# EFFECT OF CUT-BACK MC-60 ON PERMEABILITY AND COMPRESSIBILITY OF A GYPSEOUS SOIL

**Muayad A. Ahmed Al-Sharrad**
**Assistant Lecturer**
**Dep. of Civil Engineering**
**University of Anbar**
**E-Mail: abuzaidalbasri@yahoo.com**

**ABSTRACT**

A study of the effect of cutback MC-60 on the permeability and compressibility characteristics of sandy gypseous soil is presented. Series of laboratory tests are carried out including classification, compaction, and conventional oedometer tests as well as a new test named compressibility- permeability leaching test. Test results shows that the superlative enhancement in compressibility and permeability and thereby in collapsibility occurred with 7% additive.

**الخلاصة :**

تم في هذه الدراسة معرفة تأثير إضافة الإسفلت المتوسط الإنضاج من نوع MC-60 على خاصيتي النفاذية والانضغاطية لتربة رملية جبسية. تم إجراء سلسلة من الفحوصات المختبرية بضمنها فحوصات التصنيف و الرص و فحص الانضمام التقليدي بالإضافة إلى إجراء فحص جديد سمي " فحص الانضغاطية- النفاذية " . بينت الدراسة أن أفضل تحسين في خاصيتي الانضغاطية و النفاذية وبالنتيجة في خاصية الانهيارية هي عند نسبة معالجة 7%.

## INTRODUCTION

The well known phenomenon in a gypseous soils is the collapsibility which in turn resulted mainly due to salt leaching from soil skeleton. The effect of leaching will depend on several factors including the amount and the degree of cementation, soil type, mineral composition, grading characteristics, the relative density and the amount of soluble salts. (1).

Several blending agents have been used for soil stabilization, the most commonly used agents are Portland cement, asphalt binders and lime (2).

## MATERIALS AND TESTING

### Materials:

**1- Soil:**

The soil used was a sandy gypseous soil brought from University of Anbar site,10 km from Al-Ramadi city especially from. Disturbed samples were obtained at a depth of 1 m below the N.G.S.

Physical properties of the soil are shown in table (1). Some chemical properties are listed in table (2).

**2- Treatment material:**

In order to control the collapsibility of sandy gypseous soil, Cut-back MC-60 was used for this purpose. The properties of this material are listed in table (3).

### Testing Program

**1- Compaction Test:**

Standard compaction test was carried out according to ASTM D-698 (3). The test was conducted for the natural and treated soil. In order to prepare a treated sample a required amount of the treatment material is mixed thoroughly with the (passing No.4 sieve) soil in a temperature of (27$^{o}$C). The mixture then left few minuets to be homogenous. Usual Standard compaction test was then conducted.

**2- One-Dimensional Compression Test:**

This test was carried out according to ASTM D 2435-80 (3) using (5 cm) in diameter oedometer ring. Specimens for this test were obtained by placing the ring on the top of the compacted sample and inserting it axially using hydraulic pressure. Testing specimen was obtained by pushing out the compacted sample and trimming the soil surroundings the ring. All specimens were obtained at the O.M.C. After placing the cell a seating pressure of 17 kPa was applied and the sample is soaked.

**3- Compressibility –Permeability Leaching Test (CPLT):**

**3-1 Test Setup:**

This test was carried out using the setup shown in figure (1). Testing cell chosen according to the requirements of ASTM D-2434 (3) with a diameter of (7.5 cm) and (22 cm) height. This cell fitted with loading piston and three manometer outlets installed on the cell wall, which made from transparent plastic that keeps visual monitoring of the changes in soil fabric is possible.

Down ward seepage was conducted by applying constant water pressure through a constant level tank. Load was applied by a means of dead weights and the deformation is measured using a dial gauge with accuracy of (0.001 In).

