The Study Based on Collapsible Soils and Their Collapse Potentials in Semnan Desert Area in Iran

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Abstract— Collapsible-soils are numbered among problematic soils in nature that under similar tension and by increasing the ratio of humidity show very high amount of volume shortage. This volume shortage causes smashes in soil's structure and finally causes considerable settlements. The existence of these kinds of soils necessitates more and more consideration and examination of Collapsible-soils behaviors and properties. It's obvious that without considering the Collapsible-soils properties before they are under construction, it can cause irreparable damages. In present research in order to recognition of Collapsible-soils in Semnan deserted province and examination of their collapse potential, 32 points with fine grains soil layers and Aeolian soil have been studied and the relation between the factors in Collapse such as the ratio of humidity and Dry specific weight and so on, with the amount of collapse potential have been studied. In order to evaluate the collapse potential, after the classification of the provided samples of studied points Double consolidated test have been done on undisturbed samples. The results of the tests that have been done, indicate that the samples which belong to 20 points that nearly 85% of them are ML and CL-ML, have got Collapse potential with weak to hard ratio. According to research achievements the majority part of Collapsible soils are located and accumulated in south west of Semnan province.

Index Terms—Submission; Collapsible soil; Collapsial Assesment ; Collapsible Potentials; Semnan desert area;Soil Density; Double consolidation

1 Introduction

Semnan province is a deserted area located in central part of Iran affected with warm and dry air flows. As compare to researches done in different parts of the world an urgent need of the study of Collapsible soils properties in Iran becomes apparent to be more applicable. In this study geotechnical properties and Geotechnical dangers of collapsible-soils, effective factors on collapse and the methods of reparation and improvement of collapsible soils have been examined. Collapsible soils are different in admixtures, mechanical physical properties and the depth of fallen hill and deformation of repose. Generally these soils are recognized by low moisture, high porosity and repose/collapse ability layers.

Collapsible soils are able to bear considerable load. But as soon as the moisture content increases the gap between particles can decreased considerably. In addition to the reduction of bearing capacity appears. Smashes are created in soil's structure that causes considerable settlements. According to present study the

main properties which cause soils to show collapsible specifications themselves are high porosity (>40%), Low saturation ratio (<60%), high amount of Silt (>30%-90%), quick softening subject to water, low specific weight) 11-14 Kn/m3),PI<25 and LL<45.

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Besides the most important factors which effect on examination of collapse potential are dry specific weight, initial moisture content, the difference between the weight content of sand and gravel, plasticity index and coefficient Uniformity, based on the laboratories results, Collapse potential decreases with increasing in initial containing water and increases with increasing in specific weight when soil is humid.

2 CRITERIA FOR ESTIMATION AND EXAMINATION OF COLLAPSE POTENTIAL OF SOILS

Different criteria have been presented for recognition of collapsible soils that the most important of them are as followings

2-1- Ablauf criterion, 1948: In this criterion δs the coefficient of collapse in soil, Δe Reduction of air-void ratio after the saturation of soil, e1: air-void ratio of soil before getting wet.

The in above equation is used for Quantitative examination of the collapse of soil. If it exceeded more than 2%, then the soil is considered as collapsible soil.

2-2- Clonjer criterion, 1959: Clonjer presented a criterion for examination of collapse of the soils based on dry Density of soils.

Table. 1. Index of collapse potential based on Clonjer criterion

γd(gr/cm3)	Collapse potential
<1.28	High collapse potential
1.28-1.44	Medium collapse potential
>1.44	Low collapse potential

2-3- Gibbs & Bara criterion, 1962: Gibbs & Bara suggested the using of Specific weight and liquid limit as a criterion for the separation of the collapsible and non-collapsible soils. Their method is based on the assumption that the soil's cavity has the capacity of the moisture content and liquid limit in saturation state is talented for collapse because of its saturation. This criterion is valid when the soli isn't cemented and also its liquid limit is greater than 20%.

