Swelling Pressure and Potential with Atterberg Limits Relation of Expansive Soil

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Abstract

The expansive soils can be founded in various regions and extent areas in the south, middle and north of Iraq. Damage to these soils may appear immediately after construction within five years, or it may take several years until something happen to disturb to moisture structure of the soil. This work aims to find the relation between Atterberg limits, swelling potential, and swelling pressure for five samples. This work is projected to forecast the volume changes in site soil associated with the changes in soil plasticity. The behavior of an expansive soil (bentonite sand mixture) (B-S) subjected to the Atterberg limits test and swelling test were studied. Also, it was found that simple classification tests can provide reasonable estimates of field edges. The potential probability forecasts using the consolidation standard were sometimes low, often as little as possible compared to field observations.
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الخلاصة: يمكن أن نجد التربة الانتفاخية في مناطق مختلفة من جنوب ووسط وشمال العراق. قد يظهر الضرر الذي يلحق بهذه التربة مباشرة بعد البناء في غضون خمس سنوات ، أو قد يستغرق عدة سنوات لاحقة حتى يحدث ما يسبب تغيير في بنية رطوبة التربة. يهدف هذا العمل إلى إيجاد العلاقة بين حدود اتربرك ، وإمكانية الانتفاخ ، وضغط الانتفاخ لخمسة عينات. من المتوقع أن يتنبأ هذا العمل بالتغيرات الحجمية في تربة الموقع المرتبطة بالتغيرات في مرونة التربة. تمت دراسة سلوك التربة الانتفاخية (خليط الرمل البنتونيت) (B-S) الخاضعة لاختبار حدود اتربرك واختبار الانتفاخ. كما وجد أن اختبارات التصنيف البسيطة يمكن أن توفر تقديرات معقولة لمدى المجال. كانت تنبؤات الاحتمالات المحتملة باستخدام معيار التوحيد منخفضة في بعض الأحيان ، وغالبًا ما تكون قليلة قدر الإمكان مقارنة بالملاحظات الميدانية.

1. INTRODUCTION

The future behaviour of rocks and soil depends on several variables, which makes forecasting and analysing the geotechnical behaviour of soils a very complex matter. Therefore, one of the basic steps for designing any engineering project is to perform mechanical calculations for the expanded and overgrown soil for that project. [1], [2]. The type of expansive soil is detected by detecting the number of clay minerals in addition to the properties of plasticity and moisture for that soil with the largest size of the grains and the number of voids in large proportions, which means that they have high compressive properties and low durability and therefore have an unsuitable impact on the structure and the environment. [3], [4], [5]. To ensure that the structure does not fail after the completion of the construction works, it has become necessary to determine the properties of the soil and evaluate the specific criteria for the type of soil and knowledge of soil swelling and its strength characteristics.[6], [7].

Many previous studies dealt with the properties of expanded and swelling soils by studying the strength of compacted hydrophilic clay and its characteristics of the gradation of its grains, properties of plasticity, compression and unconfined compressive strength of expanded soils. [8], [9], [10]. Usually, the swelling percent, swelling pressure, and free swelling ratio are identified as three significant swelling attributes needed for the assessment process of economical designs and safety requirements of structures for engineering projects based on expansive soils. [11]. According to [12], However, in the process of preparing engineering designs and developing construction plans, expansive soils are traditionally considered to be a material with a homogeneous structure with bulging properties which is a property that has a close and consistent relationship to the depth of the soil layer being designed.

2. OBJECTIVE AND PURPOSE

The main purpose of this study is to recognize and identify the effect of expansive soils on structure theought study their characteristics depend on the relation between Atterberg limits, swelling potential, and swelling pressure for five samples.

This work aims to find

The precise aims of the study are as follows:

1. Relation between swelling pressure and potential expansion soil with Atterberg limits.

2. Forecast the volume changes in site soil associated with the changes in soil plasticity

3. EXPANSIVE SOIL

Expansive soil is considered the type of intricate soil which reveals a serious quantity of volume varying upon moistening and drying. The amount of expansion generally grows with the increase in soil's plasticity index [13][14].

It is appropriate to define expansive soil as a kind of soft soil with a wet state. Swelling soil can practically control any type of soil behavior if the amount of clay is more than 5% percent of weight [15].

