Influence of Load Duration and Load Ratio on Preconsolidation Pressure

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Abstract

Preconsolidation pressure is a very important parameter, which describes the stress history and affects the behavior of the cohesive soil in geotechnical engineering. Many graphical methods have been suggested by researchers for determining preconsolidation pressure, these methods include, Casagrande, Schmertmann, Butterfield, Janbu, Tavenas, Van Zelst, old method, and Senol and Saglamer method.

For this research, a comparison was studied between a known preconsolidation pressure and that obtained from all graphical methods. The influence of load duration and load ratio on preconsolidation pressure was also studied in this research.

It has been found that, the method of Tavenas gives the best results of preconsolidation values as compared with the results of the other methods. The value of preconsolidation pressure is affected by load duration, and the values of preconsolidation pressure predicted with load duration of 24 hours are about 10% more than these obtained with 7 days duration load. The value of preconsolidation pressure increased as load ratio decreased, the rate of increasing was about 8% when load ratio decreased from1 to 0.5.

الخـلاصـــــة

ضغط الانضمام المسبق هو عامل مهم جدا في وصف تاريخ الاجهادات ويؤثر على سلوك الترب المتماسكة في هندسة الجيوتكنيك. عدة طرق تخطيطية تم اقتراحها من قبل الباحثين لحساب ضغط الانضمام المسبق، هذه الطرق تتضمن Casagrande, Schmertmann, Butterfield, Janbu, Tavenas, Van Zelst, Old, Senol and Saglamer

أجريت دراسة مقارنة بين قيمة معلومة لضغط الانضمام المسبق وتلك المحسوبة من كل الطرق.كذلك تأثير فترة التحميل ونسبة التحميل تم دراستها في هذا البحث.

لقد وجد إن طريقة (Tavenas) تعطي أحسن نتائج لضغط الانضمام المسبق مقارنة بنتائج الطرق الأخرى. قيمة ضغط الانضمام المسبق تتأثر بفترة التحميل، وأن القيم المحسوبة خلال فترة تحميل 24 ساعة كانت بحدود 10% اكبر من تلك المحسوبة خلال فترة تحميل 7 أيام. ضغط الانضمام المسبق يزداد كلما قلت نسبة التحميل، وأن نسبة الزيادة هي بحدود ٨% بين نسبتي تحميل 1 و 0.5 .

1. Introduction

Any soil in the field at some depth has been subjected to certain maximum effective over burden pressure in its geological history. This value can be obtained from laboratory oedometer test results. Generally the preconsolidation pressure ($\sigma'c$) in the field differs from that obtained from laboratory tests. Das [1] showed that the ($\sigma'c$) obtained from the laboratory tests was more affected by disturbance of sample, load duration and load ratio. Carwford [2] found that, the void ratio decreased as the time of loading increased. Lennards and Atschaeff [3] showed that, the void ratio decreased as load ratio increased. The first step of the present work is to review the existing methods of estimation of the preconsolidation pressure. The second step, involved systematic laboratory test with known ($\sigma'c$). In the third step, a comparison is made between the ($\sigma'c$) obtained from all the methods and the known ($\sigma'c$). The fourth step, involved the study of the difference between ($\sigma'c$) obtained from load duration of 24 hr. and 7 days. The final step is studying the difference between ($\sigma'c$) values obtained from two increment load ratio ($\Delta P/P = 1$ and $\Delta P/P = 0.5$).

2. The Methods of Determining Preconsolidation Pressure

A geological estimate of the preconsolidation pressure is very uncertain. Casagrande (1936) [4] and Schmertmann (1953) [5] developed methods for determining ($\sigma'c$). **Figure (1)** and **Fig.(2)** show the graphical procedure of these methods respectively. Senol and Saglamer [6] presented other methods of estimating ($\sigma'c$), these methods are:

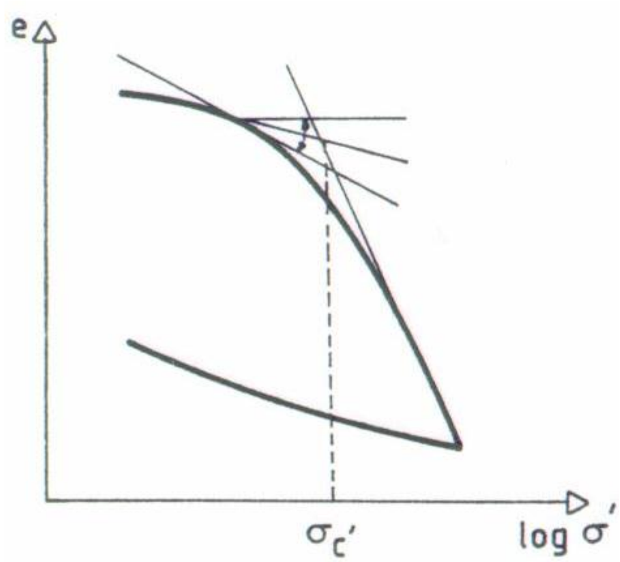

Figure (1) Casagrande method

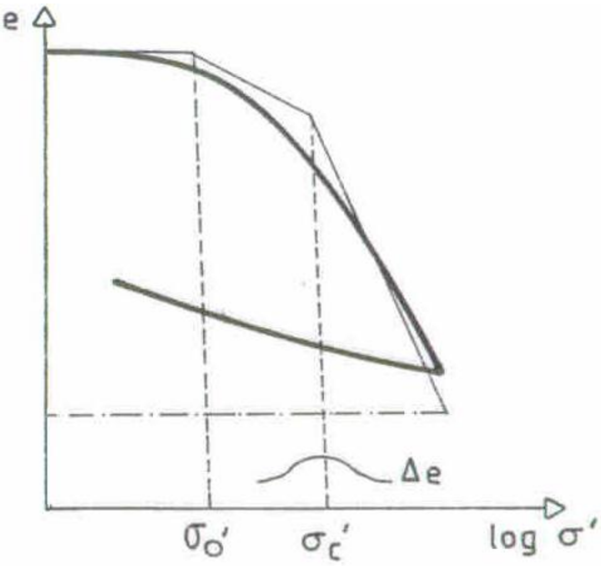

Figure (2) Schmertmann method

2-1 Butterfield Method

Figure (3) shows the plot of (ln(v)- log σ') which represents the graphical procedure of this method. This plot has three inclined lines (ab, bc, and cd). The abscissa of point c represents the value of preconsolidation pressure.

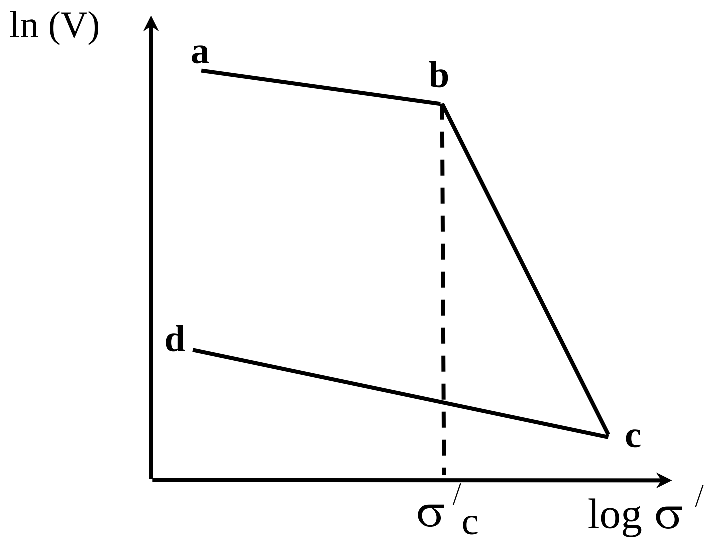

Figure (3) Butterfield method

2-2 Janbu Method

In this method the value of the preconsolidation pressure can be found from the plot of ($\Delta H/H - \sigma'$). As shown in **Fig.(4)**, the value of (σ') at the inflection point defines the preconsolidation pressure.

