LEACHING EFFECTS ON SOME PROPERTIES OF SANDY GYPSEOUS SOILS

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الخلاصة:

تمت دراسة تأثيرات الغسل على خاصيتي النفاذية والانضغاطية لتربة جبسية رملية غير مشوشة. حيث اخذ بنظر الاعتبار تأثير كل من عامل الزمن و مستوى الإجهاد وخصائص النفاذية وماء الغسل. أجري الفحص الذي يشمل التحميل والغسل وقياس معامل النفاذية باستخدام خلية النفاذية بالارتفاع الثابت بعد إجراء تعديلات خاصة عليها. أشارت نتائج الدراسة إلى أن عملية غسل الأملاح الجبسية من التربة و الانفعال الناتج عن ذلك هو عملية معتمدة على الزمن بشكل أساسي وكذلك فأن هناك تناقص مستمر في قيمة معامل النفاذية باستمرار عملية الغسل.

A BSTRACT:

Leaching effects on permeability and compressibility characteristics of undisturbed sandy gypseous soil were investigated in this study. Time, stress level, strain, leachate condition and flow velocity were considered. The loading, leaching and permeability measurements were carried out utilizing the constant head pereameter with special modifications.

Test results show that salt leaching and thereby leaching strain is a time dependent process. Also as leaching strain continued coefficient of permeability decreases.

INTRODUCTION

During the process of construction and operation of structures there is usually an intense filling of soil mass with water leading to prolonged infiltration of solutions through soil and lixiviation of the salts and variations in the physicochemical and mechanical properties of the soil (Mikheev and Petrukhin, 1973).

Many experiments showed that if the soil contains water-soluble gypsum in its load-bearing skeleton, then under the effect of seepage leaching it is subjected to gradual settlement until complete solution and removal of the gypsum (Arutyunyan, 1978).

SAMPLING

Undisturbed soil samples were obtained from Al-Ramadi city especially from aljameah hay at a depth of 0.5 m from the natural ground surface. Samples were taken according to ASTM D1587 using cylinder of 8 cm in diameter and 22 cm in height. To acquire soil sample, test pit of 0.75×0.75×0.5 was excavated. Sample tube was placed and advanced in the soil without rotation by a relatively slow motion. Sample tube was then withdrawn carefully after removing adjacent soil. Tube ends were then sealed and the sample was packaged and transported to the laboratory.

Disturbed samples were also collected at the specified depth for classification tests.

BASIC PROPERTIES

Selected site consists of light brown sandy gypseous soil. Tables 1&.2 show some physical and chemical properties of the soil respectively.

TESTING

1- Compressibility-Permeability Leaching Test (CPLT):

This test was carried out utilizing the setup shown in fig.1. Preparation of specimen in the lab was carried out by trimming both tube ends, placing wire screen and sealing rings, adjusting cell, measuring sample height and weighing cell.

Cell was then placed in the loading frame and water tubes required in constant head permeability test were connected to the cell. Loading arm and displacement dial gauge were then fixed.

Test Procedure

Test was conducted in two stages. Stage one which comprises loading the soil sample in its natural state up to specified level with load increment ratio (LIR=1) and time duration of 24 hrs. Deformation was recorded periodically. Stage two in which the inlet valve opened and sample instantaneously soaked. Currently the outlet valve also released open for air bubbles expulsion. Corresponding strain was recorded and water sample was collected.

After complete soaking, constant head permeability test was performed according to ASTM D2434. It is useful to mention that all tests were carried out under initial hydraulic gradient of (3.5-4). Changes in deformation, coefficient of permeability (k) and leachate characteristics were monitored with continuous of water percolation.

After test completion, final dry sample weight was attained and the effect of leaching on grain sizes was investigated utilizing residual sample in according to ASTM D422 (dry sieving).

2- Cyclic Leaching-Collapse Test (CLCT):

In this test sample was loaded at its natural state to a stress of 50 kPa until settlement eventually ceased. Sample was then soaked and exposed to three cycles of soaking and draining by controlling the inlet and outlet valves. Simultaneous strain and salt concentration in the leachate were monitored and recorded.

