Oedometer laboratory testing report essay sample

1. 0 INTRODUCTION

Long term settlement in clayey soils has posed a challenge to engineers for literally thousands of years. Predicting this settlement is not an easy task, but by analysing the soil on the proposed build site, engineers can get a better understanding of how the soil will react under compression, what needs to be done to make the soil suitable and whether it is worth building on the site at all. Knowing how soil on a potential building site will react under compression is essential for obvious reasons. Apart from possibly damaging the structural integrity of a building in extreme cases, settlement can also cause unsightly cracks and other faults that affect the serviceability of the construct. Consolidation is the gradual reduction in volume of a fully saturated soil of low permeability. Consolidation occurs due to the generation of an excess pore water pressure. Totally consolidation is achieved when the excess pore pressure in the soil is completely dissipated. [1] (Craig's soil Mechanics, 7th edition). In simpler terms, consolidation is the compression of a soil due to an increase in the effective stress and the removal of water from the soil.

This increase in effective stress of the soil can be caused by a building foundation or other loads on the soil. Consolidation causes settlement of the soil (Consolidation settlement) due to deformation or relocation of soil particles. . Two types of consolidation settlements can be identified;

•Primary consolidation settlement: This involves the reduction of volume of a saturated soil due to excess pore pressure being generated. Primary consolidation takes place very rapidly. (As soon as the soil is loaded)

•Secondary consolidation settlement: This type of settlement involves the reduction of volume due to the adjustment of soil particles. Secondary consolidation settlement occurs much slower providing an ideal period for predicting the rate of settlement. Other factors influence the consolidation of a soil. These factors include; the stress history (Pre-consolidated pressures), void ratio (Permeability), degree of saturation, and the structure (Nature/Homogeneity) of the soil. The Oedometer test investigates the 1-D consolidation behaviour of fine grained soils. In this experiment, a soil sample of clay will be subjected to a compressive stress by applying a constant vertical load for a duration of 24 hours whilst recording at time intervals. The compression is recorded using a highly sensitive dial gauge.

2. 0 AIM

The aim of this experiment was to investigate the consolidation and swelling process of a sample of clay by using a simple odometer test to gather settlement data and then using it to calculate parameters such as voids ratio, consolidation parameters, constrained modulus, permeability and the consolidation coefficient of the soil. 3. 0 METHODOLOGY

4. 1 Apparatus

The following equipment was used during the consolidation test;

* An undisturbed soil sample (Clay)

* A consolidation ring: Used to hold the soil in place

* Two porous plates : These allow the flow of water out of the soil in two directions (2-way drainage) * A water jacket : This provides a constant supply of water to prevent settlement due to drying * A loading device : The loading device consist of a frame, a lever and a dial gauge * Metallic weight :

Different weights are used on the loading device to provide different effective stresses * An oven : An oven is required to dry the consolidated sample, so that its moisture content can be measured * A stopwatch : The consolidation process is timed using a stopwatch * An electronic balance : Used to measure the mass of the sample at different intervals 4. 2 Setup

A. Consolidation Instrument

Image shows a Modern Consolidation machine. The safety valve, weight hanger and gauge . an be identifeied. Image shows a Modern Consolidation machine. The safety valve, weight hanger and gauge . an be identifeied.

Weight Hanger

Weight Hanger

Safety valve (Screw)

Safety valve (Screw)

Dial gauge

Dial gauge

B. Consolidation pathways

The image shows 2-way drainage of the soil. Settlement is allowed only in 1 direction

4. 3 Procedure

* The mass and height of the soil and ring was measured using an electronic balance and a measuring tape respectively. * The gauge of the loading device was zeroed and the sample was placed in it. * Water was added to the water jacket to prevent drying of the soil sample. * The safety valve of

the loading frame was activated (Screwed upward to touch the lever arm) and the first weight (Load) was mounted on the frame. * The safety valve was released and the stopwatch was started. * The dial gauge on the loading instrument was read at different time intervals. The timing was done using the stopwatch. * After measuring the settlement (Reading the dial gauge) for 24 hours, the safety jack was activated and the final gauge reading is recorded. * The load was doubled, the safety valve was released and the next set of gauge readings was taken. * After a week of compression analysis, half the load was removed and swelling was allowed to occur. Gauge readings were taken at the same intervals as compression for the first 30 mins. * After 30 mins the load was reduced again and the process repeated. * Once swelling analysis was completed, the soil sample was weighed then placed in the oven to dry. * After the 24 hours of drying, the dry soil mass was measured. * All raw data was tabulated.

