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Field Measurement of Swelling Pressure

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Abstract

The aim of this work is to evaluate and assess the swelling pressure of soils in the field using a new portable, low cost device, which was released through the task accomplished here. An empirical correlation curve is developed relating the "soil swelling pressure" to the "dial reading" obtained from the Swell Measuring Field Device (S.M.F.D.), which is presented in a graphical form to simplify its use.

القياس الحقلي لضغط التربة الأنتفاخي

الخلاصة

من خلال هذا البحث تم التوصل الى تصنيع جهاز محمول يمتاز بالتكلفة الواطئة لتقدير وتخمين الضغوط الانتفاخية بسرعة في الحقل. من خلال التجارب العملية استحصلت علاقة وضعيه تربط الضغط الانتفاخي للتربة بقراءة الجهاز وقد مثلت هذه العلاقة بشكل يسهل استخدامها.

Introduction

In many parts of the world, serious damages occurred in structures founded on expansive clayey soils due to moisture content increase of the clayey soil foundation causing it to swell and by so exerting additional forces on the structure that were not anticipated in the design. Foundation members have been damaged and unexpected movements of the structure have occurred (***Komornik and Zeitlen 1970***).

Numerous and widely different methods have been proposed in previous studies for the characterization of expansive soils in the laboratory for the purpose of predicting their behavior under field conditions. These methods can broadly be divided in two types: direct and indirect methods (***Zein 1987***).

The aim throughout this work is to release a simple low cost portable device that can evaluate soil swelling pressure directly in the field.

Experimental Work

Materials

The soil used in this work was brought from Abu-Dsheer site in Baghdad area, from a depth of about (1m) below natural ground surface. The soil was mixed with different percentages of bentonite (5%, 10%, 20%, and 30%) by weight of it in order to adjust the swelling properties of the natural soil. Table 1 shows the physical properties of the natural soil and figure 1 shows the grain size distribution of the soil used.

Sample Preparation

To prepare samples, the soil was oven dried for 24 hours and

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mixed with the predetermined amount of bentonite, then the required amount of water was added and mixed thoroughly. The soil was then compacted in the compaction mold of known dimensions, (105mm) in diameter and (115mm) in height, following the standard compaction method ASTM D (698-78). The mold was lubricated with a thin oil film in order to minimize the effect of mold side friction on the compaction process. The soil was placed into three successive equal layers and each layer was compacted by a specified number of blows. After that, the soil sample in the mold was left for 24 hours to obtain uniform moisture distribution throughout the soil. Different percentages of water content were tried with a different number of blows to obtain different densities. For each sample density two identical samples were prepared. One was used to determine the amount of swelling using the (S.M.F.D.), while the other was used to evaluate the swelling pressure using standard constant volume test. A sharp edged ring, (75mm) diameter and (19mm) height, was pressed into the compacted soil in the mold to obtain oedometer samples. The swelling pressure was evaluated according to the procedure recommended by Head (1982), and with the aid of the standard oedometer device.

The Swell Measuring Field Device (S.M.F.D.)

The Swell Measuring Field Device, used in this work, is portable and very simple both in design and manufacturing. It consists of the following parts:

- a fixed metal disc made up of cast iron and has enough weight to remain in a stable position throughout the test,
- three legs to support the metal disc,
- a dial gauge holder,
- a sliding ram,
- a moveable disc which is attached to the bottom end of the sliding ram and is in contact with the soil to be tested, and
- a dial gauge.

Figures 2 and 3 illustrate the device showing its different components.

Calibration Tests of the (S.M.F.D.)

I-Swelling Pressure Test

The readings obtained from the (S.M.F.D.) have to be related to the swelling pressure of the soil. This was achieved through planning a testing program where identical samples were undergoing two different schemes of tests. One of each of the identical samples had to be tested in the standard oedometer test to evaluate its swelling pressure, while the second sample of each twin samples was tested using (S.M.F.D.) to obtain the device reading. Later on, a calibration curve could be established. In this work, the swelling pressure was determined using the constant volume test. The oedometer apparatus was used to test samples at constant volume. In this test, a seating pressure of 7 kPa was first applied to the sample and the dial gauge was adjusted to zero reading. Water was then added to the sample and as the sample began to swell, gradual stress increments were added thus increasing the pressure on the sample up to a level that would maintain the dial gauge back to zero reading. The test was in accordance with the procedure described by Head (1982).

