TEMPERATURE EFFECT ON SWELLING SOILS

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1- INTRODUCTION

At present there is a consensus among geotechnical engineers that the problem of interaction between structures and expansive soils is one that has not as yet been fully resolved. The drastic changes in the characteristics of expansive or swelling soils upon exposure to moisture and temperature changes is the main cause of the complex problems facing the civil engineer.

There is documented evidence (Jones, 1973) that the damage caused to structures by expansive soils amounts to billions of dollars annually. There is extensive literature with regard to the behavior of the expansive soils and the extent of the damage they cause (e.g. Godfrey, 1978; Kantey, 1980; Gromko, 1974; Neill and Poormooyed, 1980). Basically, the solution to the problem of foundations on expansive soils cannot be achieved without an understanding of the fundamental characteristics of expansive soils and the variables involved that affect the swelling phenomenon. Such knowledge is a perequisite for making an important contribution to the solution of the problem. The many physical and environmental factors that contribute to the expansive nature of a soil include clay minerals, soil density, natural water content, plasticity index, surcharge pressure, temperature, and time of exposure to environmental factors.

This research was undertaken to study of temperature effect on the amount and rate of swell. The data and the analysis in the following

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sections reveal the extent to which the aforementioned objective has been realized.

2- EXPERIMENT INVESTIGATION :

In view of the fact that temperature affects the swell potential of expansive soil, it was necessary for the purposes of this investigation to control the temperature to which the soil specimens were subjected, and absolutely essential to keep the temperature applied to the test specimens at constant level, during the entire process of swell measurement.

Usually the test period for each specimen range from four to five weeks, then, two temperature - controlled triaxial cells built at the University of Hanover, were slightly modified to accommodate unidirectional free swelling test sample, 65mm. diameter and 25 mm, high, as shown in fig. 1. A swell mold, which is shown in fig-1, sits inside the temperatur - controlled chamber and allows the soil specimen to absorb water from the top and bottom boundaries and to deform only in the vertical direction.

The temperature control unit is located on top of the chamber, fig. 1. the temperature is regulated by a thermostat that has an on-off difference of about 0.5°c. The sensing bulb of the thermostat is fixed under the chamber top plate and submerged in water in the chamber during the test.

The bulb is also connected to the thermostat indicator and control box by a capillary tube which passes through an airtight bushing mounted on the top plate. The temperature indicator and control box are mounted on an insulated shelf which extends from the top plate. An electric relay switch is mounted alongside and supplies electric current to a resistance heater whenever the thermostat bulb indicates that the temperature in the fluid has fallen below that set on the thermostat control.

The heating element extends through a bushing in the top plate and is submerged in the test - chamber water. To ensure uniform temperature distribution within the chamber, electrically powered mechanical agitator keeps the water in the test chamber circulating. The system is capable of maintaining uniform temperatures, as evidenced by cheeks on the temperature of the water in the test chamber. At 65°c the temperature is controlled to about ± 1°c. At lower temperatures the variation is somewhat less.

3- SOIL PROPERTIES :

This investigation was necessary to have a large number of test specimens as near to identical as possible. This condition could be met only by having carefully prepared soil samples in the laboratory. The number of variables also could be minimized if soil with know physical and mineralogical composition were used for the preparation of the test samples to achieve these requirements, Sodium montmorillonite and silica sand were mixed in different proportions to obtain samples with varying degrees of potential expensiveness.

Table 1. Gives the mineralogical composition for the tested soil.

Composition	Percent By Weight
Silica, Sio_2	60 - 62
Alumina, Al_2O_3	21 - 23
Ferric Oxide, Fe_2O_3	3 - 4
Sodium Oxide, No_2O	2.5 - 2.7
Magnesium Oxide, MgO	2 - 3
Colcium Oxide, CaO	0.5 - 1.5
Potassium Oxide, K_2O	0.4 - 0.45

Table 2. shows six soil samples representing six different soil types, each with a different degree of potential expansives. All volume changes that may occur in these soils in the presence of moisture are assumed to be contributed totally by the clay, as no volume change is expected from the sand. The soils were tested for their consistancy limits, and the results are shown in Table 2.