**3-2 Test Procedure:**

Test specimen was prepared as in standard compaction test with moisture content close to the optimum value. Soil specimen was formed in the cell utilizing a rodding compaction procedure that recommended by Head (1982)(4). Many trials were made to obtain the required maximum dry density. After this, the top cover is placed and rubber tube of the manometer was connected. then a seating pressure of (17) kPa was applied and the sample was soaked with water by opening the pinch clips of inlet tube. for saturation to be occur the sample was left for 24 hrs.

Soil sample was loaded till it reaches (200 kPa) with LIR=1 and time duration of 24 hrs. Falling head permeability test was conducted periodically. The deformation and the change in the coefficient of permeability was recorded with time till piping and collapsibility phenomena occurs or when the test time exceeds (180) days. The load was then removed and chemical test was conducted to determine the amount of the removal gypsum.

## RESULTS AND DISCUSSION

### 1- Compaction Test:

Results of compaction test that carried out on the natural and treated samples are shown in figure (2). It can be noticed that the increase in the percent of treatment matter leads to increase in the dry unit weight and decrease in the optimum moisture content, with respect to the natural state, up to 7% then the state is reversed, . This trend can be attributed to the role of this matter as a lubricating agent. The decrease in the dry unit weight can be interpret by the fact that the fluid may take up the spaces that might have been occupied by soil solids. The same approach was obtained by Al-Hassany (2001)(5).

### 2- One-Dimensional Compression Test:

Figure (3) shows the results of loading in oedometer apparatus. It is clearly noticed that an increase in treatment material percent up to 7% leads to reduce the initial void ratio. An increase in this percent above 7% results a decrease in the initial void ratio. This may be interpreted by the effect of increase of treatment percent on the value of maximum dry unit weight as shown in figure (2). With loading the same behavior is attained.

### 3- Compressibility –Permeability Leaching Test (CPLT)

### 3-1 Load –Strain Relationships:

Figure (4) shows a relationship of pressure and void ratio for samples of 0%, 5%, 7% and 9% treatment. It can be shown that samples with 0%, 5%& 7% shows nearly the same behavior with loading. This may be attributed to the converging value of initial void ratio.

Increase in treatment percent up to 9% results in decrease in strain this may be due to the lower void ratio that exerted by the increase in treatment percent increase which is partly results in increase the relative sliding among particles in the soil skeleton.

A comparison between the strain measured in consolidometer and that in the (CPLT), under a pressure of 200 kPa, is shown in figure (5). Generally it can be noticed that loading in oedometer apparatus produce higher strain. This reflect the role of sample size on compressibility characteristic of such gypseous soil. This found may be confirmed by the results of Al-Sharrad (2003)(6). Also it can be noticed that treatment of soil with 5% not yield any change in strain, this may be due to the relatively low treatment percent.

**3-2 Treatment Percent –Permeability Relationship:**

Due to loading the coefficient of permeability decreases with loads. For 0%, 5%, 7% and 9% treatment percent, this situation is shown in figure (6).

From this figure, it is clearly noticed that treating the soil with 7% yields lower value of initial coefficient of permeability. This is simply proved by resuming the results shown in figure (4) where the lower value of initial void ratio is at 7% treatment. Considering the 9% treatment, it can be seen that the increase in the percent yields higher permeability, keeping that the added material may act as a waterproof. This confirms the reverse effect of increase in this material over than 7% on the initial void ratio.

Generally, there is a slight reduction in the coefficient of permeability with pressure increase. This may be due to low strain attained by the applied pressure.

**3-3 Strain-Permeability Relationships:**

The relations of the strain and the coefficient of permeability with time under a constant pressure (200 kPa) and continuous percolation of water through the soil sample is shown in figures (7) & (8) respectively. The main problem of such gypseous soil is shown evidently with the curve of the 0% treatment.

The general relationship of permeability- time is the event to the opposite effects of both delayed compression and softening with leaching on the void ratio. Forward the high increase in permeability may agree with the occurring of collapsibility.