II-Swell Assessment using the (S.M.F.D.)

The (S.M.F.D.) under consideration was assembled and as shown in figure 3. A sample corresponding to that tested in the oedometer is used here , which is also prepared in a standard compaction mold having a diameter of (105 mm) and a height of (115mm) .The collar of the mold was placed after placing plenty of grease along its lower rim. The sample is placed below the (S.M.F.D.) having its centroid coinciding with the apparatus sliding ram, then the moveable disc is adjusted to rest properly on the soil sample surface and the dial gauge is adjusted too. After that the sample is flooded with water and the dial reading was recorded after 24 hours.

Presentation and Discussion of the Results

Since the main aim of this work is focused on the development of a device capable of measuring the swelling pressure in the field, the experimental work was mainly concerned with finding a relationship which correlates the swelling pressure obtained from standard constant volume test, using the standard oedometer, with the corresponding swell readings obtained from the (S.M.F.D.). Twenty-two pairs of specimens were tested under different conditions to define, in a graphical form, the swelling pressure-device reading relationship and as illustrated in figure 4. Examining figure 4 and using proper statistical approach, an empirical formula can be obtained from the plotted data and as follows:

$$SP = 6.5 (R+1)$$

where,

SP: swelling pressure (kN/m^2).

R: (S.M.F.D.) reading (mm).

Conclusions

This newly released device is a portable handy device for measuring the swelling pressure in the field and to get a reasonable estimation for the value of the expected swelling pressure for expansive soil through the established calibration curve .An empirical formula was released relating the field device reading to the expansive soil pressure ,which makes it easy and quick to calculate soil pressure directly in the field .

References

1. Annual ASTM Standards", Annual Book of the American Society for Testing and Materials", Part 4, 1989.

2. Head, K.H.,"Manual of Soil Laboratory Testing", Vol. 2, Pentech Press Publishers, London, 1982.

3. Komornik, A., Zeitlen, J.G.,"Laboratory Determination of Lateral and Vertical Stresses in Compacted Swelling Clay", Journal of Materials, Vol. 5, No. 1, pp. 108-128, 1970.

4. Zein, A.K.M.,"Comparison of Measured and Predicted Swelling Behaviour of a Compacted Black Cotton Soil", 6th. Int. Conf. on Expansive Soils, New Delhi, India, pp. 121-126, 1987.

Table 1: Physical Properties of the Natural Soil and Bentonite Used.

Property	Type of Soil	
	Natural Soil	Bentonite
Liquid Limit, L.L., %	58	125
Plastic Limit, P.L., %	22	73
Plasticity Index, P.I., %	36	52
Linear Shrinkage, L.S., %	16.14	*
Specific Gravity, Gs	2.71	2.65
% Passing Sieve # 200	97.92	100
Clay Content (% < 0.002mm)	22	100

