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Compressibilty Charactereistic of Irbid Clay, Jordan

[Omer S. Mughieda]

***Abstract*—The magnitude of preconsolidation pressure plays important role in civil engineering practice. Effect of preconsolidation should be considered in settlement and stability problems. In this study laboratory tests have been conducted in order to investigate the preconsolidation pressure of Irbid clay. Several methods have been employed to investigate the range of preconsolidation pressure. Laboratory tests have indicated that Irbid clays are overconsolidated due desiccation. This conclusion has been reached because overconsolidation ratio decreased with depth until it becomes one at certain depth; this means that only the top layers are overconsolidated which can be due only to desiccation. Also, it was concluded that the most convenient method to determine the preconsolidation pressure of Irbid clay is Casagrande method as compared with other examined methods.**

***Keywords*—preconsolidation pressure, Casagrande method, Schmertmann method, minmum possibe presconsolidation pressure**

I. Introduction

A soil deposit that has been fully consolidated under a pressure (σ'_c) larger than the present overburden pressure (σ'_o) is said to be overconsolidated, and (σ'_c) is called the preconsolidation pressure. The magnitude of preconsolidation pressure plays an important role in civil engineering practice. It should be considered in settlement and in stability problems; the preconsolidation pressure in soil strata is of paramount importance in choosing a foundation system for support of a structure. If such preconsolidation pressure is high with respect to existing overburden conditions and newly imposed structural loadings, the resulting settlement of the structure will typically be minimal. In this instance the shallow foundation system generally becomes a feasible foundation system for support of the structure. If the preconsolidation pressure is low or equal to the existing overburden pressure, transferring the structural loadings through these materials to underlying more competent soil or rock materials via a deep foundation system or improving the properties of soils through ground-modification techniques may be required. Also the preconsolidation pressure is important in many aspects of underground construction such as tunneling, where it may be related to general stability and standup time of the tunnel walls.

II. Field Work

A. *Site No.1 (Taberia School)*

Block samples were taken from this site which was already excavated to a depth 3.5 m.

Civil Engineering Department, Abu Dhabi University
UAE

Visual field inspection have shown that the upper part of the soil is stiff dark brown silty clay and consists mainly of silt and clay size down to a depth of 2.0 m. It is underlain by light brown stiff moist silty clay.

B. *Site NO.2 (Queen Noor Roundabout)*

This site is located I km to the NE of Queen Noor Roundabout, which is on Omer Al-Mukhtar street, in the eastern part of Irbid. Core samples by Shelby tube sampler were taken from this site continuously from 0.5 m under the surface to a depth of 2,7 m. The samples taken indicate that two types of soil exist upper one which is dark brown silty clay to a depth of 1.5m, underlain by light brown moist silty clay.

III. Laboratory Work and Results

A. *Physical Properties*

Undisturbed samples taken from the various sites were tested in the soil mechanics laboratory to determine the water content, particle size distribution, consistency limits, specific gravity of solids and dry unit weight as determined at the end of test. The test were conducted according to procedures suggested by [1], [2], [3], [4] and [5] respectively. Results are shown in Table 1.

B. *Consolidation Tests*

Consolidation tests were carried out on specimens having 75 mm diameter and 20 mm height; these samples, were prepared by standard trimming process. The samples were allowed to swell under a seating load equal to 25 kPa for 24 hours. Then, if the soil is consolidated the process of loading is continued; but if the soil is expanded the seating load is neglected and loading started from that seating load.

Specimens were loaded daily with a pressure increment ration of 1.0. The results of these tests are presented in the form of void ratio versus logarithm effective pressure as shown in Figures 1- 6 for different sites. Using these curves the field compression lines were constructed and compression index (C_c) values were obtained as the slopes of virgin field lines. Also compression index values (C_c) for lab virgin lines were determined too.

Unloading parts of the curves were approximated to straight lines and swelling index (C_s) values were obtained as the slope of those straight lines.

Rutledge method for minimum preconsolidation pressures [6], Schmertmann method [7] and Casagrande constructions [8] have been utilized for determination of the preconsolidation pressure of the tested soils. Detailed description of the methods used is available in [9]. These results with calculated (OCR) are presented in Table2.