Although compacting of the gypseous soil yields small value of void ratio (about 0.52) but this not prevents collapse to occur, due to bond softening and the leaching of the salt from the soil skeleton. Table (4) shows this fact. It is worth noting that collapse occurs even when the soil treated with 5%. This may be related to the insufficient coating and the relatively high coefficient of permeability. Treating the soil with 7% yields both minimum coefficient of permeability and strain. The small relatively strain can be attributed mainly to the best coating of the particles. When the treatment increase to 9% the situation is as shown in the foregoing figures, this may due to increase in the initial void ratio.

## CONCLUSIONS

The research yields the following conclusion:

1- Maximum dry unit weight increases to optimum value then decreases as cut back MC-60 additive increase.

2- Cut back MC-60 additive enhance both the load- strain and time- strain characteristics.

3- Cut back MC-60 additive reduces the value of coefficient of permeability from about ($1\times 10^{-3}$) cm/sec to about ($4\text{-}7\times 10^{-6}$) cm/sec.

4- Considering the load-strain, strain-time & durability relations, the optimum value of cut back MC-60 additive is 7%.

## REFERENCES

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5-Al-Hassany, H. Y. (2001), "Gypseous Soil Improvement Using Fuel Oil", M.Sc. Thesis, Building And Construction Department, University Of Technology, Baghdad.

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Table (1): Physical properties of the soil

| | |
|---|---|
| Specific gravity | 2.45 |
| Percent finer than 0.075 mm | 5.1 |
| Plasticity | Non plastic |
| Unified soil classification | SP-SM |
| Soil description | Poorly graded sand with silt |

Table (2): Chemical properties of the soil

| | |
|---|---|
| pH value | 6.9 |
| T.D.S% | 55.1 |
| CaO% | 20.3 |
| $SO_3$% | 24.65 |
| CL% | 0.026 |
| Gypsum % | 52.99 |

Table (3): Properties of cutback MC-60

| Properties | Grade of binder |
|---|---|
| Grade | MC-60 |
| Viscosity (Stokes at 60$^o$C) | 60 |
| Flash Point | 65 |
| Penetration at 25$^o$C (100 gm,5 sec) | 127 |
| Ductility 25$^o$C (gm/min) | 100 |
| Solubility in trichloroethylene % | 99 |

Table (4): Results of strain with removal gypsum

| Treatment % | Removal Gypsum | Strain |
|---|---|---|
| % | % | % |
| 0 | 5.5 | 7.09 |
| 5 | 5.02 | 6.76 |