4. 4 Precautions

The following precautions were taken to reduce the amount of errors obtained; * The water level in the water jacket was checked every day to prevent the drying of the soil. * When adding the load on the instrument, the new load is added before removing the previous load. This prevents the soil from swelling during the swapping process. 4. 0 RESULTS/CALCULATIONS

All calculations were hand written and can be found in the appendix along with all raw data tables. Below is a table of the main parameters of the soil sample that were found. Cc| 0. 11|

Cs| 0. 34|

σv, max'| 165 kPa|

cv| 27. 65mm2/s|

5. 0 DISCUSSION

6. 5 Voids ratio, consolidation parameters and pre-consolidation pressure

Once all raw data was collected, the first calculations were done to determine the void ratio for each effective stress increment. The following equation was used: ΔHH0=Δe(1+e0)

The data and sample calculations are available in tables in the Appendix. The voids ratio was then plotted against the vertical effective stress (Appendix G) on a log graph to produce a compression curve for the soil. The graph showed a clear relationship between voids ratio and effective stress, as compression increases, voids ratio decreases. This can be explained as the reshuffling and rearranging of particles within the sample. Because soil particles will not deform unless under tremendous pressure, as the effective stress is increased, the soil particles move into the voids present in the sample. It is assumed that the soil is fully saturated, meaning as the soil particles fill the voids, water is displaced and consolidation takes place.

Looking at the compression phase of the plot, there is a distinct change in the gradient. The point where it changes is known as the pre-consolidation pressure, and indicates the highest effective stress that the soil has undergone prior to the current compression. It marks the transition from the recompression line (over consolidated soil) to the virgin compression line (normally consolidated soil). The pre-consolidation pressure for our soil was found using hand drawn construction lines shown on the graph in the appendix and was determined to be 165kPa. The consolidation parameters for the soil were also determined from the slopes of the recompression and virgin compression line. The compression index was 0. 34 and the swelling index was 0. 11. Considering that the typical values of the compression index of normally consolidated clay range from 0. 2 to 0. 5, the results of our investigation are reasonably accurate.

6. 6 Constrained modulus, coefficient of consolidation and permeability

The constrained modulus refers to the stiffness of the soil in one dimension. The formula for constrained modulus is: E’0=Δσ’vΔHH0

The constrained modulus was calculated for each loading increment. Once again the data was plotted on a graph which is available, along with the calculations, in the appendix. There was a clear trend in the data for the loading phase of the investigation, as the effective stress increased, so did the stiffness. This is also clearly illustrated in the equation used to calculate the constrained modulus. For the fourth loading increment (400kPa), the settlement was plotted against the square root of the time (Appendix ?) with the aim of calculating a coefficient of consolidation. The coefficient of consolidation was calculated using the following formula:

Where d is the furthest distance to the drainage boundary, and tx was calculated by projecting a line from the linear part of the settlement curve, then finding the time at which it crosses the horizontal line representing the final settlement. This method produced a value of 27. 65mm2/s. Another formula used for calculating the coefficient of consolidation is:

By equating these two calculations and substituting in all known values, a permeability value of 42. 56×10-6 m/s was obtained. Simply by looking at the equation above, you can deduce that permeability will not remain the same over each load increment. It is clear that the permeability and constrained modulus have an inversely proportional relationship. As explained previously, as the effective stress increases (stiffness is proportional) the voids of the soil are filled by the soil particles. The soil becomes more tightly packed and there are less voids for water to travel through, thus reducing the permeability of the soil.

6. 7 Error Analysis

The results and trends displayed in our experimental data indicate that it is fairly accurate, but there were also a number of different sources of error that would have had a significant effect on the results. The first and probably most significant was basic human error. When the new load was first imposed on the soil sample, the gauge moved quickly and the time intervals were fairly rapid making it hard to make accurate readings. This was only augmented by the fact that the gauge spun backwards during consolidation. Error was also present in the hand drawing of the graphs and using construction lines to obtain specific values from these graphs. In all calculations, the soil was assumed to be saturated. This greatly simplifies many calculations, but in reality, soil is rarely ever 100% saturated. The actual degree of saturation before and after consolidation was calculated and was 98% and 94% respectively. Error in the instruments is always a possible source of inaccuracy but in this case it cannot be explicitly said to have had an impact.

6. 0 CONCLUSION

It can safely be said that the initial aims of the investigation were completed. Settlement data gathered from the odometer testing was used to calculate and analyse the key parameters of the clay. A number of significant relationships between these parameters were identified. In conclusion, a successful investigation into the settlement of clay was completed.

7. 0 REFERENCES

Craig soil mechanics 7th edition

Evaluation and interpretation of soil consolidation test by Carl B. Crawford

Evaluation of consolidation parameters of cohesive soils by Rohit Raj (August 2007)