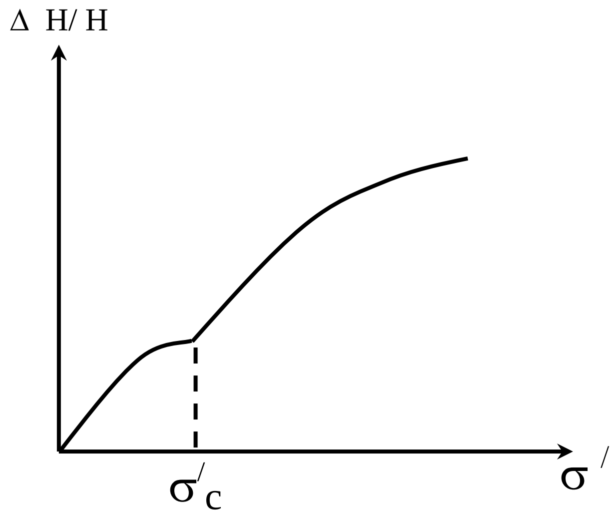

Figure (4) Janbu method

2-3 Tavenas Method

To obtained the preconsolidation pressure from this method, the values of ($\sigma^{/}$ ΔH/H) are plotted versus the values of ($\sigma^{/}$) as shown in **Fig.(5)**. This plot consists of two inclined lines, the preconsolidation pressure is the value of pressure at the intersection point.

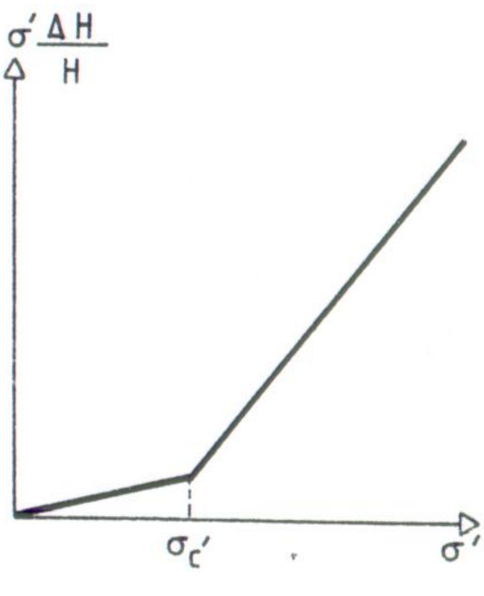

Figure (5) Tavenas method

2-4 Van Zelst Method

The graphical procedure of this method is shown in **Fig.(6)**. The slope of the line (ab) has approximately the same slope of rebound curve (cd). The abscissa of point (b) represents the preconsolidation pressure.

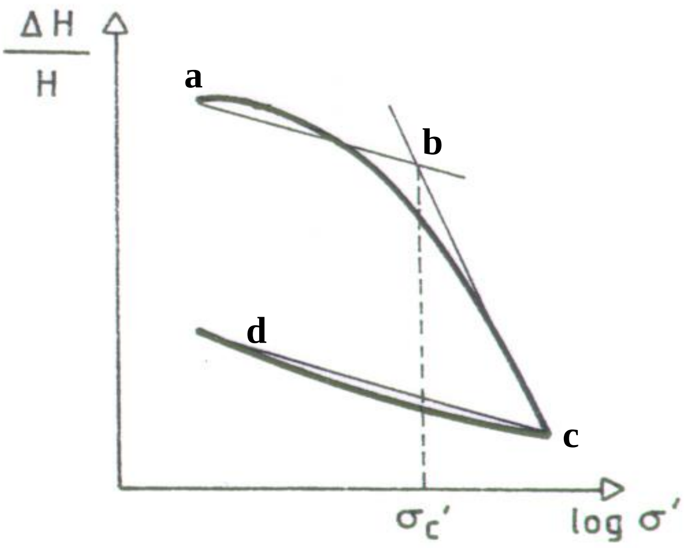

Figure (6) Van Zelst method

2-5 Old Method

The main difference between this method and Van Zelst method is the slope of the line (ab). As shown in **Fig.(7)**, the line (ab) represents the tangent line of the initial curve of the plot (ΔH/H – log σ′).