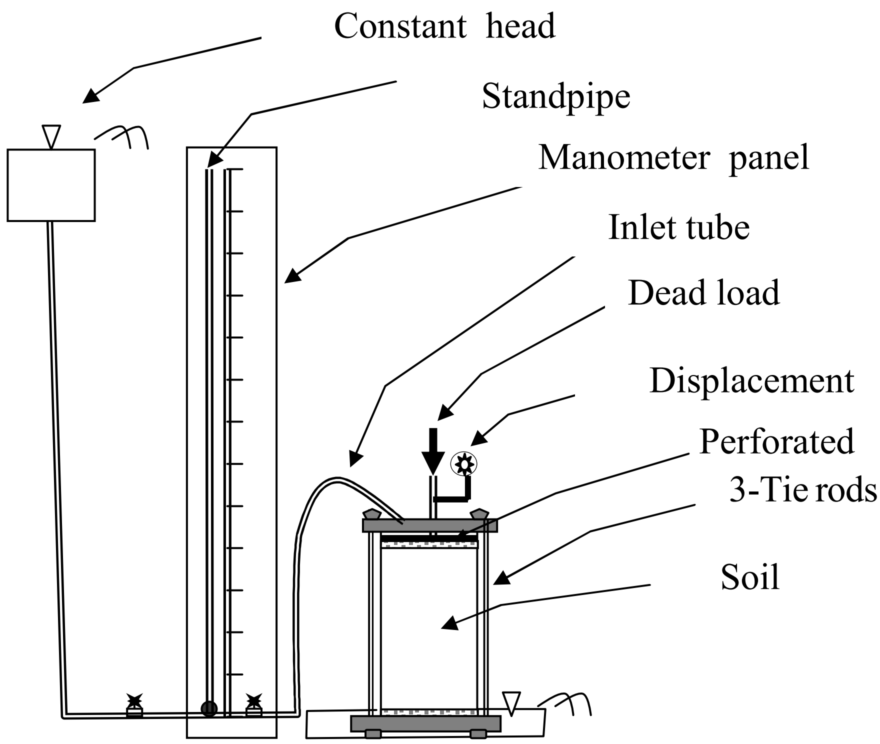


Figure (1): Schematic Diagram for Test Setup

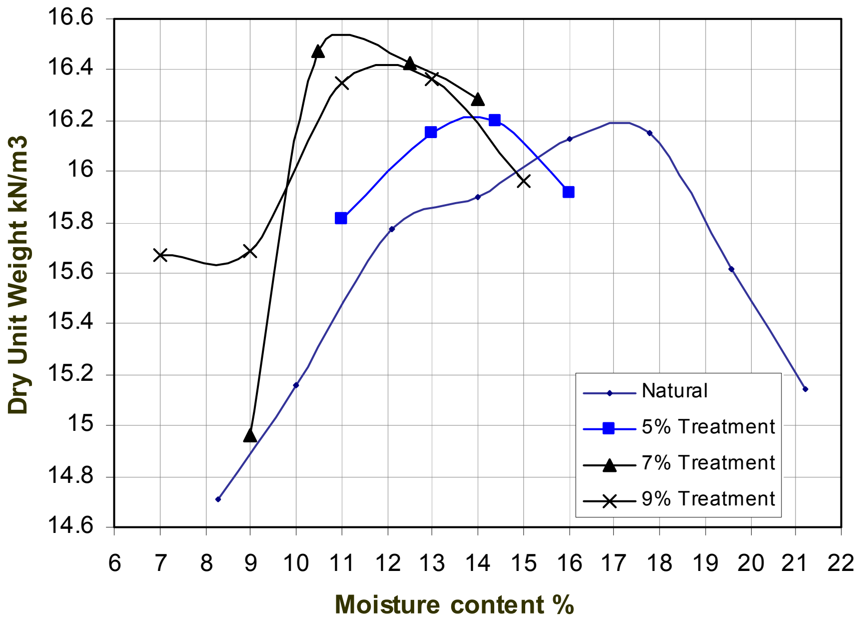


Figure (2): Results of Compaction Test