Several equations have been proposed by different authors to predict [16] the soil swelling potential considering different criteria (e.g., plasticity index, soil activity, clay percent…. etc.), the equations proposed by [16] are presented below as stated by [17] in addition to their own equation:

1. (Seed) in [17] on artificially prepared compacted soil indicates that, for a specified kind of clay mineral, the swelling potential of soil, SP, is having a relationship to its activity. A, and clay content C, by the equation1:

$$SP = k(A^{2.44})(C^{3.44}) \tag{1}$$

Where:

k= a constant for all type of clay minerals = 3.6*10-5

2. (Seed) in [17]also reported that the plasticity index (PI) is the most important factor in forecasting the swelling potential of soils. The final formula of the equation in terms of plasticity index is:

$$SP = kM(PI^{2.44}) \tag{2}$$

Where:

M= constant, 60 for natural soil, 100 for artificial soil.

3. (Nayak and Christensen) in [18] indicate that the swell percent can be best related to the plasticity index, clay content and water content as seen in equation 3.

$$SP = 2.29 * 10^{-2}(PI^{1.45}) * \left(\frac{C}{w.c}\right) + 6.39 \tag{3}$$

Where:

w.c. = soil initial water content

Several trial mixes of bentonite sand were performed. Five ratios of expansive to the sand (10:0, 8.5:1.5, 7:3, 5.5:4.5, 4:6) were selected. At these ratios, the soil remains highly expansive and its permeability is increased with increased sand content.

4. RELATED LITERATURE

Many studies dealt with expansive soil and this paper will present some of these studies, (Ömür) in [19] defined the methodology of how to predict the potential for free swelling and pressure in compact clay, proposing a simple relationship.

While (Mohsen and Abdel Mohsin) in [20] in the ability of the inflation parameters, obtained under the conditions of capacitance scale and three-axis loading, seek to accurately predict the potential soil rigidity. The applicability of the amplitude scale and the three-axis swell data were examined using the results of a field experimental station.

The (Yeliz and Abidin) in [21] results suggest that MB methods yield precise prediction of some properties of soil index, which is easy to apply using simple testing equipment. Results also show that test methods can be applied to soil with different metals on a large scale.

In their article, (Masouda and Mas'ud) in [22] describe the extended soil, whose behavior is amplified and controlled by factors that affect swelling and structural damage. On the other hand, (Lim and Siemens) in [23] were presented in this paper, and improvements were reported in a three-axis swollen organ. SELs were distinguished for two new swelling tumors, and a framework for predicting SEL was developed.

5. RESULTS AND DISCUSSION

The results obtained from all tests included in the testing program are presented and discussed. The results tests are grouped into three main categories. These categories. These categories are Atterberg limits, grain size distribution and swelling test.

A. Grain Size Distribution

Firstly, the grain size distribution test is carried out on five soils. The first to fourth soils are sorted as clay with high plasticity (CH), while the fifth soil is sorted as sand with clay (SC). The grain size classification of all soils is presented in figure 1.
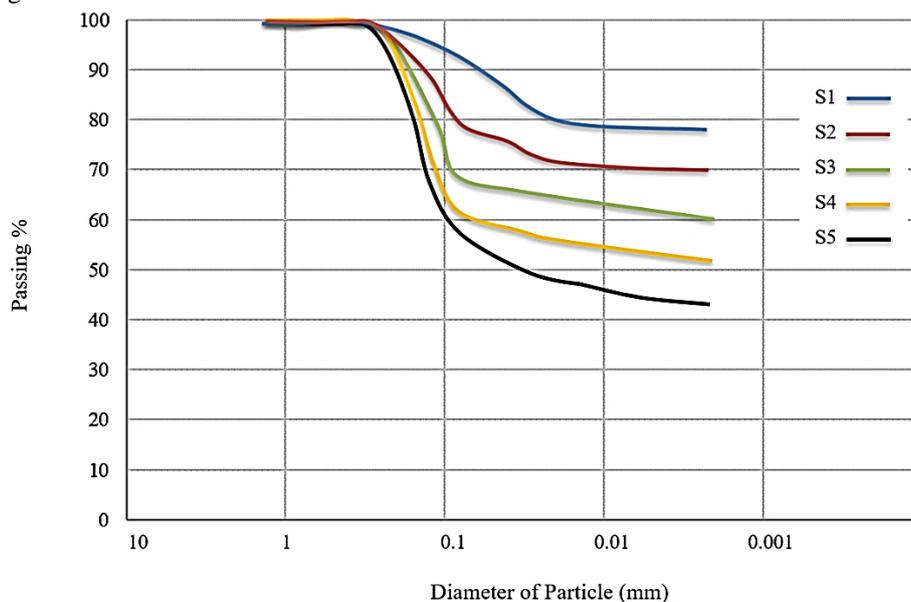

Figure 1. Grain size distribution of all soil.