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TABLE 1: PHYSICAL PROPERTIES AND ATTERBERB LIMITS OF THE TESTED SOIL

Site No.	Depth (m)	G_s	Particle Size			w_n (%)	LL (%)	PL (%)	PI (%)	γ_d (kN/m^3)
			%Sand	%Silt	%Clay					
1	2	2.74	15	38	47	33	69	33	36	13.5
	3	2.75	11	41	48	33.66	72	34	38	13.33
2	1-1.5	2.75	2.28	39.72	58	32.5	71	34	37	15-14
	1.5-2.5	2.75	3.56	34.24	62.2	31	66	32	34	14-14.4

TABLE 2: CONSOLIDATION TESTS RESULTS OF THE TESTED SOILS

Sample No	Depth (m)	σ'_o (kPa)	Minσ'_c (kPa)	Casσ'_c (kPa)	Schmσ'_c (kPa)	$(C_c)^*_s$	$(C_c)^+_c$	$(C_c)_s$	$(OCR)_s^*$	$(OCR)_c^+$
S1.1	2.0	35.92	210	270	255	0.365	0.242	0.058	7.10	7.52
S1.2	3.0	53.45	200	290	260	0.265	0.239	0.052	4.86	5.43
S2.1	1.0	19.4	-	240	-	-	0.222	0.066	-	12.1
S2.2	1.5	27.83	250	310	340	0.219	0.215	0.044	12.2	11.14
S2.3	2.0	37.20	220	290	270	0.25	0.242	0.058	7.28	7.82
S2.4	2.5	47.16	135	330	300	0.265	0.233	0.037	6.36	7.00

