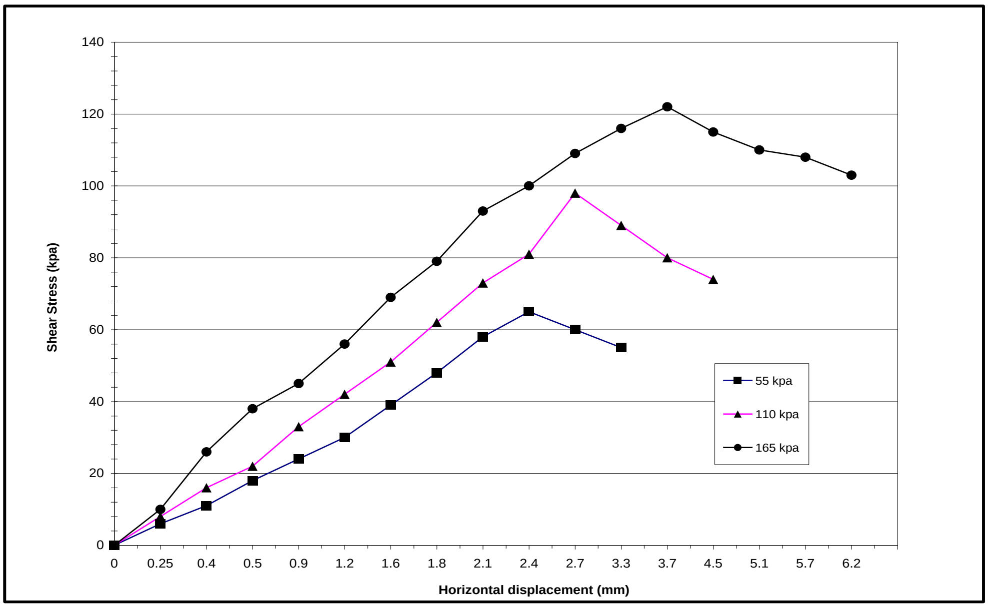
A series of direct shear tests were carried out to determine the shear strength parameters of the dry and soaked samples. The tests were carried out according to the procedure proposed by (ASTMD 3080, 1972). The specimen size was (60*60*20) mm.(Bowles, 1988), A calibrated proving ring of (200) kg capacity and (0.002) mm precision dial gage for vertical deformation reading was used ,while for horizontal deformation a (0.001)mm gage was used .The rate of strain was (0.3) mm/min . The time of soaking in water was about (3) hour Bowles, 1988).

To predict the shear strength parameters **(**c and , Φ), two types of tests were conducted on (6) samples which were obtained from three soils samples, (3) samples of them are tested in dry state, while the other (3) samples were tested after soaking in water for (3) hours.

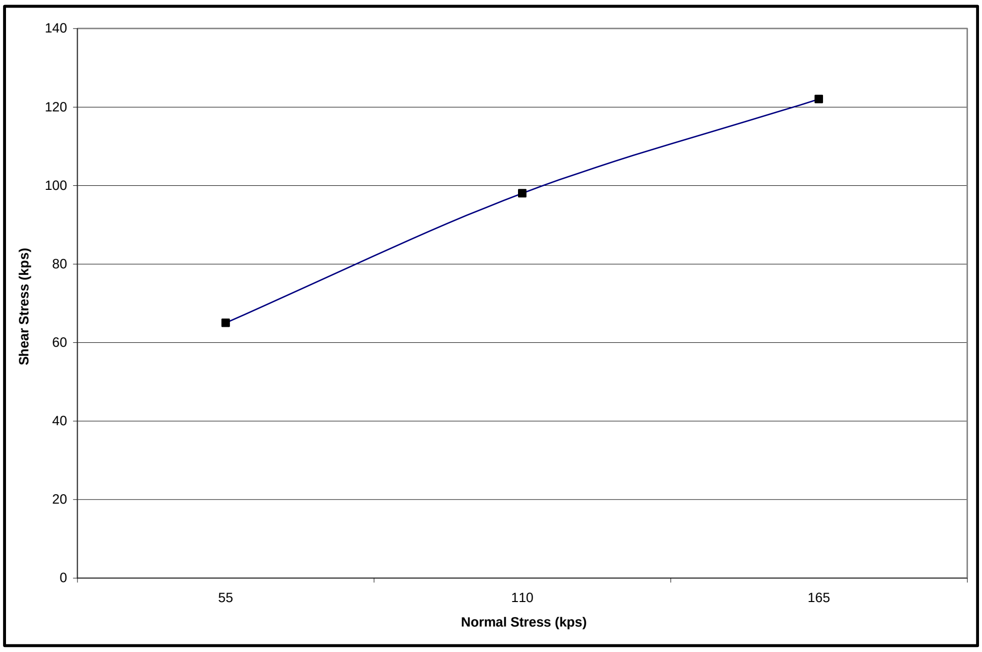
The summary of the results of direct shear tests conducted on the three soils (CS, HS and AS) for both dry and soaking state is given in table (5) and figures (9 a) and (10 a) show the relationship between horizontal displacement and shear stress. It is clear that the stress – strain relationship of dry soils and soaked soils are similar . But one difference is noticed that the peak value of stresses at each normal stress of dry samples is more than the corresponding values of soaked because the cohesion is much more in dry state than in soaked state . Figures (9 b) and (10 b) show the shear stress-normal stress relationship,on the other hand ,the reduction in the values of angle of internal friction is observed after soaking . This behavior may be due to bonds destruction in the soil after soaking in water.