2-4- Denisova criterion, 1964: Denisova used the ratio: e/eLL for defining the collapse of the soil. In this criterion eLL is air-void ratio in liquid limit and e is air void ratio in natural state. In this criterion if , then the soil is collapsible.

2-5- Foda criterian, 1966: Foda has suggested collapse index as below.

Where 'm' is natural moisture, 'sr' is saturation degree, 'PL' plastic limit and 'Pl' is plasticity index.

In this equation soil sample should have critical porosity more than 40% and applied load should be big enough to cause collapse in soil when it is saturated. Besides whenever the collapse index is more than 85%, then this amount shows the soil is semi stable. Critical porosity is such an amount of soil porosity if it increases then the soil is talented for collapse.

2-6- Hendi criterion, 1973: Hendy suggested liquid limit- soil moisture content ratio in saturation state to determine the collapse of soil. If the ratio is less than 1, soil is collapsible

2-7- Jenninger criterion, 1975: Jenninger completed and used the double consolidation test to quantitative examination of soil. Table 2 presents index of collapse potential Intensity based on this criterion. This table shows that soils with the collapse more than 1% are considered as semi-stable soils.

Table. 2. The definition index of collapse problem Intensity

Severity of Problem	Cp(%)
Without problem	1-0
Relatively problematic	5-1
The average problem	10-5
Relatively high	20-10
high	20<

2-8- ASTM standard: In this standard the topic of recognition of collapsible soils began with representing of Holtz Table 3 indicates collapse index classification of ASTM .

Table. 3. The definition index of collapse problem Intensity

Severity of Problem	Cp(%)
Without problem	0
Relatively problematic	2-0.1
The average problem	6-2.1
Relatively high	10-6.1
high	10<

3 Research Method

According to laboratory achievements double consolidation test is the most method for examination of soils collapse or for a quantitative examination of shortage volume status in soil which comes from enhancement in soil moisture. Based on Jenninger & Knight criterion. This test is done with method of ASTM D5333. According to this method, by applying consolidation test on an undisturbed soil sample and the one with natural moisture, the collapse of soil can be determined. For applying the method the soil sample is put on consolidation test ring, as well as the load with step increasing to about 2 kg/cm2 (depends on p=γh Overhead pressure) is applied. In such a pressure, sample is coming into saturated state and can be on its state further for 24 hours. In this experiment, e1 and e2, proportion of empty space before and after soil saturation and natural void ratio (e0) is obtained, which the collapse potential can be defined as the following equation.

In this research in order to recognition and evaluate the potential of collapsible soils , some studies have been done on 32 points in 12 different regions in desert province Semnan. With layers of fine-grained and Aeolian soils.

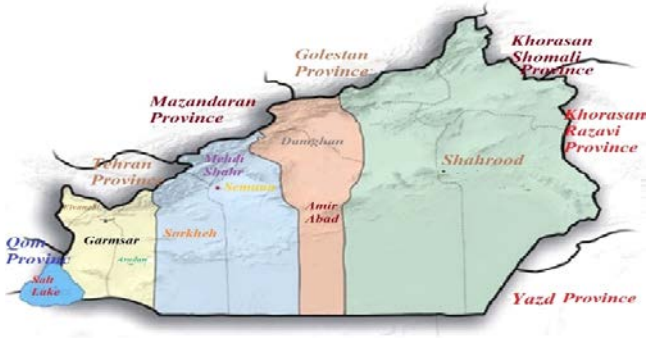

Fig. 1. Study sites in Semnan Province in Central Iran

4 Results and Discussions

To evaluate the collapse potential, after determining the classification of the disturbed soil samples taken from a depth of 0.5 to 12 meters, consolidation testing in accordance with ASTM D5333 method was performed on undisturbed soil samples. Results of tests that are carried out, showed that the specimens belong to 20 studied-points in province have collapse potential with varying degrees and 12 of other points have no collapse potential.