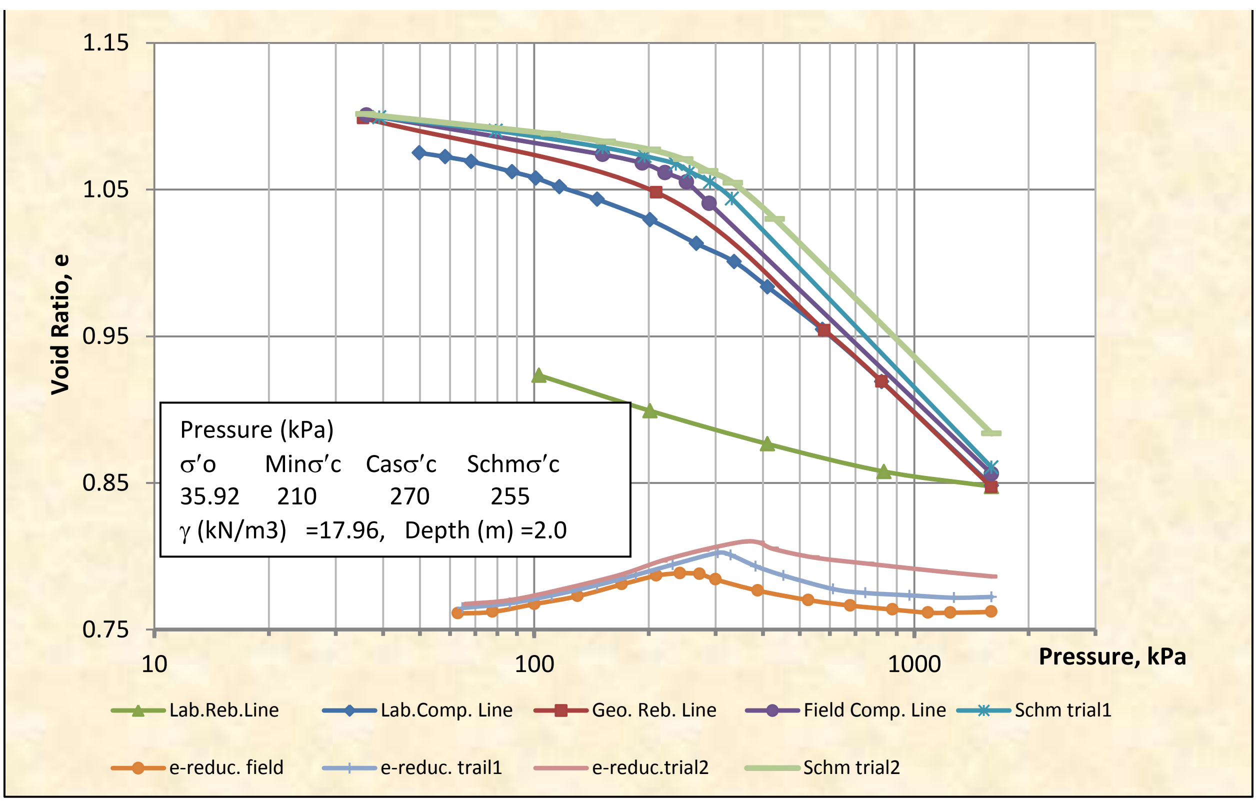

Figure 1. Conventional Consolidation Test (S1.1)

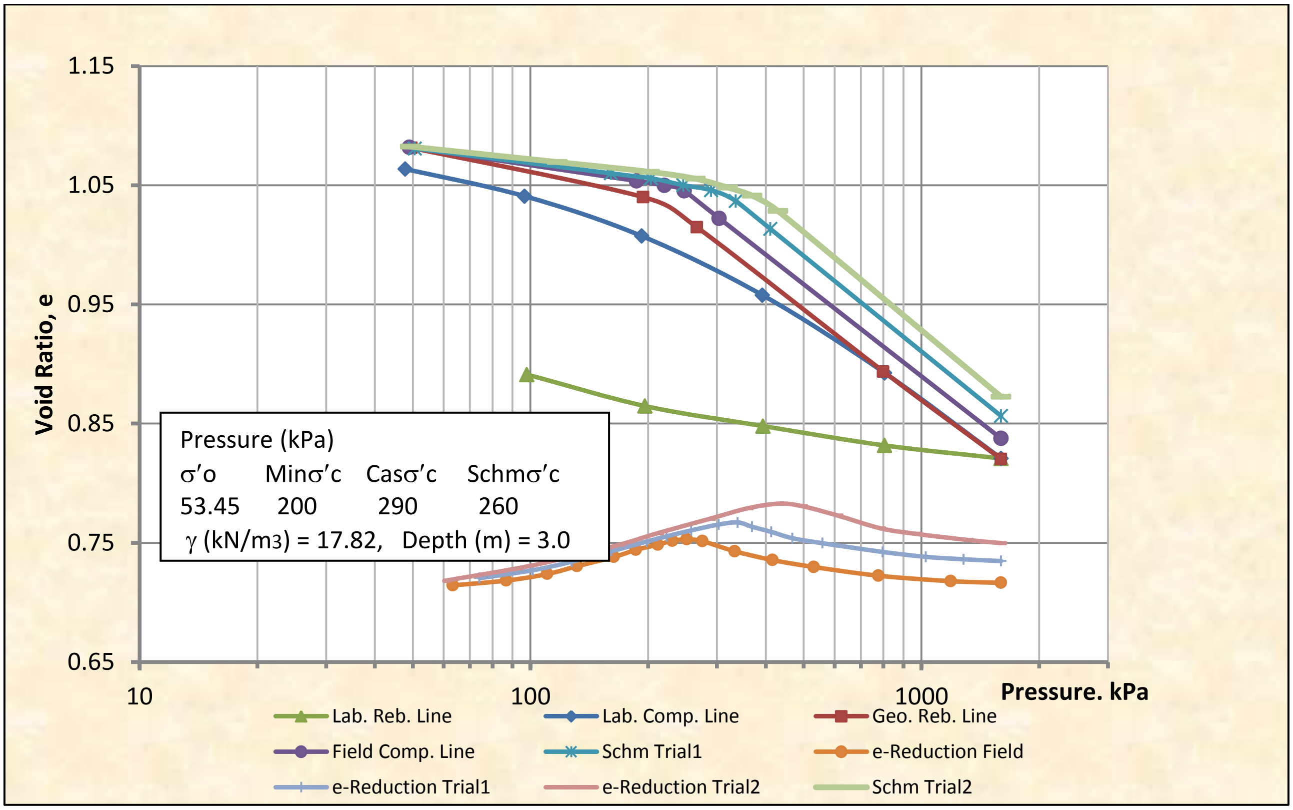

Figure 2. Conventional Consolidation Test (S1.2)