B.   Atterberg Limits

The results of the liquid limit and plastic limit are obtained for five soils. Also, the plasticity index is calculated by the difference between liquid and plastic limits. All these results are shown in table1.

Table1. Atterberg Limits Results of Five Soils.

Sample No.	Liquid Limit	Plastic Limit	Plasticity index
S1	123	33	90
S2	109	26	83
S3	94	23	71
S4	77	21	56
S5	57	18	39

It can be understood that the plasticity index decreases with an increasing percent of sand and decreasing bentonite content.
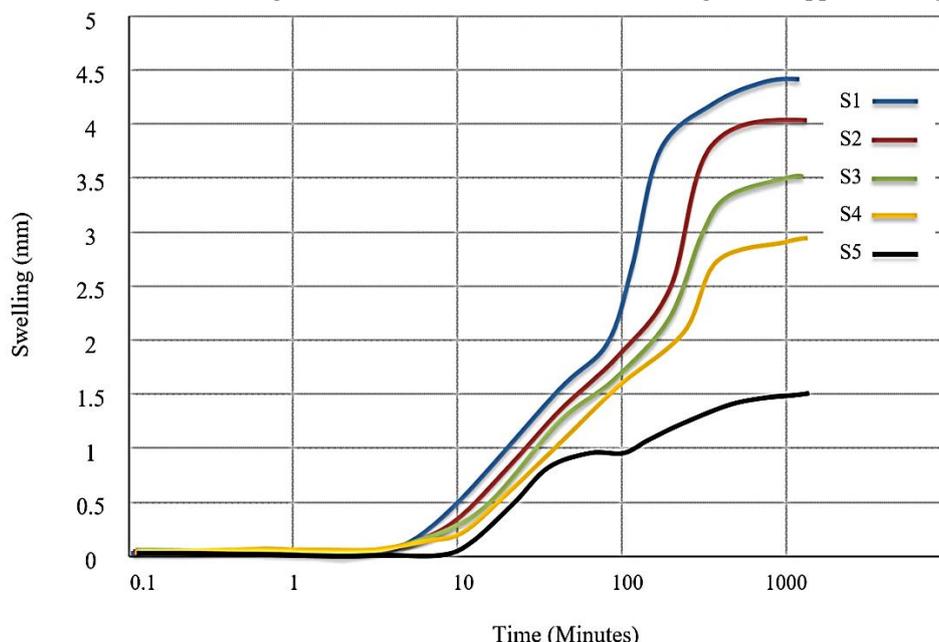
C. Swelling Test

All samples are prepared at a dry unit weight of 13.5 kN/m^3 and water content of 20%. The results of swelling potential and swelling pressure for five soils are shown in table 2. It is clear that the swelling potential and pressure decrease from soil 1 to soli 5 due to a decrease in bentonite content which is caused swelling in soil.

Table 2. Results of Swelling Potential and Swelling Pressure of Five Soils.

Soil No.	Swelling Potential%	Swelling Pressure (kPa)
S1	31.5	350
S2	29	290
S3	25.5	200
S4	20.7	170
S5	11.6	130

The results of swelling potential for five soils are shown in figure 2. It is clear from this figure that soil 1 has a larger swelling potential than other soils. In general, the swelling increases slightly and then begins to increase sharply. At the end of the test, swelling became constant which means swelling in soil approximately stopped.

Figure 2. Time versus swelling of five soils.

C. Relation between Atterberg Limit and Swelling Potential and Pressure

After completing the above tests, we conclude different relations which are:

1. Relation between liquid limit and swelling potential

Figure 3. Shows the relation between liquid limit and swelling potential. We can notice that increase in liquid limit caused increases in swelling potential. The relation has a polynomial curve with R2= 0.99 as shown in this figure 3.
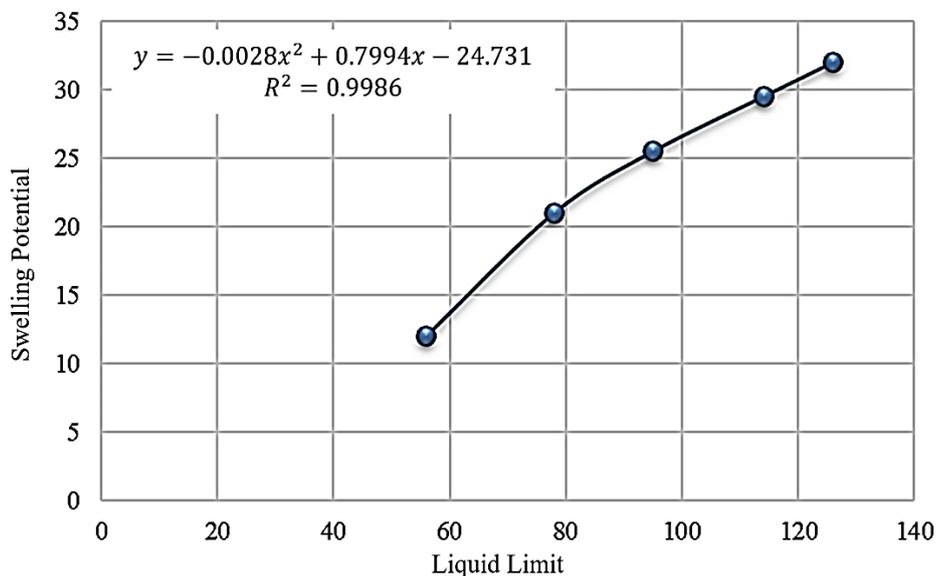

The figure shows:
$$y = -0.0028x^2 + 0.7994x - 24.731$$
$$R^2 = 0.9986$$

Figure 3**.** Relation between liquid limit and swelling potential.

2. Relation between liquid limit and swelling pressure

Figure 4. Shows the relation between liquid limit and swelling pressure. We can notice that the increase in liquid limit caused increases in swelling pressure. The relation has a polynomial curve with R2=0.98 as shown in this figure 4.

The figure shows:
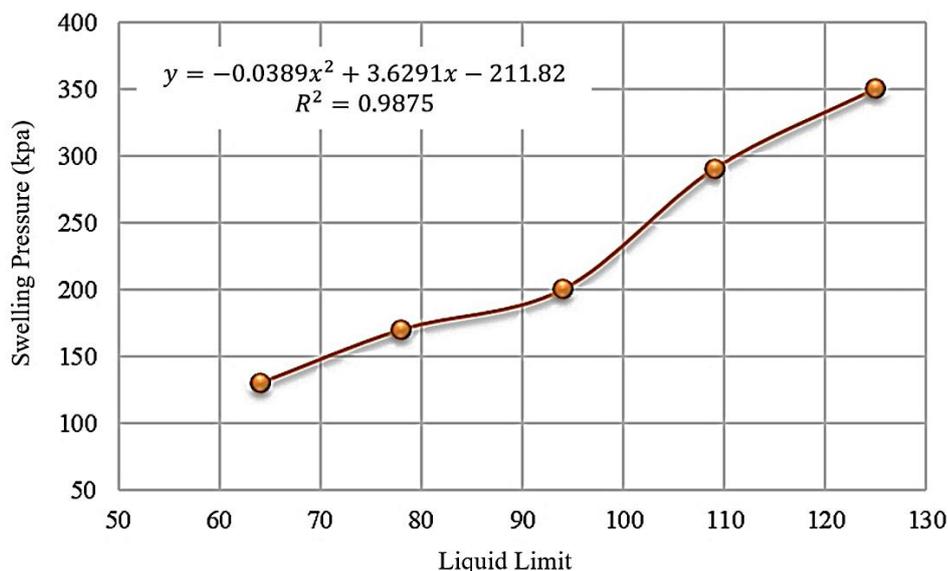$$y = -0.0389x^2 + 3.6291x - 211.82$$
$$R^2 = 0.9875$$

Figure 4. Relation between liquid limit and swelling pressure.