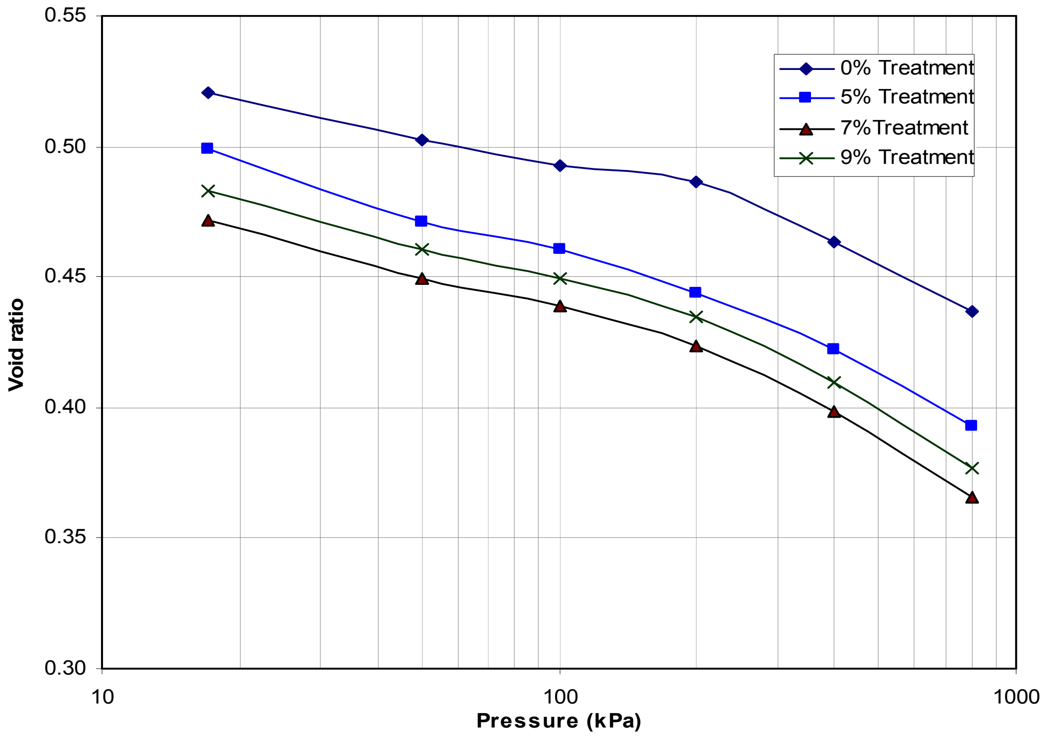


Figure (3): Results of One-Dimensional Compression Test

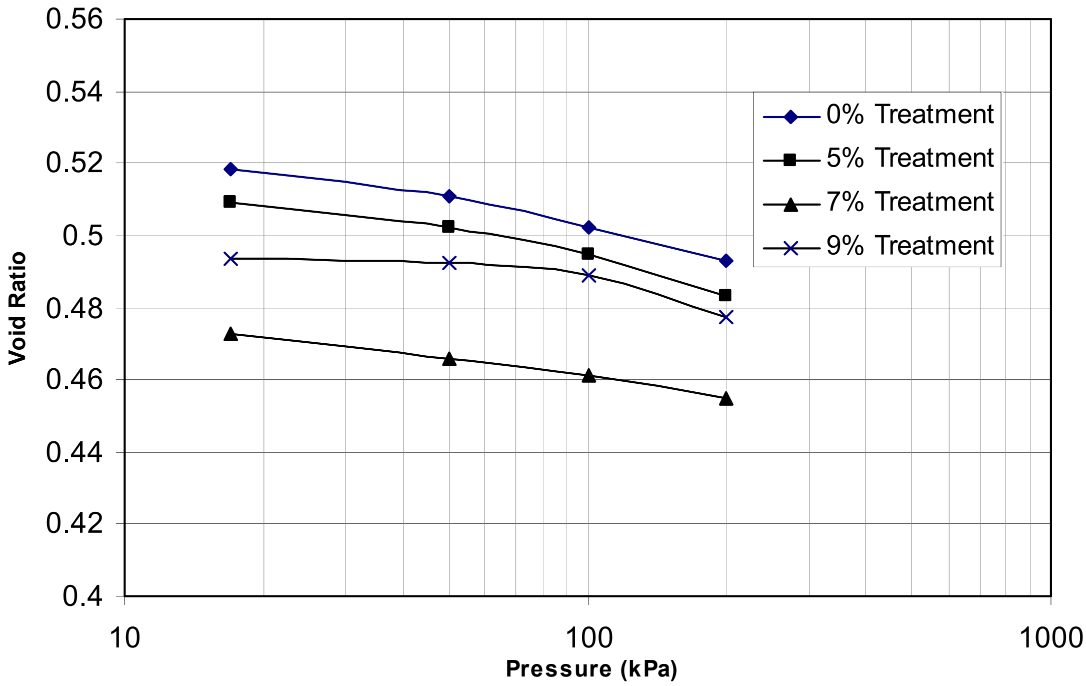


Figure (4): Void ratio-Pressure