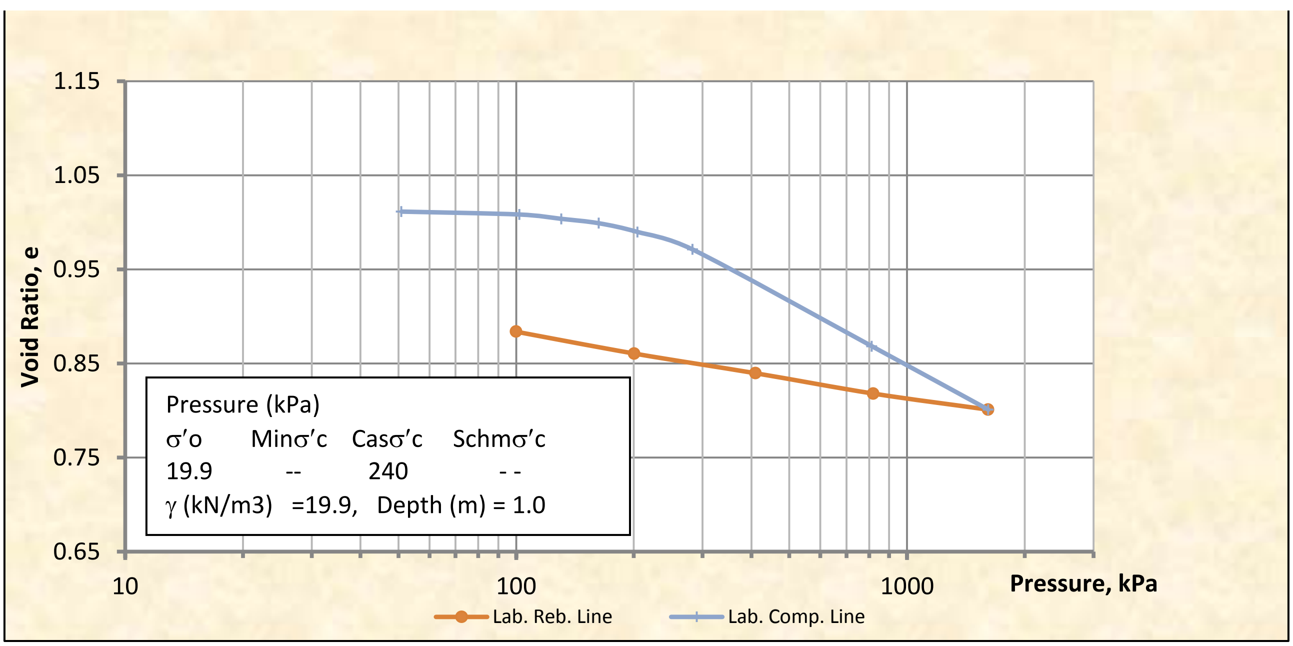

Figure 3. Conventional Consolidation Test (S2.1)

