EXPERIMENTAL STUDY OF UNIAXIAL SWELLING OF CLAY IN TIME

ETUDE EXPERIMENTALE DU GONFLEMENT UNIAXIAL D'ARGILE AVEC LE TEMPS

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SYNOPSIS

Uniaxial swelling tests of Tertiary clay lasting 247 days were carried out on two samples. The curve describing relationship between the magnitude of swelling and time plotted in semilogarithmic scale acquires after certain time a straight character, which allows a simple mathematical expression using a coefficient of swelling B. The longtherm character pf swelling was also proved.

INTRODUCTION

It has been frequently observed slopes of cuts in clay, keeping their stability for several years, suddenly failed, even when no change of external factors (e.g. groundwater level) took place. After a failure slopes keep their stability again with a new slope gradient, smaller than the original one. In an area, investigated by the author, slopes of cuts were stable, if the slope gradient was at least 1:3.

Undisturbed samples of clay were taken from the depth of 6,5 metres, where the overburden pressure was 1,3 kp/cm2. Index properties of the clay were: liquid limit w_l = 82,8%, plastic limit w_p = 28,46 %, and plasticity index I_p = 54,34 %. Grain sizes corresponding to the weight percentage of 10, 20....% (called d_{10}, d_{20},.....) were: d_{10}=0,001mm, d_{30}=0,0021mm, d_{50}=0,004mm, d_{70}=0,0073mm, d_{80}=0,015mm, d_{90}=0,0245mm, d_{100}=1,00 mm.

Two clay samples, both 50 mm high, were loaded in an oedometer by the original overburden pressure 1,3 kp/cm2, to which they were exposed in situ. Under this load the samples consolidated about a month. Sample No.1 settled 0,31 mm, while sample No.2 settled 0,47 mm. After the consolidation period both samples were completely unloaded and left for swelling under free access of water. The course of swelling in time was recorded, as shown on Fig.1.

The swelling curve, plotted in semilogarithmic time scale, had at the beginning a waving character, which changed into one or two straight lines after a time of about 7 days. The swelling effect could be than described by an equation

$$\Delta h_t = h \cdot B \cdot \log t$$

where h means the original height of the sample, B is a coefficient of swelling defined as

$$B = \frac{\Delta h_{10}}{h \cdot \log 10}$$

where Δh_{10} is the magnitude of swelling during a period of 10 minutes, t denotes time.

The coefficients of swelling B were found for the sample No.1 as B_1=0,006 min^{-1}, B_2=0,0113 min^{-1} and for the sample No.2 as B_1' = 0,006 min^{-1}, B_2'= 0,0101 min^{-1}.

When loaded by the pressure of 3 kp/cm2 the sample No.1 settled 0,31 mm. After unloading the sample reached its original height by swelling in 57 minutes. The sample No.2 settled under the same load about 0,47 mm. Swelling after unloading returned the sample to its original level in 180 minutes.

A further swelling, lasting 247 days, raised the sample No.1 2,53 mm(i.e.5,06%) above its original height. Sample No.2 rose by swelling 2,62mm, i.e. 5,24% of its original height.

The porosity before swelling was with the sample No.1 n_1= 43,5%, while after swelling it rose to n_2= 46,1 %. The difference was