Relationship for CPLT

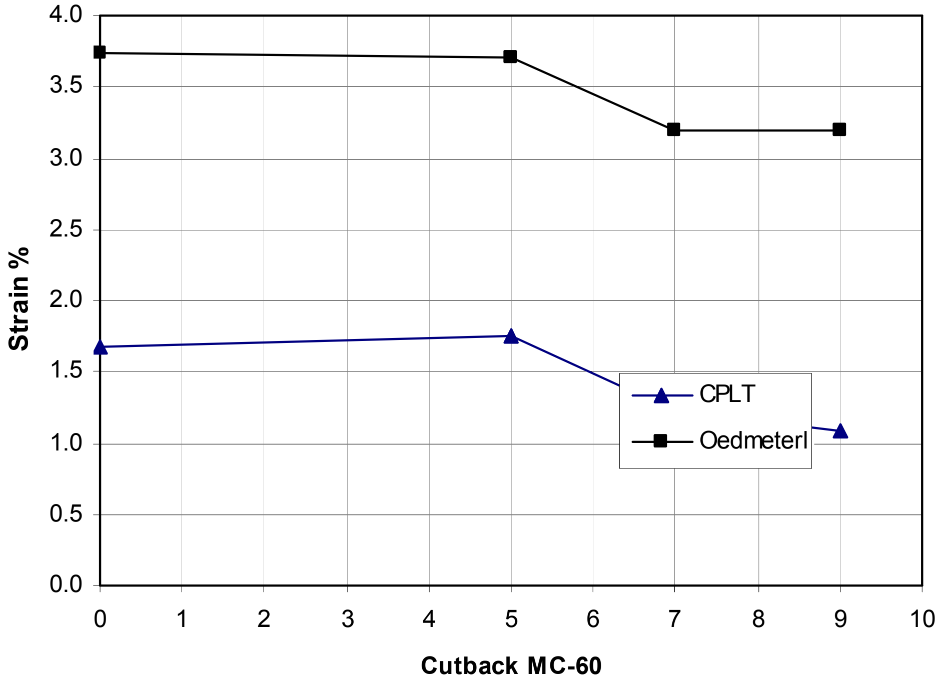


Figure (5): Comparison between Strain in Oedometer and CPLT for 200 kPa

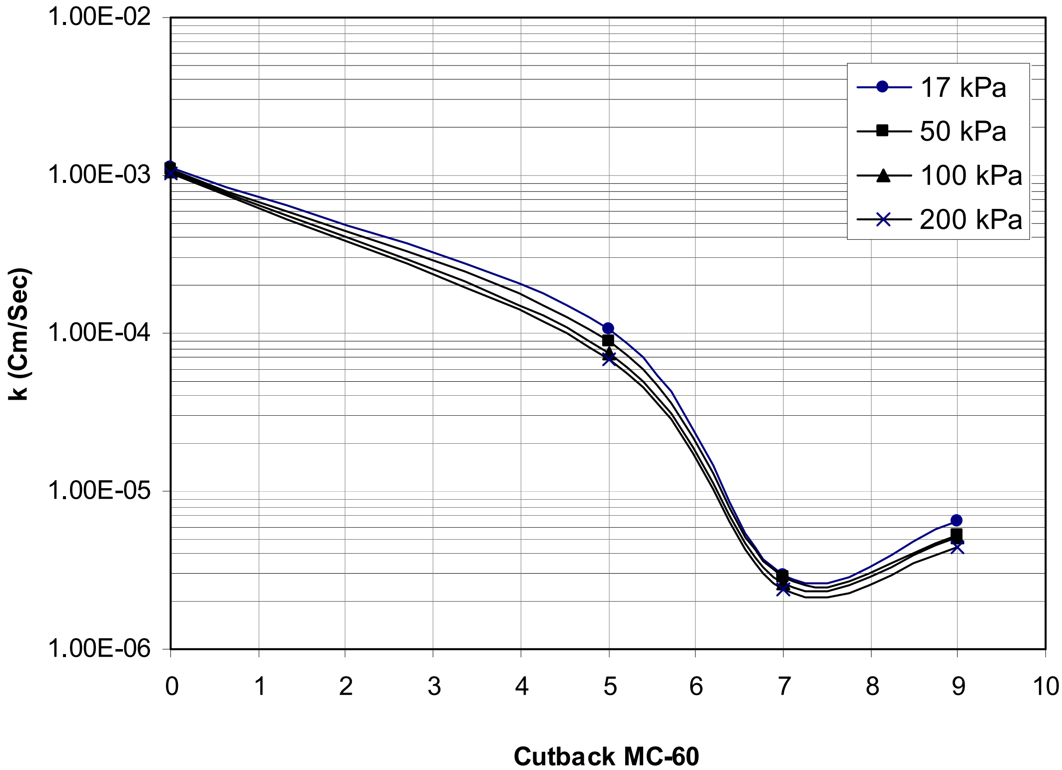