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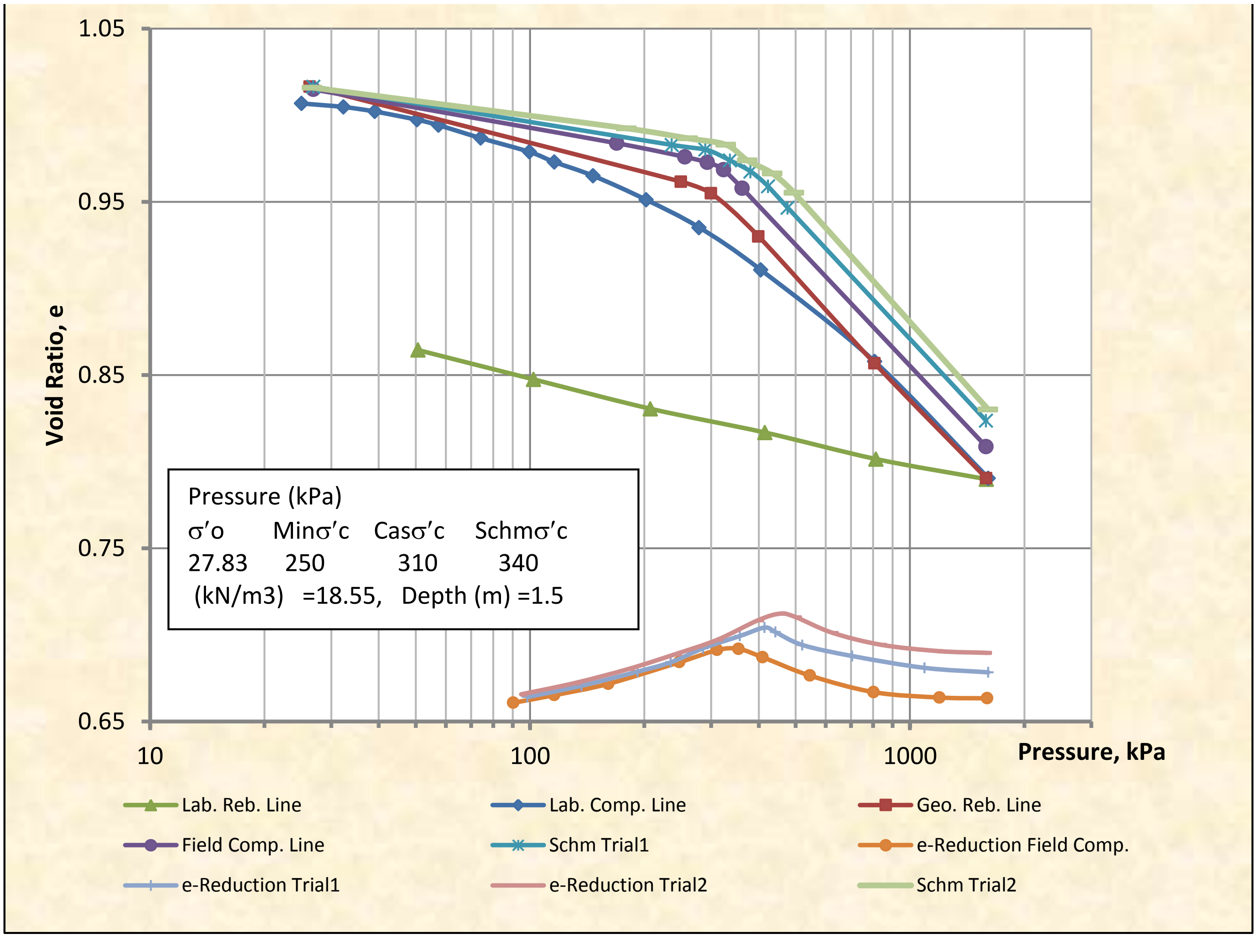

Figure 4. Conventional Consolidation Test (S2.2)