3- Chemical Tests:

Chemical tests were conducted according to BS1377 and included initial and final gypsum content and total soluble salts.

Hydro-chemical tests comprise performing total suspended solids (T.S.S) and the total dissolved solids (T.D.S). These tests were conducted according to Water Quality Control System that recommended by General Company for Water and Sewerage –Iraq.

DISCUSSION OF TEST RESULTS

1- Stress-Strain Relationship:

Fig.2 shows the variation of strain with stress. As shown strain is sharply increases as stress exceeds 25 kPa. This may caused by crashing of some gypsum bonds which act as cementation agent.

2- Effect of Leaching on Grain Sizes:

Referring to fig.3, it is clearly noticed that leaching yields finer gradation . This may be interpreted by the dissolution of gypsum that overlocking particles by percolated water. This also observed by Ismael and Mollah (1998). Increase in finer than 0.075 mm soil of 4% is record for 150 kPa loaded sample.

3- Results of Compressibility-Permeability Leaching Test (CPLT):

3-1 Prediction of True Sample Weight:

Due to salt leaching from the soil skeleton and movement of weakly bonded soil particles due to gypsum dissolution in the interparticle contacts, sample weight is significantly decreases with continuous of water percolation.

Utilizing the results of hydrochemical tests, sample weight may predict as suggested below:

$$w_s = w_0 - w_r \qquad (1)$$

$$w_s = w_0 - \sum_{T=t_1}^{T=t_2} \left[(T.S_{st} - T.S_w)(k_t i_t A) \Delta t \times 6 \times 10^{-5} \right] \qquad (2)$$

Where: w_s= true sample weight at time t(gm); w_0= initial sample weight(gm); w_r=removal weight(gm); t_1 & t_2 = initial and final times respectively; $T.S_{st}$ & $T.S_w$= total solids concentration in the leachate and tab water at time t (PPM) respectively; (T.S=T.D.S+T.S.S); k_t& i_t = coefficient of permeability(cm/sec) and hydraulic gradient at time t respectively; A= sample cross section area; Δt = time interval between successive readings (min).

Fig.4 shows variation of (Ws) with accumulative total solids concentration for 200 kPa loading, where large loss in sample weight takes place with time progress as salt leached out. An interested comparison between actual loss in weight and that predicted in equations 1&2 is prepared as shown in fig.5. Good agreement is attained (R^2=0.89) however for more enhancive relation, read out time interval may be reduced.

3-2 Time Dependence of Gypsum Leaching:

The effectiveness of time in leaching problem may be explained in the following articles:

***a.* Hydrochemecal Characteristics:-**

Changes in concentrations of T.D.S & T.S.S with time, for various stress levels, are illustrated in figs.6&7 respectively. Initial values are concentrations of this salt in soaking water. With respect to T.D.S concentration, unconstrained salt particles that exposed to water movement may be dissolved and leached out immediately after water flows. Simultaneously some unpacked soil particles are suspend therefore it clearly noticed in the leachate immediately after water flows as indicated in fig.7. Concentration of T.D.S remains steady till time reaches 30 min. then decreases. This may be explained by time required for bonds softening. Decrease in T.D.S concentration may be interpreted by decrease in boundary layer of diffusion transport of hydrated ions. The diffusion mechanism was pointed out by James and Kirkpatrick (1980) for comparison. Zakaria (1995) recorded that total soluble salts concentration fluctuated randomly and tent to decrease with time.

***b.* Strain Characteristics**

Fig.8 depicts the variation of strain with time of leaching. Marked increase in strain attain as time exceeds 30 min. This may be interpreted by sequent deterioration of soil structure with continuous of salt leaching as may clarify by fig.9. With respect to stress level, a continuous of salt leaching yields the same trend of leaching strain with time especially after (30 min) due to the attained weakening of soil structure that resulted by the dissolution of gypsum from the interparticle contacts which may reduce the ability of load carrying by soil skeleton. Conversely a pronounced effect of stress level is encountered in strain with the accumulative concentration of total solids.