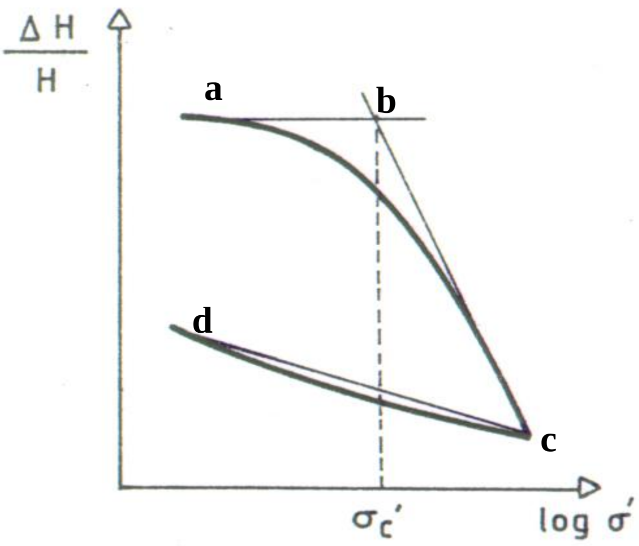

Figure (7) Old method

2-6 Senol and Saglamer Method

The plot of (σ ΔH/H – log σ′) has three phases as shown in **Fig.(8)**. Phases (1) and (3) are linear while phase (2) is curve. The abscissa of point of intersection between the extensions of phases (1) and (3) represents the preconsolidation pressure.

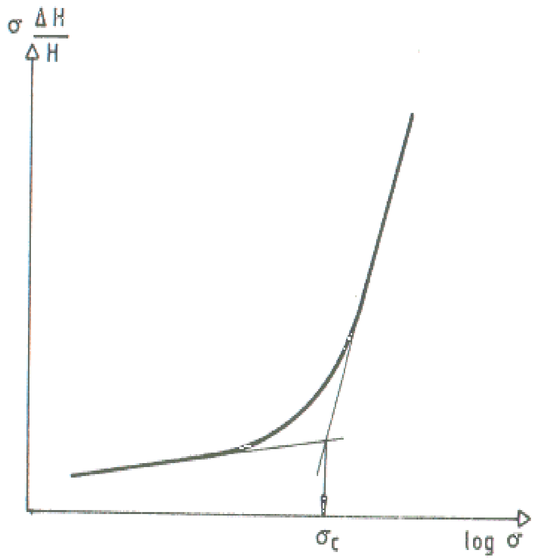

Figure (8) Senol and Saglamer method

3. Experimental Work

A disturbed samples of clay soil obtained from Al-Shaab city in Baghdad, was used in this study. More than 75 samples were prepared in the ring of the oedometer device. These samples were divided into five groups according to the known preconsolidation pressure, load duration, and load ratio. The samples of the first three groups were consolidated up to pressures of 100 kPa, 200 kPa, and 300 kPa, then these pressures were released and standard consolidation tests were started. Each increment was maintained for 24 hours and the ratio of each increment to the applied load ΔP/P was equal to unity. The fourth group was consolidated up to a pressure 200 kPa, and then released, the consolidation test were started with duration load of 7 days and ΔP/P = 1. The final groups also consolidated up to a pressure of 200 kPa but after pressure released, the consolidation tests were started with standard duration load of 24 hours but the load ratio was (ΔP/P) =0.5. **Table (1)** shows the details of all groups.

Table (1) Details of experimental work

Group No.	1	2	3	4	5
Number of samples	15	15	15	15	15
Known pressure	100	200	300	200	200
Load ratio	1	1	1	1	0.5
Load duration	24 hr	24 hr	24 hr	7 day	24 hr

4. Comparison between the Methods of Determining Preconsolidation Pressure

Depending on the experimental work of this study, **Table (2)** shows the average values of the preconsolidation pressure of many tests that obtained from all the methods of determining ($\sigma'c$). It can be seen that all the methods give values of preconsolidation pressure less than the known ($\sigma'c$). In order to choose the best method of determining ($\sigma'c$), **Fig.(9)** shows the plot between ($\sigma'c$) obtained from all the methods and the known ($\sigma'c$). It can be seen that. Tavenas method is the best method of estimating ($\sigma'c$) as compared with the other methods.