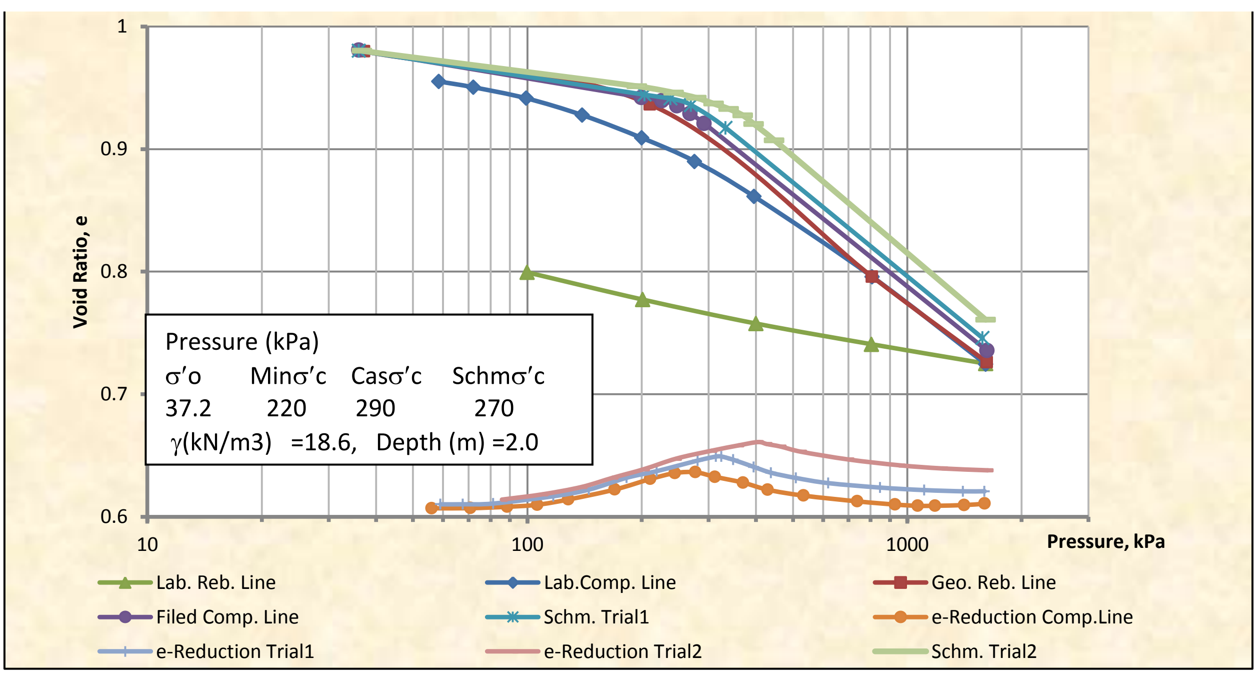

Figure 5. Conventional Consolidation Test (S2.3)

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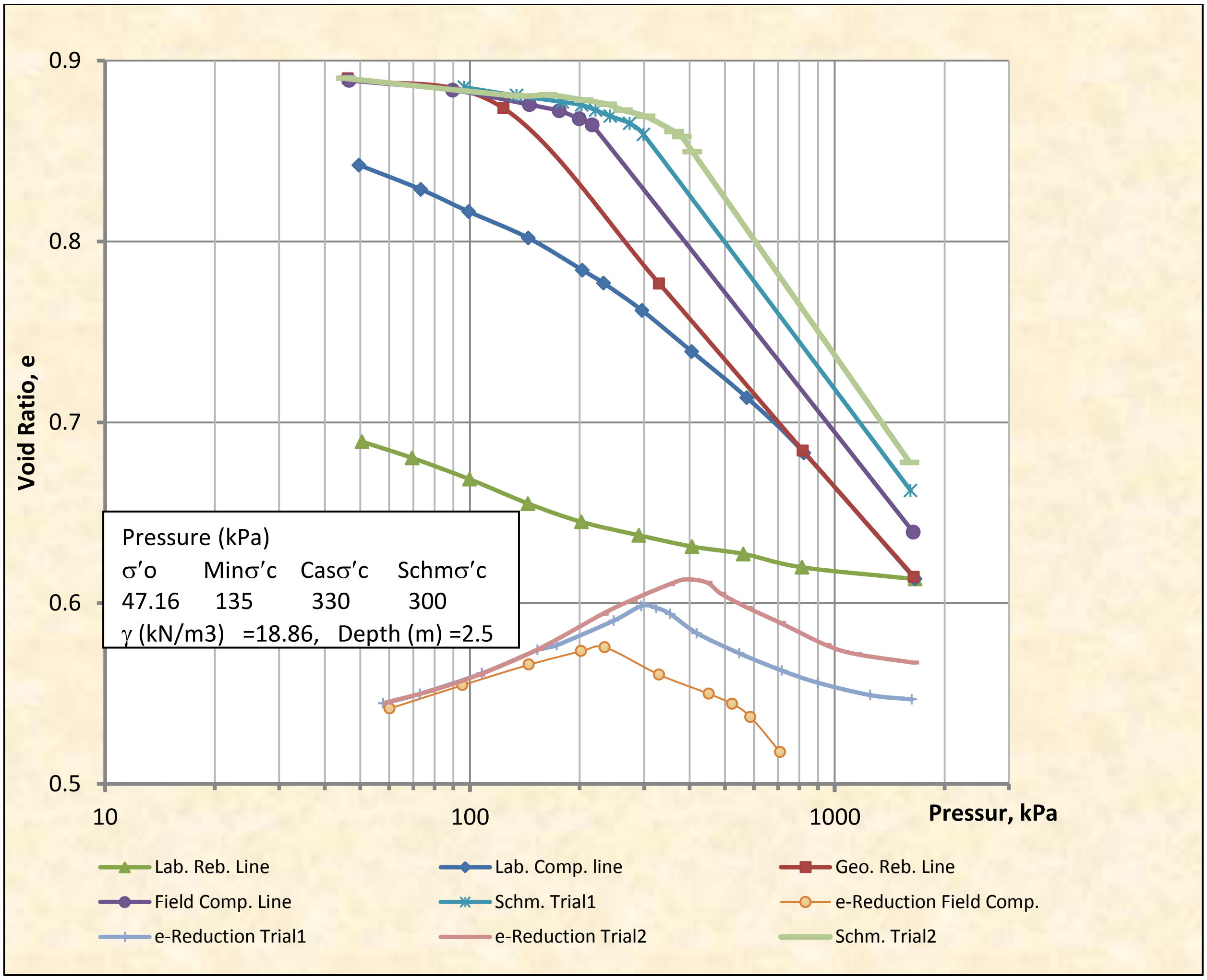