***c.* Permeability Characteristics:-**

The k - time curves are plotted in fig.10, for comparison. At low pressure high k value results due to low strain accomplished. Disregarding of stress level, k value decreases with time of leaching considerably. That is although voids are enlarged due to salt leaching, some flow paths are clogged due to leaching strain. Nashat(1990) observed a decrease in k value with time and he stated that this phenomenon is a complicated process as both removal of gypsum -as voids are enlarged- and the collapse occur simultaneously.

Forward, it may useful to clarify a relationship between T.D.S- K. This relation is shown in fig.11. A secure inspection of these curves yields several interesting observations. For the same k value, it can notice that T.D.S concentration decreases with time. This may be due to early removal of easily soluble and weakly cemented salts. It may be notable that at a specified time, T.D.S concentration decreases or be stable then increases as k value decreases. This may be evidence to the effect of flow velocity on aqueous saturation where an increase in effect of diffusion phenomenon and mass transport of hydrated ions may occur as k flow velocity decrease.

Finally, it is valuable to declare that stress level plays a minor effect gypsum leaching process.

4- Results of Cyclic Compressibility- Leaching Test (CCLT):

Fig.12 explains the effect of changes in leachate characteristics on strain. As shown, T.S concentration decreases as valve open and vice versa. This may emphasis the effect of time, aqueous saturation, flow velocity and diffusion phenomenon on the amount of leached salt and thereby the resulted compressibility. Where, as flow velocity decreases aqueous saturation increases by the effect of diffusion phenomenon.

CONCLUSIONS

From the above details it can concluded that:

1. Time is the most notable effective parameter in the gypseous soil leaching problem.
2. Stress level plays minor role in the leaching problem.
3. Reduction in soil sample weight is continuous as salt leaching continuous and it may be predicted depending on the amount of total leached solids.
4. Void ratio must be predicted with respect to the corrected sample weight.
5. Leaching strain increases in ascending approach with time and a pronounce strain results after a specified time with regardless stress level.
6. Leaching strain is related directly to amount of leached salt.
7. Coefficient of permeability (k) decreases as leaching strain increases duo to blocking of some flow paths.

8. For a specified (k) value, total dissolved solids (T.D.S) decreases with time. Whereas, for a specified time, (T.D.S) concentration increases as (k) decreases due to providing adequate time for salt leaching and transporting by diffusion phenomenon.

REFERENCES

Mikheev, V. V. and Petrukhin, V.P. (1973), Construction Properties of Saline Soils Used As foundation Beds in Industrial and Civil Construction, *Soil Mechanics and Foundation Engineering, Vol.9, No.3, Pp 30-36.*

Arutyunyan, R. N. (1978), Development of Gypsified Soils in the Bases of Buildings and Structures n Erevean, *Soil Mechanics and Foundation Engineering, Vol.15, No.3, Pp 183-185.*

Water Quality Control System, General Company for Water and Sewerage –Iraq, *Project IRQ/94/001*.

Ismael**,** N. F. and Mollah, M. A, Leaching Effect on Properties of Cemented Sands in Kuwait, *Journal of Geotechnical and Geoenvironmental Engineering, Vol. 124, No.10, October, 1998***.**

James, A. N. and Kirkpatrick, I. M., (1980), Design of Foundation of Dams Containing Soluble Rocks and Soils, *Quarterly Journal of Eng. Geology, Vol.13, Pp 189-198.*

Zakaria, W. A. (1995), *Permeability of Gypseous Soil*, M.Sc. Thesis, Building and Construction Department, University Of Technology, Baghdad.

Nashat, I. H. (1990), *Engineering Characteristics of Some Gypseous Soils In Iraq*, Ph.D. Thesis, Department Of Civil Engineering, University Of Baghdad.

Annual Book of ASTM Standard, Vol.04.08, 1989.

British Standard Institution (1975), *Methods of Testing soil for Civil Engineering Purposes*, B.S 1377.