All test results for all samples except sample (1), which was nonplastic, will fall above the A-line in the plasticity chart, in the region of high plasticity.

4- TEST PROCEDURE :

All samples are mixed with water at their plastic limits. The soils are placed in the swell mold and compacted to the maximum density as per modified proctor. The soil and swell mold are placed in the temperature - controlled chamber and the sample vertical movement is measured by dial gauge attached to the aluminum rod resting on top of the specimen. Three different testing temperatures were chosen during this investigation (25°c, 35°c and 65°c).

Table 2. Results of Consistency Limits

Sample Number	Sand %	Clay %	Liquid limit	Plastic limit	Plasticity Index
1	40	60	289	16	273
2	55	45	258	17	241
3	60	40	228	18	210
4	65	35	190	18	172
5	70	30	165	19	146
6	75	25	150	19	131

5- TEST ANALYSES AND INTERPRETATION

Amount of free swell : Free swell is defined as the volume change of soil test specimen upon inundation without restrain or applied pressure. It is assumed that the amount of vertical pressure (about 0.16 psi) exerted on the soil due to the weights of the top porous stone, the top cap and the aluminum rod is negligible. The free swell curves shown in Figs (2), (3) and (4) were obtained by plotting free swell (%) against elapsed time, for all the soil samples tested at 25°c, 35°c and 65°c respectively.

It is noticed the curves corresponding to different temperatures and different samples are similar in shape even though they exhibit differences in the amount and rate of swell. The maximum free swell is found to occur at 40 days for all soil samples. The maximum amount of swell is 65°c temperature, but the minimum free swell occurred at 25°c temperature.

The maximum free swell occurred for soil sample (1), (40% sand + 60% clay), and the minimum occurred for sample (6), (75 sand + 25% clay). The amount of swell increased by 20% and 30% when the temperature were increased from 25°c to 35°c and 65°c respectively.

From these results it is evident that the test temperature has a noticeable effect on the amount of swell, Figs (5) and (6). It is also observed from Fig. (7) that the amount of swell increases linearly the liquid limit and time. This affect has to be taken into consideration when analysing soil swell problems.

6- CONCLUSIONS :

Swelling characteristics of swelling soil formed of montmorillonite clay and silica sand mixtures were experimentally investigated. The soil mixtures with liquid limits less then 100% were not susceptible to expansion.

It was found that the amount of soil swell is effected by the test temperature. The amount of swell increased by 20% and 30% when the temperatures were increased from 25°c to 35°c and 65°c respectively.

Therefore, in order to estimated the amount of swell of a given soil in the field, the laboratory swell tests on the same soil should be conducted at temperatures similar to those that previal in the field.

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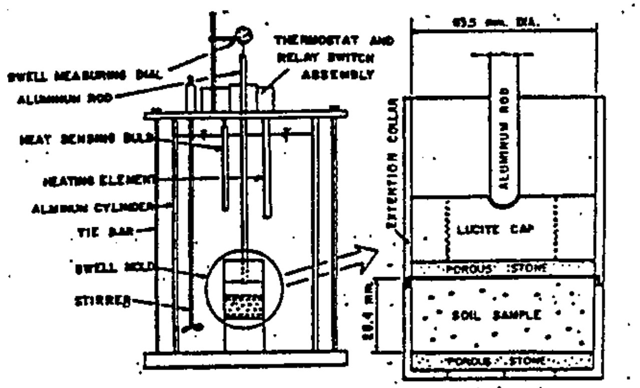