Table. 4. Studied locations in Semnan Province

NO	Location		Number of studied location	Number of studied location	
				with Collapse Potential	No Collapse Potential
1	Garmsar	Garmsar	5	3	2
2	Semnan	Aradan	1	1	0
3		Semnan	9	6	3
4		Seyed Abad	1	0	1
5		Sorkhe	1	1	0
6	Damghan	Damghan	1	0	1
7		Amir Abad	2	0	2
8		Dibaj	2	2	0
9	Shahrood	Shahrood	4	4	0
10		Bastam	2	2	0
11	Mayame	Mayame	2	1	1
12		Kalpoosh	2	0	2
Total			32	20	12

A summary of the results obtained from duplicate consolidation and classification tests carried out on the samples in 20 studied sites of the province that have the collapse potential, has been shown in Table 5. It has been ignored to present the results of 12pt with no collapse potentials due to extension of the information.

Parameters given in table 5 are as follows: USCS: soil classification used by the Unified Soil, Gravel: percentage of Gravel, Sand: percentage of sand, Silt: percentage of Silt, Clay: percentage of clay, LL: liquid limit, PI: plasticity index W: initial moisture content, γd: soil dry density, Cp: collapse potential.

Table. 5. A Summary of the results for Double consolidation test and grading of the samples of studied points

NO	Location	GPS(UTM)		USCS	Gravel	Sand	Silt	Clay	LL	PI	W	γ_d	C_P
		x	y		(%)	(%)	(%)	(%)	(%)	(%)	(%)	(gr/cm³)	(%)
1	Garmsar	621995	3899061	ML	0.0	35.3	57.7	7.0	*	NP	10	1.51	4.70
2	Garmsar	625840	3898043	CL-ML	0.0	11.0	71.0	18.0	23	7	15.2	1.60	0.24
3	Garmsar	622019	3899086	ML	0.0	25.7	65.3	9.0	*	NP	13.8	1.52	2.22
4	Aradan	392669	648672	ML	1.8	40.4	54.8	3.0	16	NP	11.1	1.61	1.46
				CL-ML	0.3	35.0	59.7	5.0	21	5	15.5	1.61	1.33
5	Semnan	719146	3940608	ML	0.0	17.7	75.3	7.0	*	NP	3.1	1.44	8.66
				CL-ML	0.0	10.3	70.7	19.0	19	5	8.8	1.48	5.36
6	Semnan	725745	3941533	CL-ML	0.0	19.7	62.3	18.0	20	6	7.1	1.41	10.65
				CL	0.0	20.9	62.1	17.0	26	10	6.8	1.47	2.01
7	Semnan	717980	3937194	CL	2.7	19.8	63.5	14.0	24	9	13.6	1.49	2.19
8	Semnan	720054	3941197	ML	0.0	22.9	67.1	10.0	17	NP	10.5	1.51	2.70
				ML	0.0	22.5	65.5	12.0	16	NP	7.1	1.47	6.52
9	Semnan	726991	3939505	SM	0.0	54.9	38.1	7.0	22	NP	4.8	1.73	0.19
				CL	0.0	31.4	42.6	26.0	29	13	7.3	1.45	4.02
				CL	0.0	15.9	63.1	21.0	27	11	12.1	1.50	0.78
10	Semnan	719695	3941707	ML	0.0	24.1	72.9	3.0	19	NP	10	1.51	2.20
11	Sorkhe	706424	3926912	ML	5.2	30.7	62.1	2.0	19	NP	4.1	1.45	9.03
12	Dibaje	251847	4035007	ML	0.0	16.8	72.2	11.0	16	NP	9.1	1.50	4.87
				CL	0.2	39.5	46.3	14.0	27	10	12.7	1.54	0.67
13	Dibaje	251656	4034887	CL-ML	0.4	20.7	60.9	18.0	20	5	14.6	1.55	2.53
				CL-ML	1.0	18.0	57.0	24.0	23	7	13.1	1.58	1.23
14	Shahrood	316729	4031038	ML	0.0	36.3	52.7	11.0	*	NP	8.1	1.51	4.66
15	Shahrood	317557	4026296	CL	0.0	14.8	57.2	28.0	26	9	12.3	1.52	0.87
				CL-ML	0.0	14.0	73.0	13.0	20	5	10.9	1.50	5.19
16	Shahrood	316936	4026715	ML	0.0	14.1	74.9	11.0	*	NP	9.5	1.49	4.05
				CL-ML	0.6	9.0	79.4	11.0	23	4	14.6	1.57	0.70
17	Shahrood	318852	4031451	ML	0.0	45.7	49.3	5.0	21	NP	3.2	1.46	5.09
18	Bastam	321211	4039554	ML	1.7	27.6	49.7	21.0	17	NP	6.4	1.47	4.66
				ML	2.4	39.6	49.0	9.0	16	NP	10.5	1.49	4.27
19	Bastam	320773	4039843	ML	3.4	23.3	62.3	11.0	17	NP	6.8	1.48	6.61
				CL-ML	0.0	26.1	63.9	10.0	20	4	11.5	1.51	4.54