Table 1: Physical properties of the soil

Test	Specification	Result
Initial Water Content	ASTM D2216	4-6.5 %
Specific Gravity	BS1377-Test No.6	2.45
Grain Size Distribution Finer than 0.075 mm	ASTM D422 (Dry Sieving)	3.83%
Classification	ASTM D2487	SP
Atterberg Limits	ASTM D4318	Non
Initial Void Ratio	ASTM D2435	1.16-1.25

Test	Result
SO_3%	30.10
CL%	0.026
CaO %	24.30
pH	6.80
T.S.S%	30.50
Gypsum %	64.71

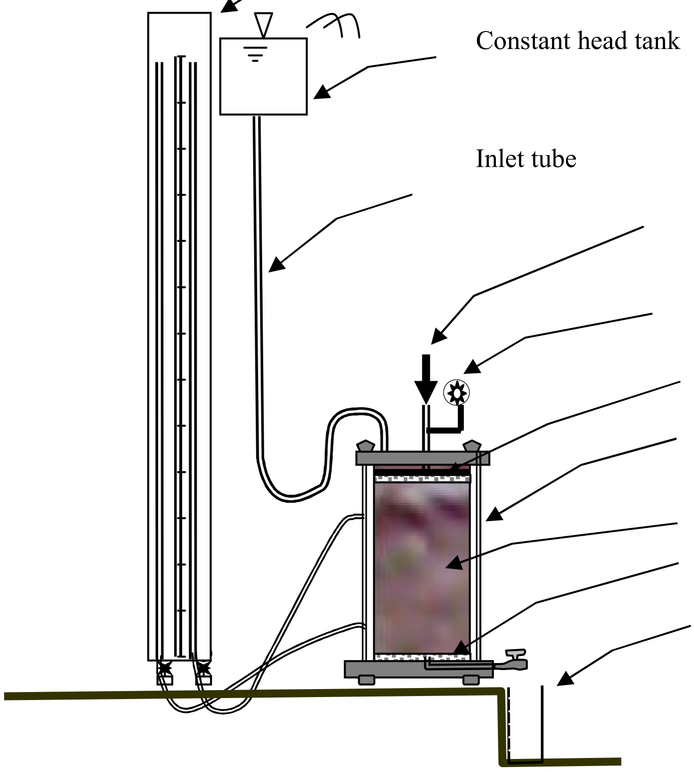

Figure 1: Schematic Diagram for Test Setup

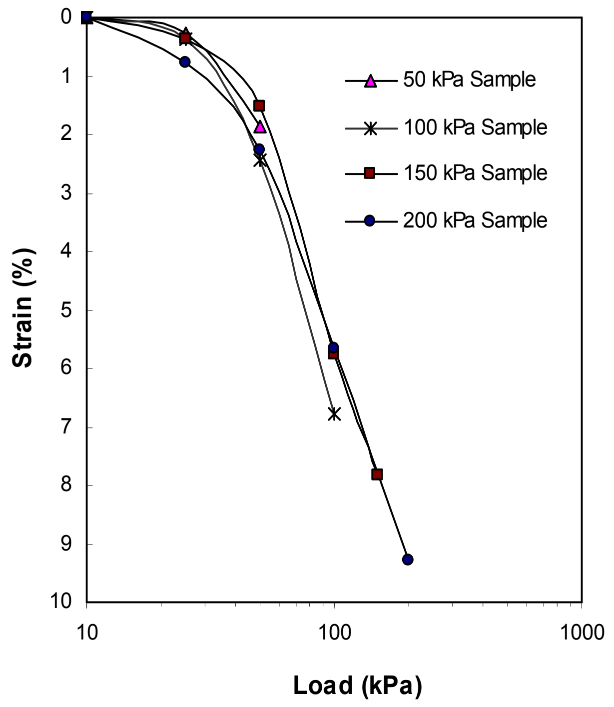

Figure 2: Variation of Strain with Stress

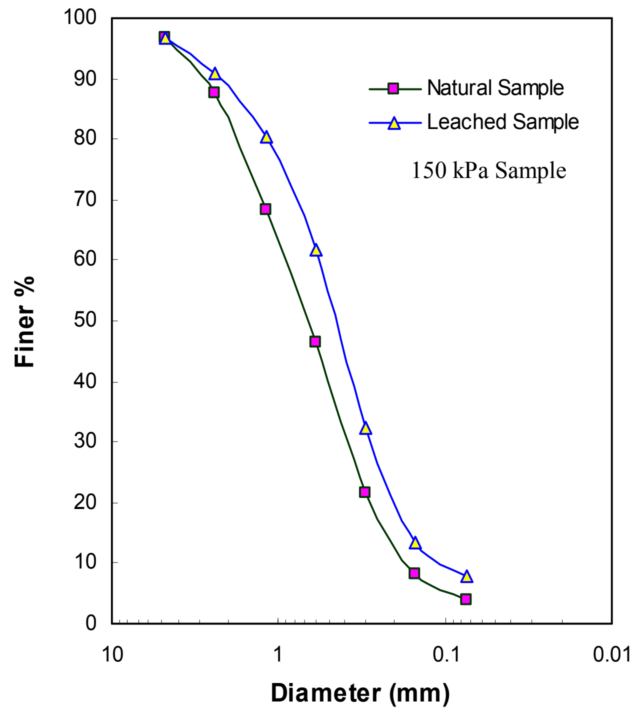

Figure 3: Grain Size Distribution Graphs (150 kPa Sample)