Figure 6. Conventional Consolidation Test (S2.4)

IV. Discussion of Tests Results

A. *Consistency Limits*

It is known that the natural water content of a preconsolidated soil is closer to the plastic limit (PL) than the liquid limit (LL) of the soil [10]. Based on this fact it is obvious that Irbid soil is overconsolidated since its natural water content is closer to plastic limit rather than liquid limit. This can be seen from test results obtained from the current work as shown in Table 1.

B. *Compression Index*

Compression index for all samples was determined by the Casagrande construction [8] and Schmertmann method [7]. Compression index as determined by Casagrande construction $(C_c)_c$ varies between 0.215 and 0.242 with an average value of 0.232. this rsult coincide with the results found by previous studies. [11, 12]. Compression Index by Schmertmann method $(C_c)_s$, varies between 0.219 and 0.365 with an average value of 0.273. The compression index values by Schmertmann method are (1 to 1.5) times the values determined by Casagrande method. The results are shown in Table 2.

C. *Preconsolidation Pressure*

In the present work: Rutledge method for minimum possible preconsolidation pressure, Schmertmann method and Casagrande construction have been used for determining the preconsolidation pressure. It was relatively difficult to determine preconsolidation pressure by Casagrande construction, because the point of minimum radius of curvature was not clearly observed or identified on the (e-log σ′). Preconsolidation pressure values determined by Casagrande construction (Cas.σ'_c) vary between 270 and 330 kPa with an average value of 288.3 kPa.

Preconsolidation pressure values determined by Schmertmann method (Schm.σ'_c) vary between 255 and 300 kPa with an average value 285 kPa. Schmertmann method needs more time than Casagrande construction does, but it is more reasonable because the results do not vary considerably from one person to another. Values of preconsolidation pressure of Irbid soil determined by the two methods are very close to each other. Therefore Casagrande method is recommended due to its simplicity and easiness. The results are shown in Table 2.

Table 2 shows the variation of overconsolidation ratio with depth as determined by both Casagrande and Schmertmann methods. The value of (OCR) at depth equal to 1.0 m is 12.1 and it decreases with depth down to 4.8 at a depth of 3 m. Masoud [12] reported that (OCR) even decreases more with depth till reaches 1.0 at certain depth. This result indicates that the effect of overconsolidation is getting weaker with depth. The soils which are subjected to periodic wetting and drying as a result of seasonal climatic changes are subjected to desiccation and this phenomenon is responsible for overconsolidation, as it can be explained as fo11ow: While a soil dries tension develops in the pore water. This tension increases with decreasing water content, whereas the total normal stress on a given section through the soil remains practically unaltered. Since the total normal stress is equal to the sum of the pore water and effective stresses, the increasing tension in the pore water involves an equivalent increase of the effective pressure. As the effective stress increases, the soil is compressed resulting preconsolidation pressure more than the effective overburden pressure. The effect of desiccation is limited to shallow depths, this is why (OCR) is high at shallower depth. The same behavior was observed in soils subjected to desiccation all over the world [13]. Based on the results of the present study it can be concluded that Irbid soil is mainly overconsolidated due to desiccation effect.

V. Conclusions

The present study showed that the overconsolidation is mainly due to the desiccation. This conclusion could be reached by examining the overconsolidation ration which varies from 12 at the top down to 4 at depth of 2.5 m. Also, the study showed that there was no significant difference among the values determined by different methods. So, It is recommended to use Casagrande method due to its simplicity and the reasonable predicted values of the preconsolidation pressure.

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