Fig (1) Swell Test Apperatus

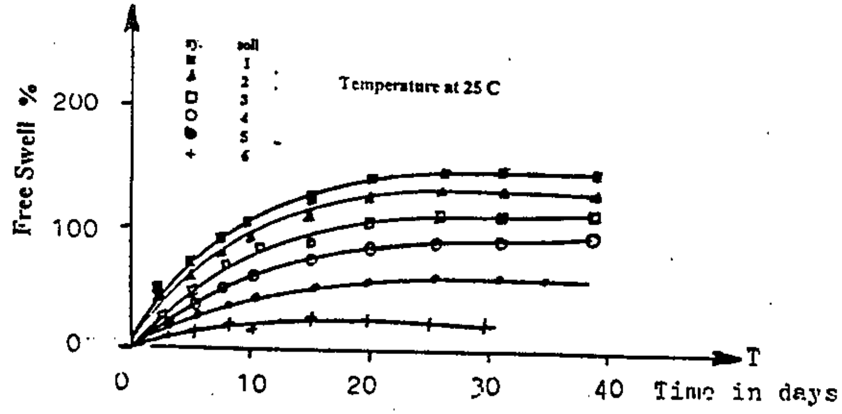

Fig (2) Free Swell Curves at Temperature 24 C.

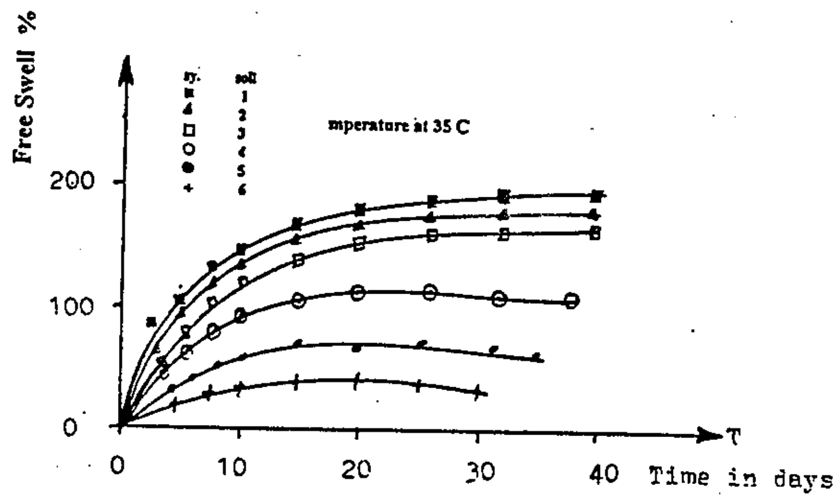

Fig (3) Free Swell Curves at Temperature 35 C.

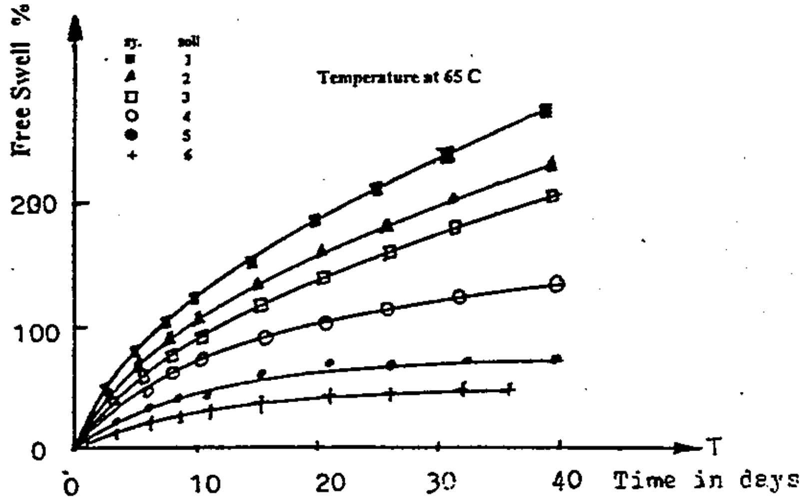

Fig (4) Free Swell Curves at Temperature 65 C.