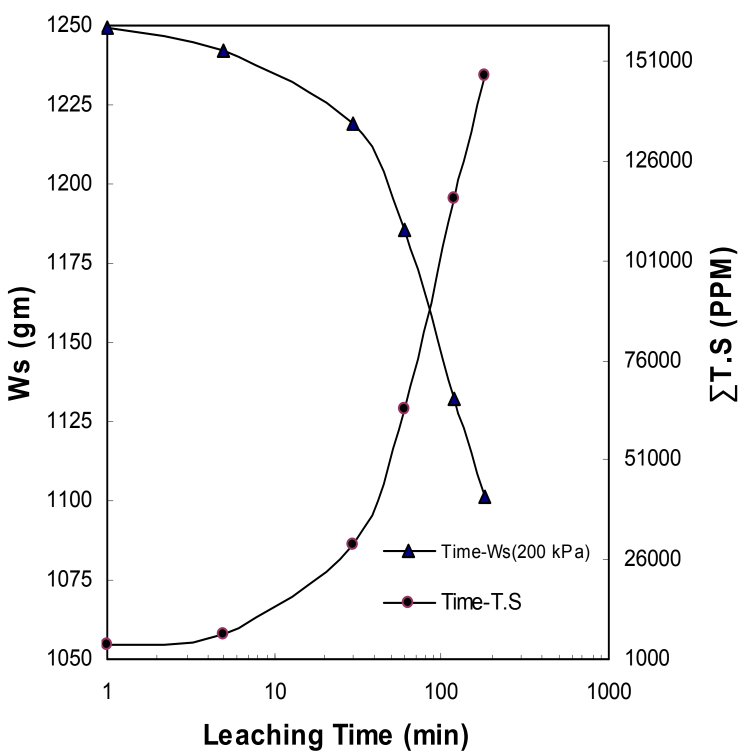

Figure 4: Variation of Sample Weight and Total Solids Concentration with Time

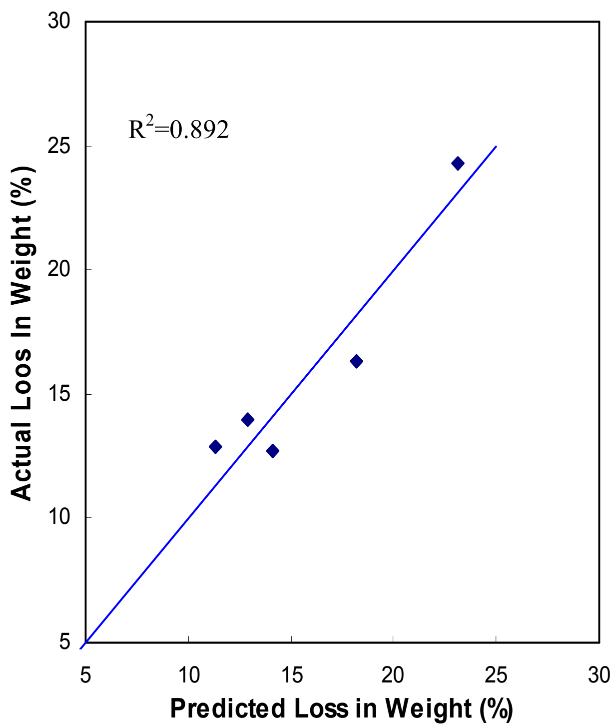

Figure 5: Comparison between Actual and Predicted Loss in Weight