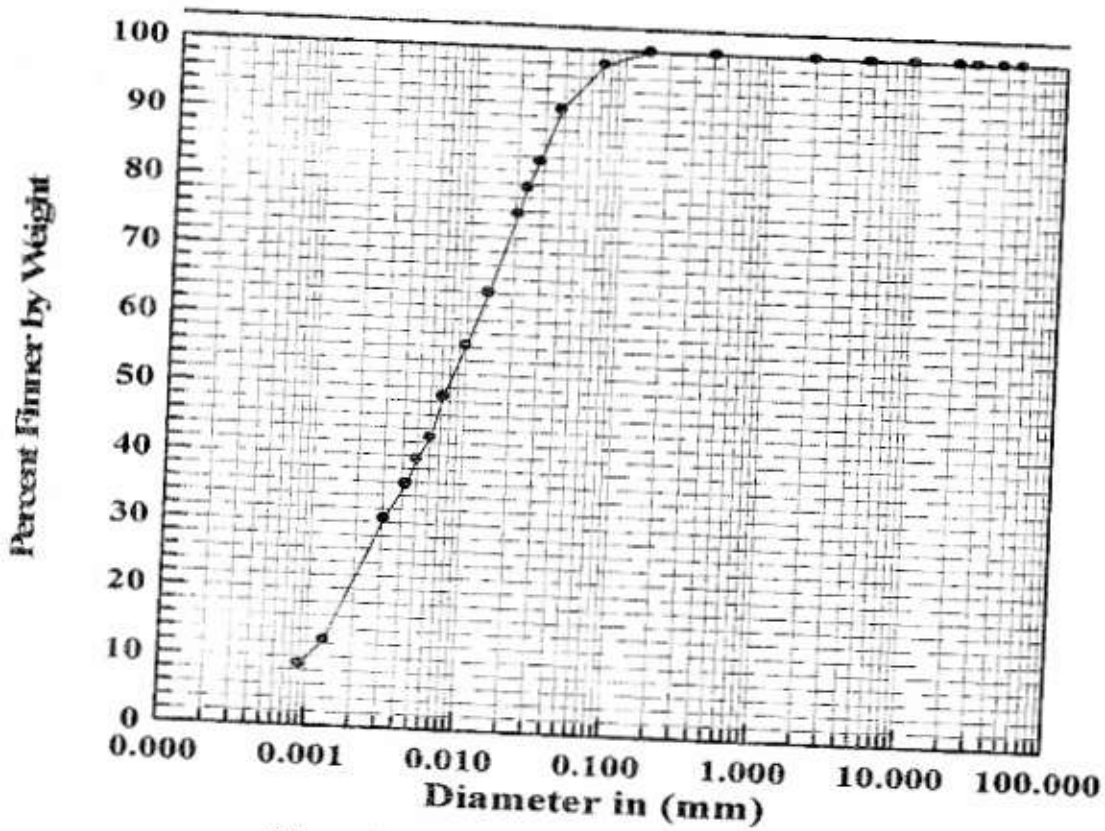

Figure 1:Grain Size Distribution of the Soil Used.

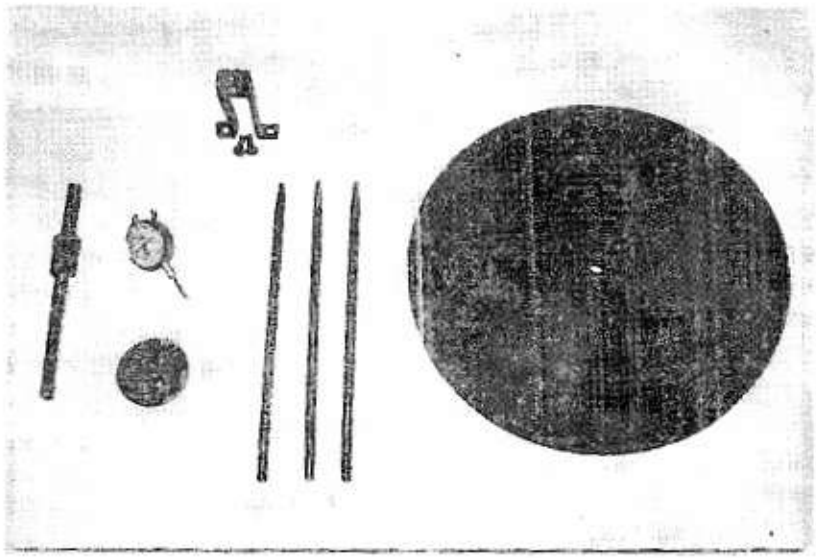

Figure 2: Parts of the Swell Measuring Field Device.