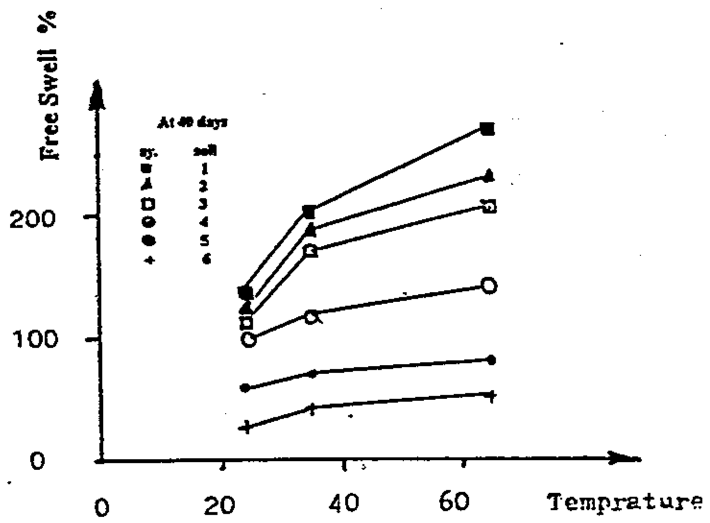

Fig (5) Relation Between Free Swell and Temperature at Time 40 Days.

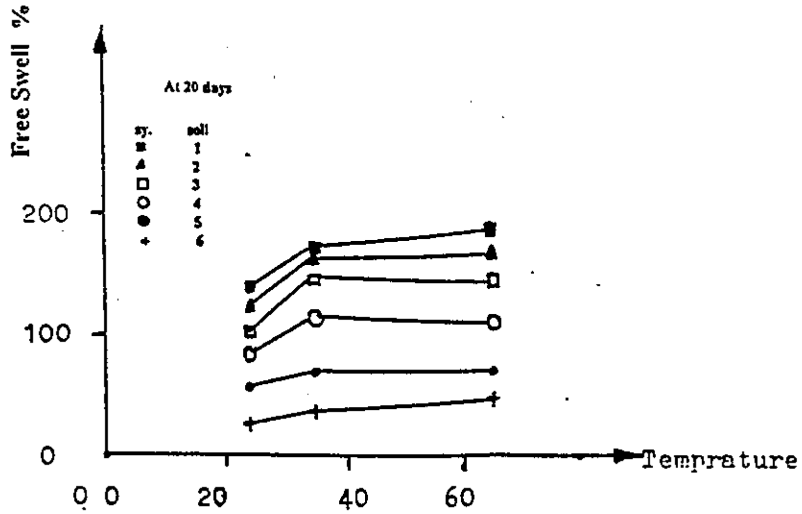

Fig (6) Relation Between Free Swell and Temperature at Time 20 Days.

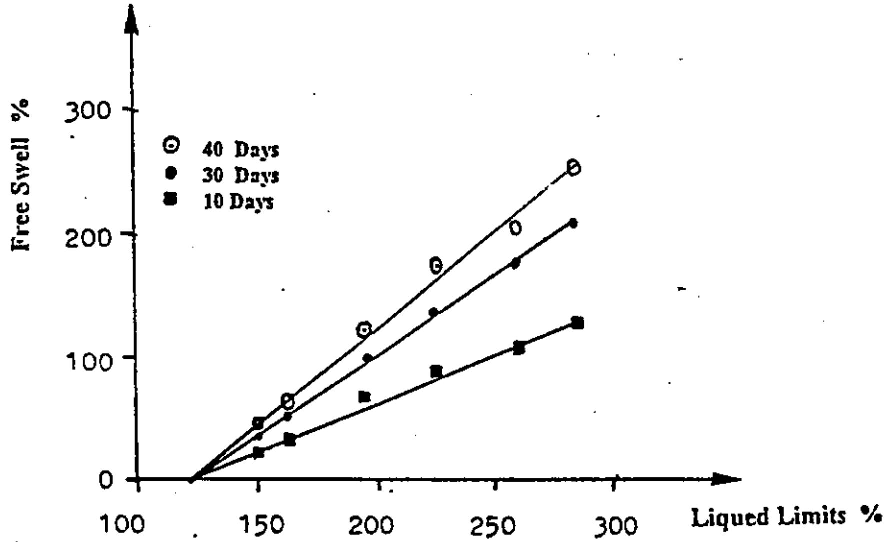

Fig (7) Free Swell and Liquied Limit Relationship at 65 C