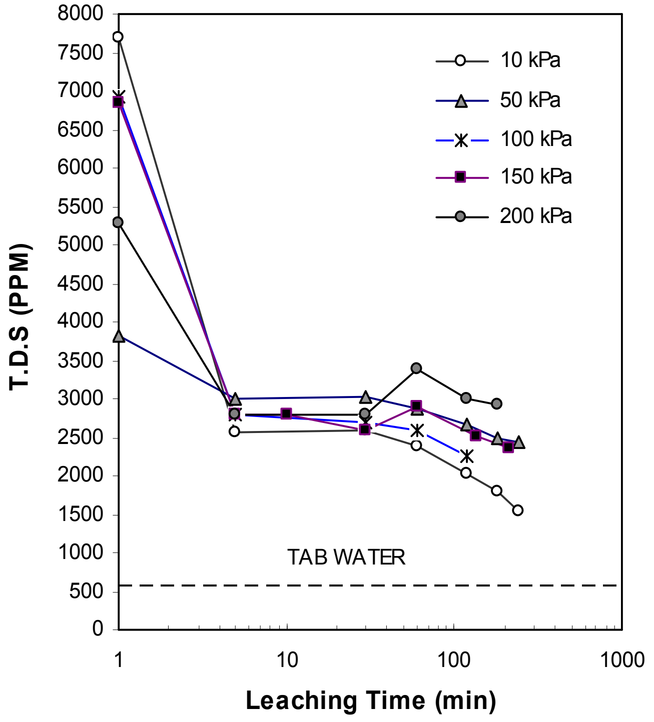

Figure 6: Variation of T.D.S with Time

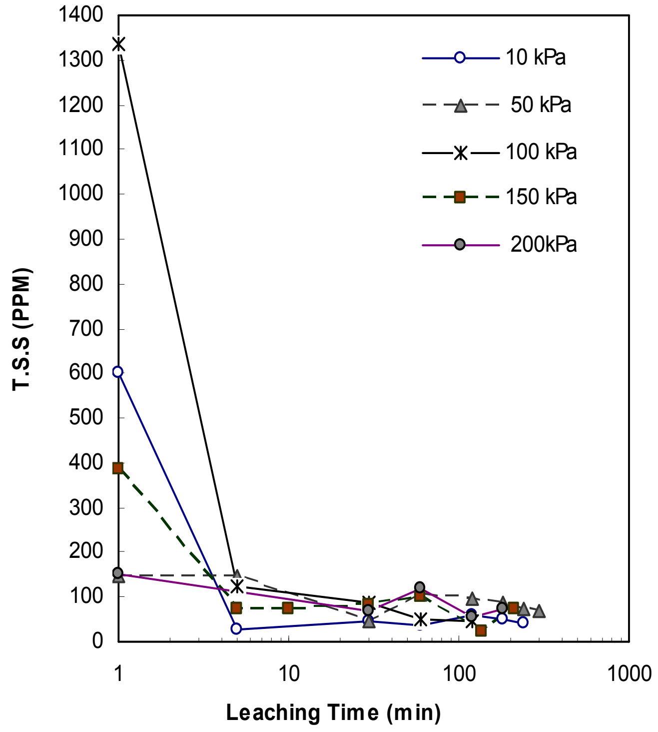

Figure 7: Variation of T.S.S with Time

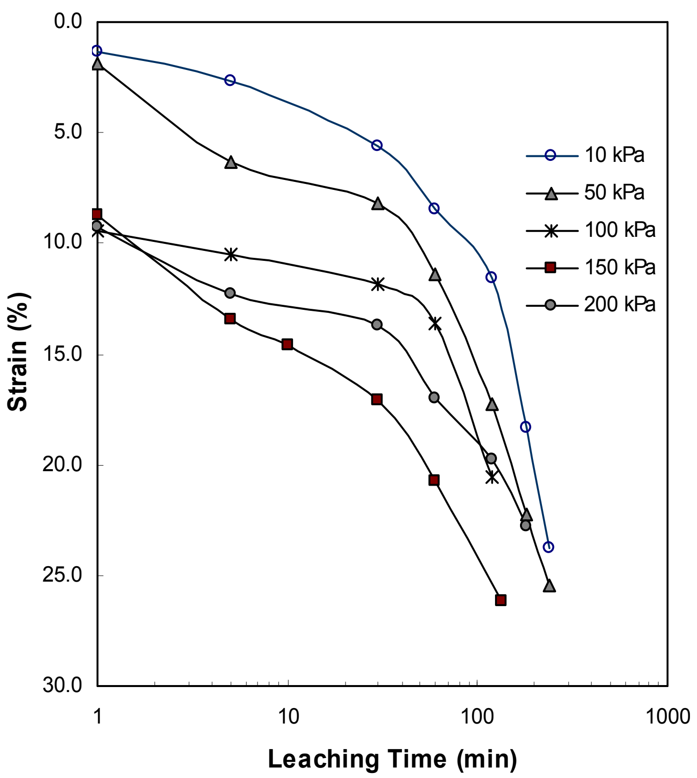

Figure 8: Variation of Strain with Leaching Time