20	Mayame	380882	4030665	ML	14.0	35.5	48.5	2.0	17	NP	9.1	1.51	2.20
				SM	4.0	52.4	37.6	6.0	16	NP	11.5	1.70	0.75

According to the information provided in the above table and the calculation of collapse potential using Equation 3, the calculated amount of collapse potential of samples belonging to 20 points, which 50 percent of those layers are ML, 35% has been classified as CL-ML and 15% has the classification of CL layers, are variable between 0.24% to 10.65%; And also with comparison the results of collapse potential (Cp%) with Tables 2 and 3 (Jenninger and Knight criterion and standard ASTM D: 5333) it can be concluded that the soils of studied locations in province, are placed among the soils with poor collapse potential (with no problem) and also with relatively high problems.

One of the most important factors affecting on the collapse potential are initial moisture content and dry density. The Figures 2 and 3 show the effect of initial moisture content and dry density on collapse potential, respectively. In these Figures the results of experimented samples have been shown in three separate groups which have the same classification.

Fig. 2. The effect of dry density on collapse potential

Fig. 3. The effect of dry density on collapse potential

The downtrend in the above figures shows that regardless of the impact of other factors on collapse potential, increasing in dry density and increasing in initial moisture content reduces the collapse potential.

In Figure 4, the Correlation between the particles of sand, silt and clay with collapse potential has been shown. Based on this figure it can be concluded that in the soil with collapse potential, silt content is more than clay and sand. Also there is a possibility of a high percentage of silt as compare to the other particles may be an important factor in the occurrence of the collapse phenomenon.

Fig. 4. The relationship between the percentage of sand, silt and clay particles with collapse potential

Conclusions

In general it can be said that the phenomenon of soil collapse is a kind of a gradual process that can increase evenly by increasing in humidity and its amount depends on the initial moisture content. Besides it has direct

relationship with dry specific weight and applied stress when it is the time of wetting with the rate of increasing in moisture. The collapse phenomenon causes sudden changes in soil structure and generally is irreversible. In other words, after volume shortage of soil, if there is reduction in moisture content, the further collapse won't take place. These type of soils which can be observed in most parts of Iran , the problem of soil settlement especially in the design of surface and groundwater construction are important and should be taken into consideration.

Identifying the soils with collapse potential in 20 studied-points out of 32 studied-points in Semnan province which shows a high risk of hazardous occurrence in the region.

According to the results obtained from Soil Classification tests, half of samples of soil layers are ML, 35 percent of them have CL-ML classification and 15 percent of them are classified as CL.

In fact the silt content is more than sand and clay contents in the studied-tubes, it can be concluded that high percentage of silt is effective in occurrence of the collapse phenomenon.

Collapse Potential varies between 0.24 to 10.65 % in the studied samples. Comparing the values obtained from collapse potential of studied samples with Knight and Jenninger and ASTM D: 5333 the intensity of soil collapse of Semnan
province can be estimated from weak points of the class with no problem to moderately high and high degree.

According to the graphs presented in the text, it can be concluded that the initial moisture content and dry density are two most important factors in reducing the collapse potential.

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