$$n_2 - n_1 = 46,1 - 43,5 = 2,6 \%.$$

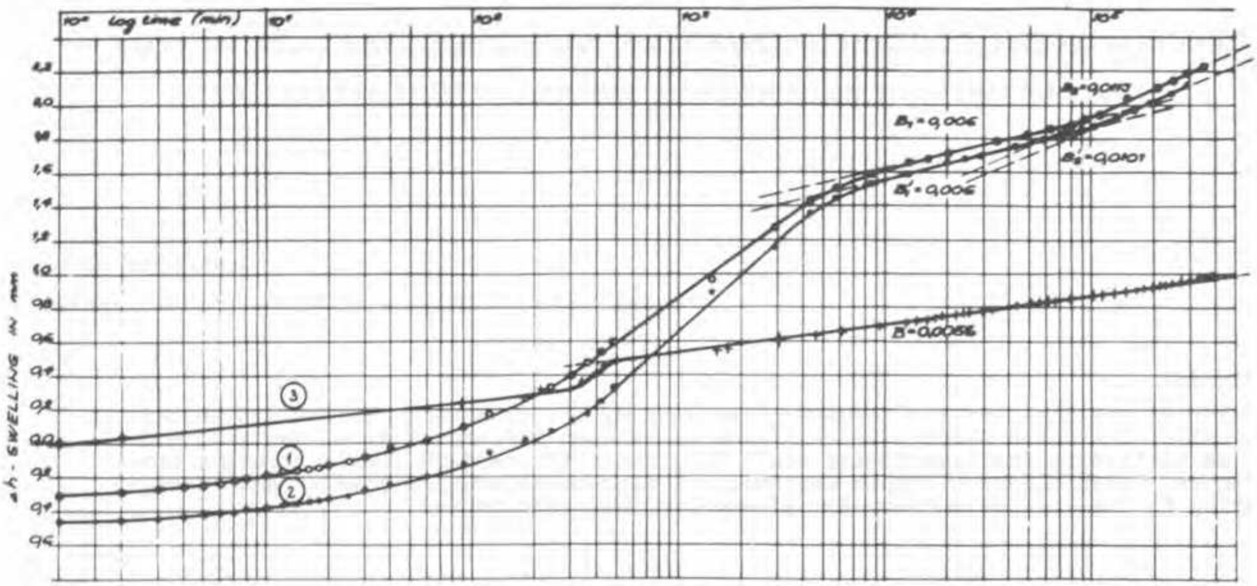

Fig.1. Swelling curves

The same with the sample No.2 gave values of n_1=45,4%, n_2=47,7% and n_2-n_1=47,7-45,4= =2,3%.

Another sample of clay, sample No.3, with the original height of 30 mm,was loaded in oedometer by a pressure of 8 kp/cm2. Its settlement reached 1,57 mm. After unloading the sample was left for swelling under free access of water. Graphical record of the swelling against time in semilogarithmic scale becomes a straight line, when a time of 500 minutes elapses. The coefficient of swelling obtained from this test was $B=0,00566 min^{-1}$. The swelling of that sample, lasting 278 days raised its top 1,45 mm, which was still less than the previous compression caused by the pressure of 8 kp/cm2.

The experimental tests of swelling, lasting 247 and 278 days, clearly indicated the swelling effect has not ceased even after so long time. Swelling is a longterm phenomenon, however the derived equation does not fit for the extreme value of time $t = \infty$.

Explanation of the swelling effect might be found in the fact, that molecules of water are attracted against the surface of solid particles,where create unfree water.

A soil in situ is swelling as far as a depth, in which the swelling pressure equals the overburden pressure. If the over - burden pressure is higher than the swelling one,there is no swelling. The swelling pressure can be found in a laboratory, when a series of identical samples, loaded by various pressures, is being left under the loads for swelling. Samples with applied pressures smaller than the swelling pressure should swell, while samples loaded with higher pressures should settle down. Plotting the magnitudes of swelling or settlement against the values of applied pressure a straight line can be obtained . Its intersection with the "applied pressure axis " determines the value of swelling pressure. In the investigated case (Fig.2) the swelling pressure was found as 1,4 kp/cm2 .

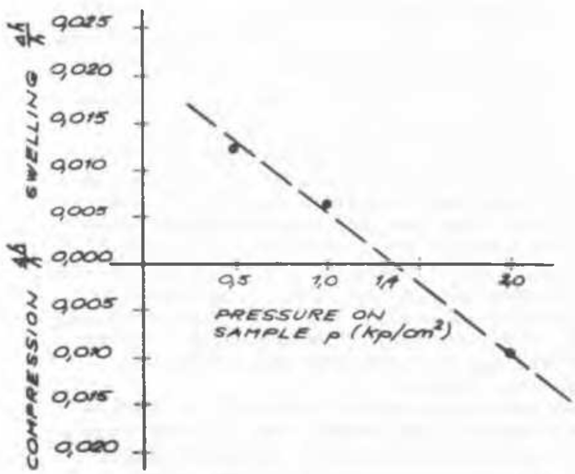

Fig.2. Swelling Pressure

CONCLUSIONS

Swelling of clays is a longterm phenomenon. Due to a swelling the porosity and moisture content increase, while shearing resistance decreases . Slopes of cuts, keeping their stability for years, may fail suddenly due to a loss of shearing resistance by swelling. Failures of foundations, caused by a swelling effect, have also been recorded .

REFERENCES

1) Myslivec A., Eisenstein Z., Užití bobtnavých jílů na inženýrské stavby Bratislava, Inženýrské stavby 1965/3

2) Feda J., Colloidal activity, shrinking and swelling of some clays . Proc.of the seminar on soil mechanics and foundation engineering, June 1964, Lodž .