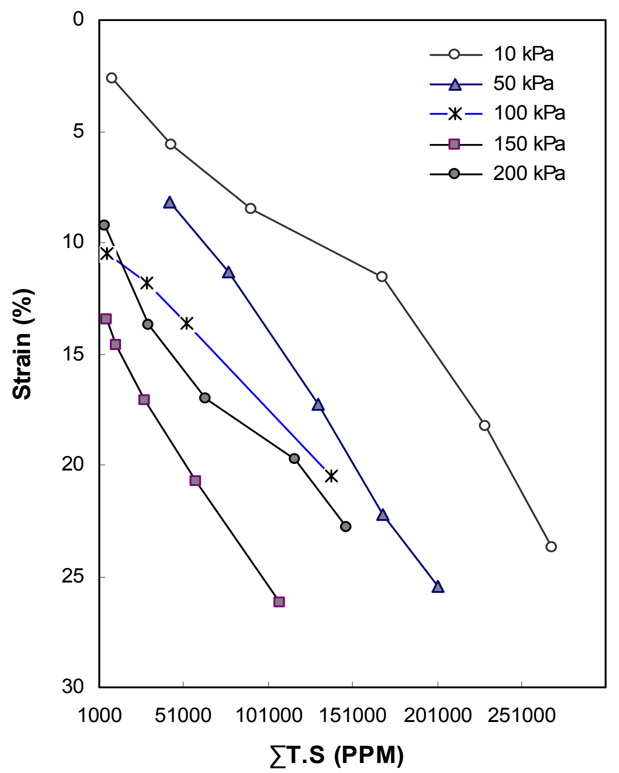

Figure 9: Variation of Strain with Accumulative Total Leached Solids

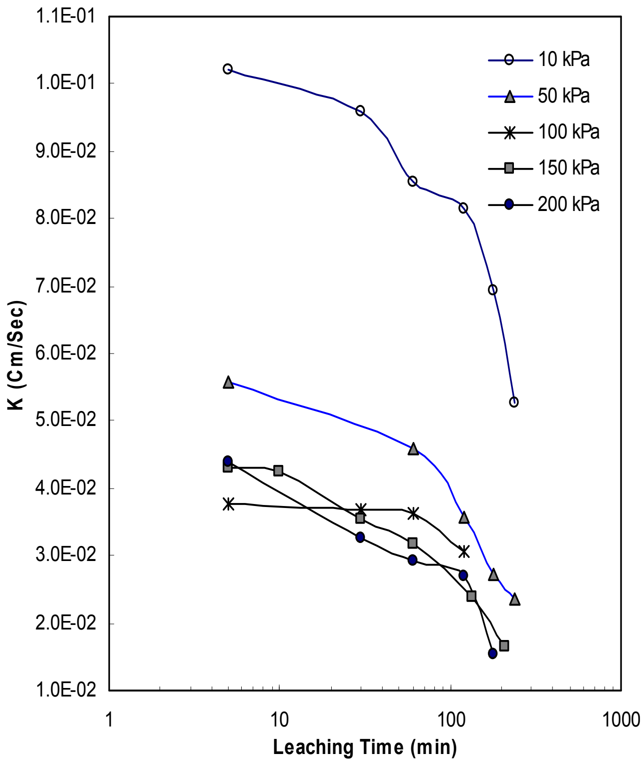

Figure 10: Variation of Coefficient of Permeability with Leaching Time