3. Relation between plasticity index and swelling potential

Figure 5. Shows the relationship between plasticity index and swelling potential. We can notice that the increase in plasticity index leads to increases in swelling potential. The relation has a polynomial curve with R2= 0.99 as shown in this figure 5.
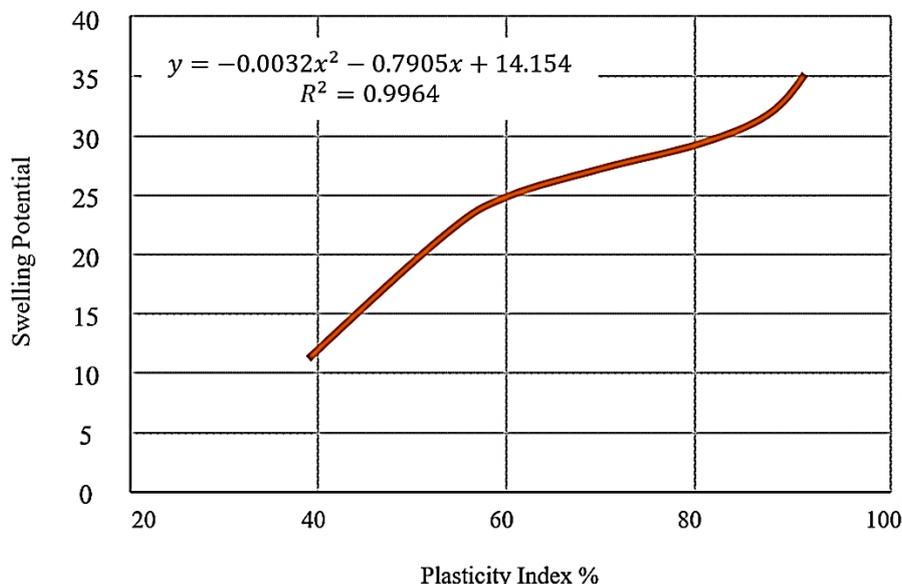

The equation shown on the graph:
$$y = -0.0032x^2 - 0.7905x + 14.154$$
$$R^2 = 0.9964$$

Figure 5. Relation between plasticity index and swelling potential.

4. Relation between plasticity index and swelling pressure

Figure 6. Illustrates the relationship between plasticity index and swelling pressure. We can notice that the increase in plasticity index caused increases in swelling pressure. The relation has a polynomial curve with R2=0.98 as shown in this figure 6.
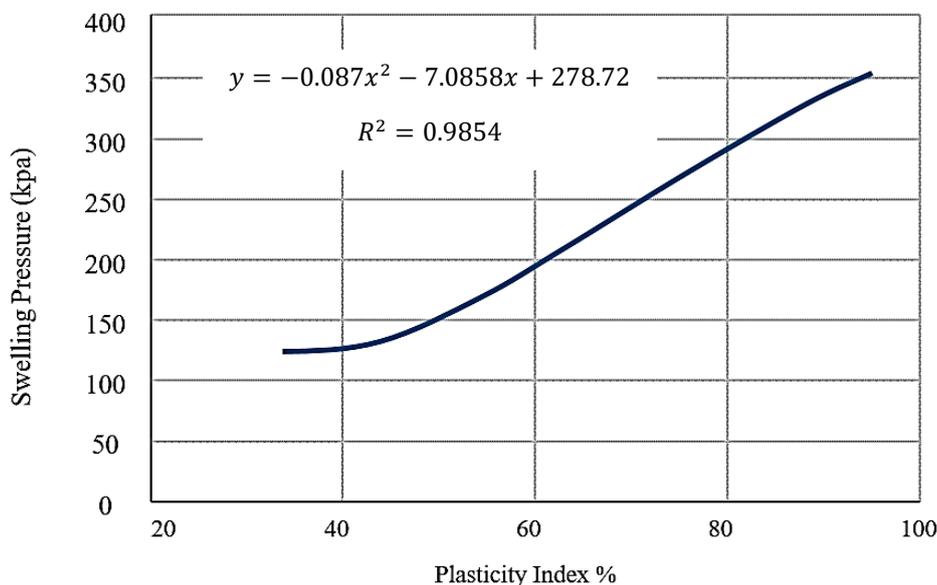

The equation shown on the graph:
$$y = -0.087x^2 - 7.0858x + 278.72$$
$$R^2 = 0.9854$$

Figure 6. Relation between plasticity index and swelling pressure.

6. CONCLUSIONS

According to the experimental results, the research can be summarized in the following conclusion:

1. The plasticity index decreases with increasing percent of sand and decreasing bentonite content.

2. The swelling potential and pressure decrease from soil 1 to soil 5 due to a decrease in bentonite content which is caused swelling in soil.

3. The increase in liquid limit and plasticity index   leads to increase in swelling pressure and potential

4. In general, the relations between Atterberg limits and swelling potential and pressure are polynomial curves with R2= (0.98-0.99).

5. It should be noted that the sign of plasticity (P.I) is only an indicator, but there are other factors that determine the susceptibility of the soil to bloating such as soil structure, as well as the depth of the swell layer, which are responsible for the extent of movement on the surface of the earth.

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