Table (2) The average values of ($\sigma'c$) obtained from all the methods compared with the known values

The known (σ'_c)	100	200	300
Casagrande method	75	150	235
Schmertmann method	80	160	245
Butterfield method	70	140	230
Janbu method	80	165	240
Tavenas method	90	185	270
Van Zelst method	70	145	240
Old method	65	135	230
Senol and Saglamer method	85	170	250

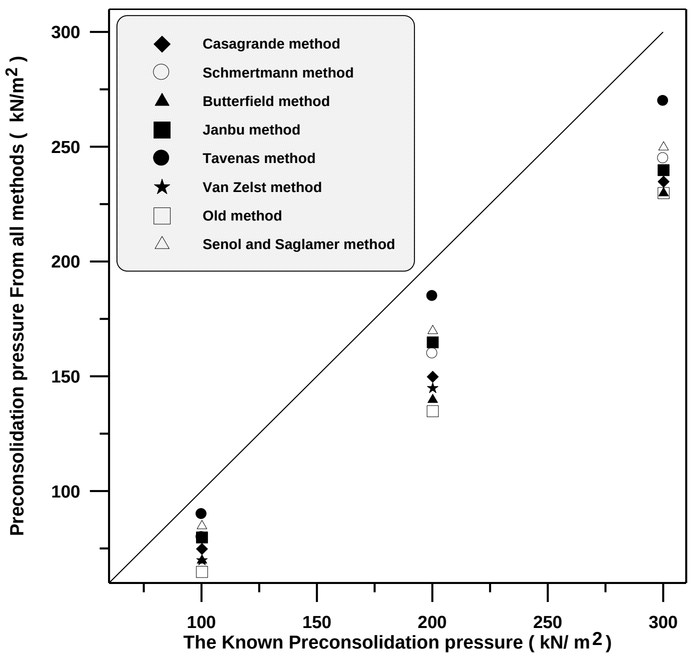

Figure (9) The plot of the average values of ($\sigma'c$) obtained from all the methods and the known values

5. Effect of Duration Load on the Preconsolidation Pressure

Table (3) shows two values of preconsolidation pressure, the first value represents the average preconsolidation pressure when the duration loads of 24hr., while the second value depends on duration load of 7 days. It can be found that the values of (σ'_c) predicted from duration of 7 days is about 10% less than that obtained from duration load of 24 hr., since the deformation of the soil sample in the consolidation test increases as the time of load increased.

Table (3) Average values of preconsolidation pressure with two duration load

Load ratio	No. of tests	Average values of (σ'_c)	Standard deviation
24 hr.	15	145	4.2
7 days	15	130	5

6. Effect of Load Ratio on the Preconsolidation Pressure

Two values of (σ'_c) are shown in **Table (4)**, the first value represents the average values of (σ'_c) when the load ratio ΔP/P =1, while the other represents (σ'_c) when the load ratio ΔP/P =0.5. It can be seen that, the value of (σ'_c) at load ratio ΔP/P =0.5 is about 8% more than the value of the load ratio ΔP/P =1.

Table (4) Average values of preconsolidation pressure with two load ratios

Load ratio	No. of tests	Average values of (σ'_c)	Standard deviation
ΔP/P =1	15	145	4.2
ΔP/P =0.5	15	160	7.3

7. Conclusions

1. The values of the preconsolidation pressure obtained from all the methods of estimation are less than the known values.
2. Tavenas method is the best method for determining the preconsolidation pressure.
3. The values of the preconsolidation pressure derived from duration load of 7days are about (10%) less than these obtained from duration load of 24hr.
4. The preconsolidation pressure is increased as the load ratio decreased. The preconsolidation pressure with ΔP/P =0.5 is about (8%) more than the value obtained with ΔP/P =1.

8. References

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