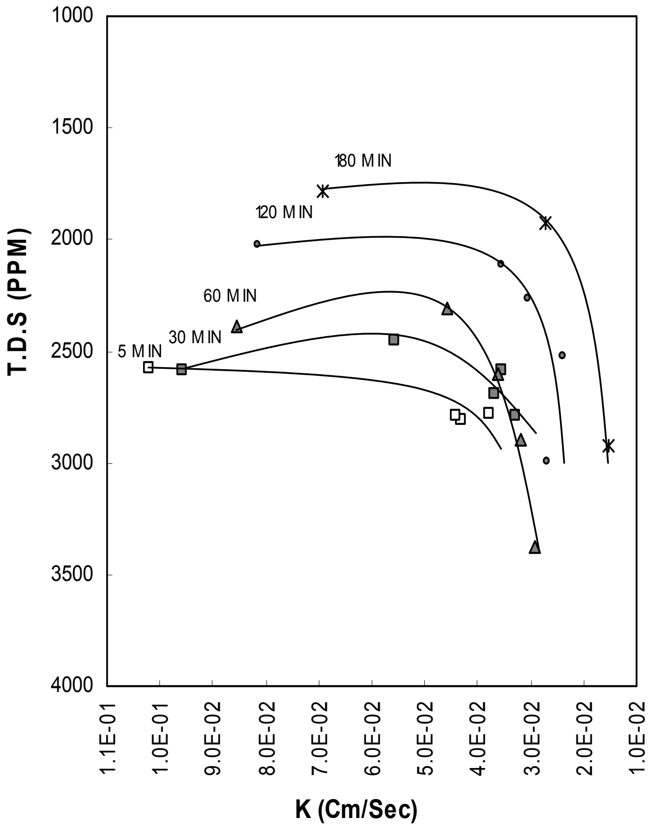

Figure 11: Variation of Total Dissolved solids with Coefficient of Permeability

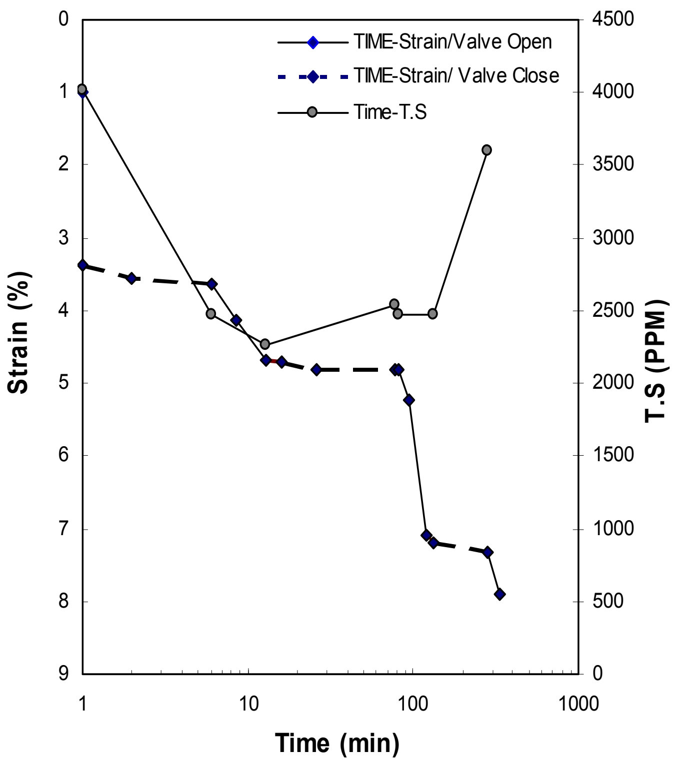

Figure 12: Variation of Strain with Leaching Time for CLCT