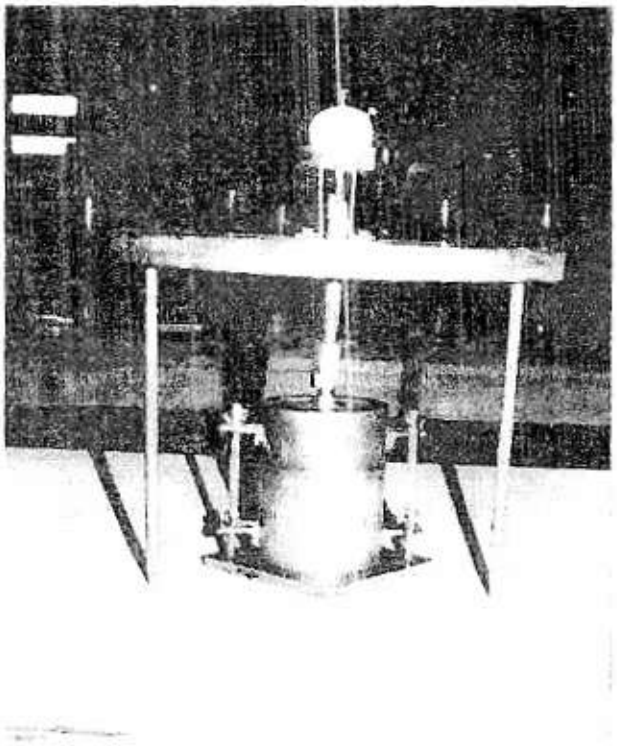

Figure 3: Swell Measuring Field Device.

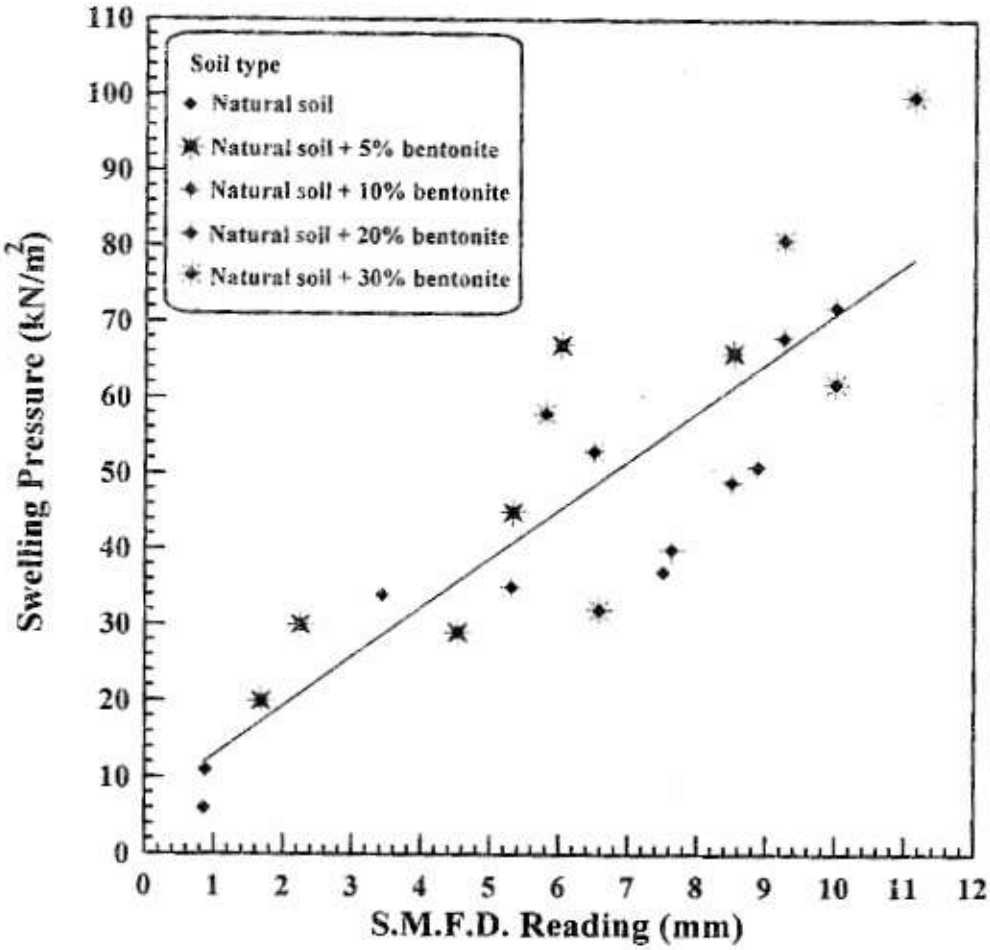

Figure 4: Calibration Curve of S.M.F.D.