Table (5) Summary of the Variation of Cohesion and Angle of Internal Friction of Soaked and Unsoaked By the Direct Shear Test of Soils.

Type of Test		Unsoaked			Soaked		
Type of Soil	**σ_n kPa**	**τ_{max} kPa**	**c kPa**	**Φ deg**	**τ_{max} kPa**	**c kPa**	**Φ deg**
Alchebaish soil	55	65	35	28	42	10	27
	110	98			76		
	165	122			95		
Alhalfaiya soil	55	63	30	27	54	14	26.75
	110	88			76		
	165	117			98		
Almejar Alkabeer) Soil	55	81	42	27.5	51	25	24.4
	110	104			72		
	165	129			101		

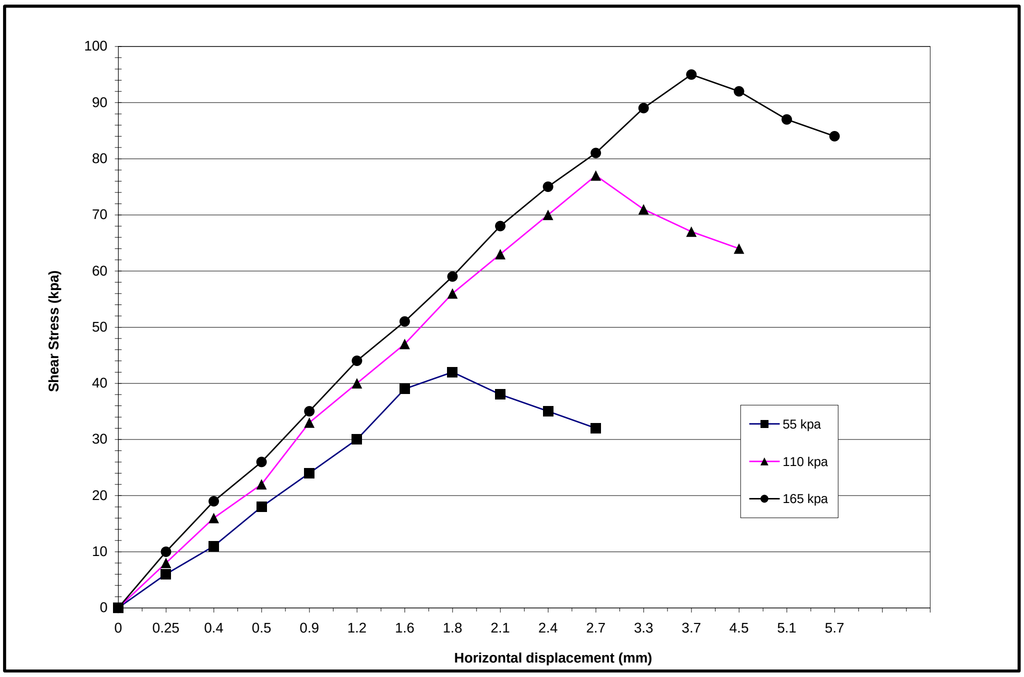


a: Shear Stress-Horizontal Displacement Relationship

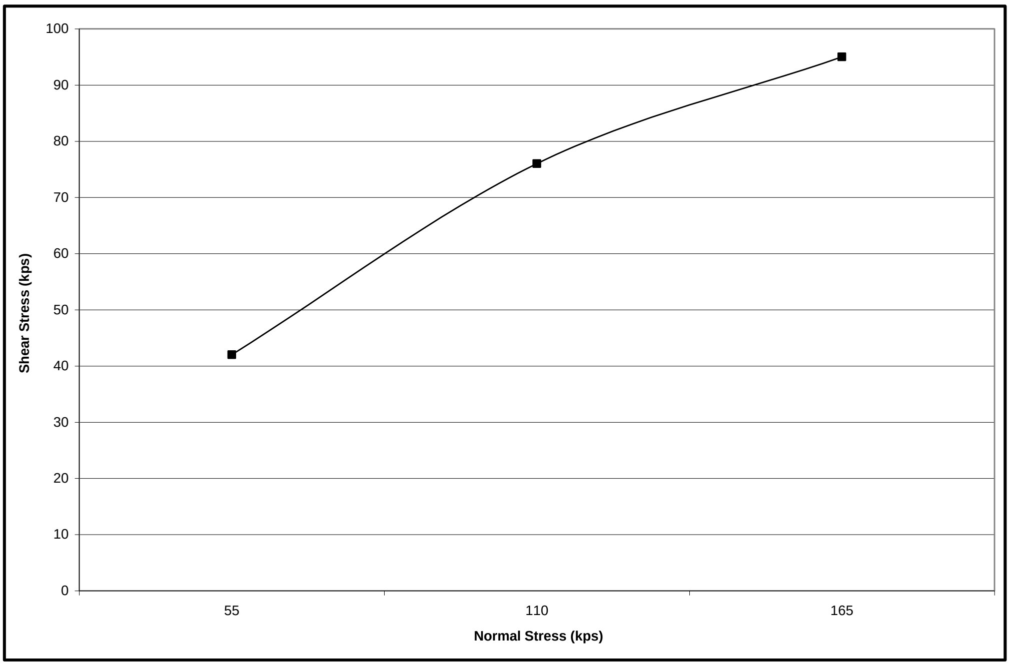


b: Shear Stress-Normal Stress Relationship

Figure (9) Direct Shear Test Result for Unsoaked Alchebaish soil



a: Shear Stress-Horizontal Displacement Relationship



b: Shear Stress-Normal Stress Relationship

Figure (10) Direct Shear Test Result for Soaked Alchebaish soil.

Conclusions:

From the results obtained, the following conclusion may be extracted:-

1. The marshes soils have high collapsibility.
2. Soaking of soils reduced cohesion by approximately (2) folds, while the angle of internal friction exhibited marginal reduction.
3. The value of collapse potential seems to depend mainly on the natural water content and initial void ratio.
4. The collapse potential increases with the increase of void ratio and decreases with increase of water content.

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List of Symbols

c: Cohesion Component of Strength, (kPa)
CT: Collapse Test
DOT: Double Oedometer Test:
Gs: Specific Gravity
L.L: Liquid Limit (%)
P.I: Plasticity Index
P.L: Plastic Limit (%)
T.S.S: Total Soluble Salts
O. C: Organic Content (%)
G. C. Gypsum Content (%)
Gs : Specific Gravity
AS : Soil from Almejar Alkabeer
CS : Soil from Alchebaish
HS : Soil from Alhalfaiya
SO_3 : Total Sulphate Content (%)
ϕ: Angle of Internal Friction (degree)
γ: Unit Weight (k N/m^3)
γd: Dry Unit Weight (k N/m^3)
σ_n: Normal Stress (kPa)
τ_{max} :Maximum Shear Stress (kPa)
wn: Natural Water Content (%)