Figure (6): Permeability- Treatment% Relationship for CPLT

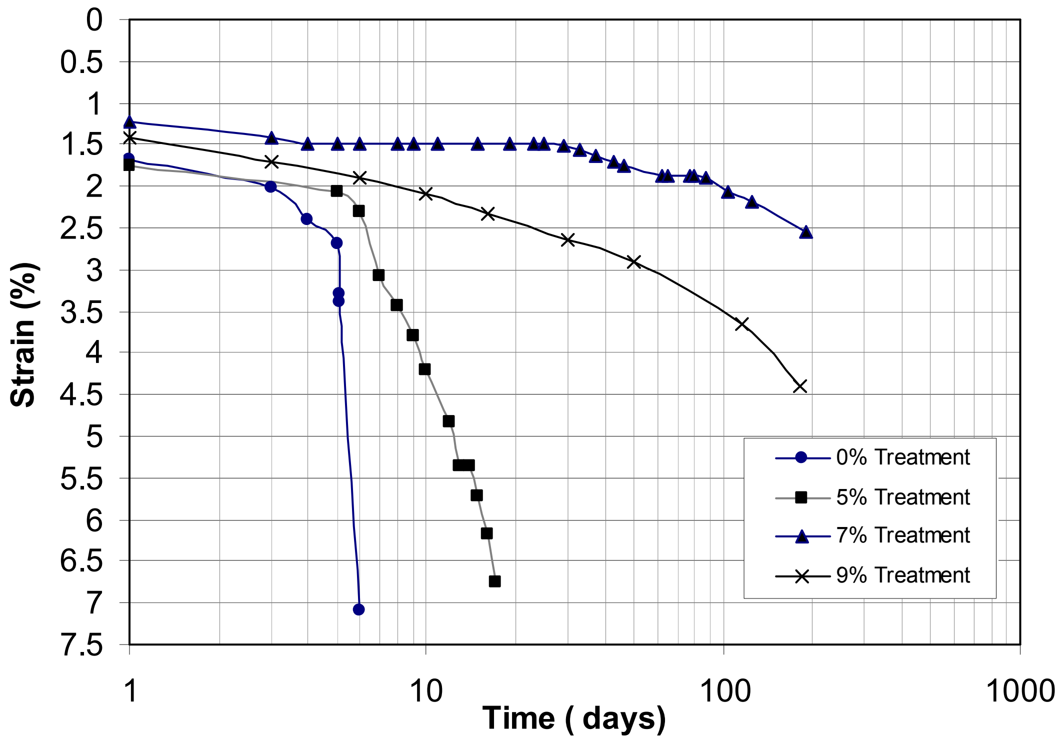


Figure (7): Strain- Log Time Relationship for CPLT

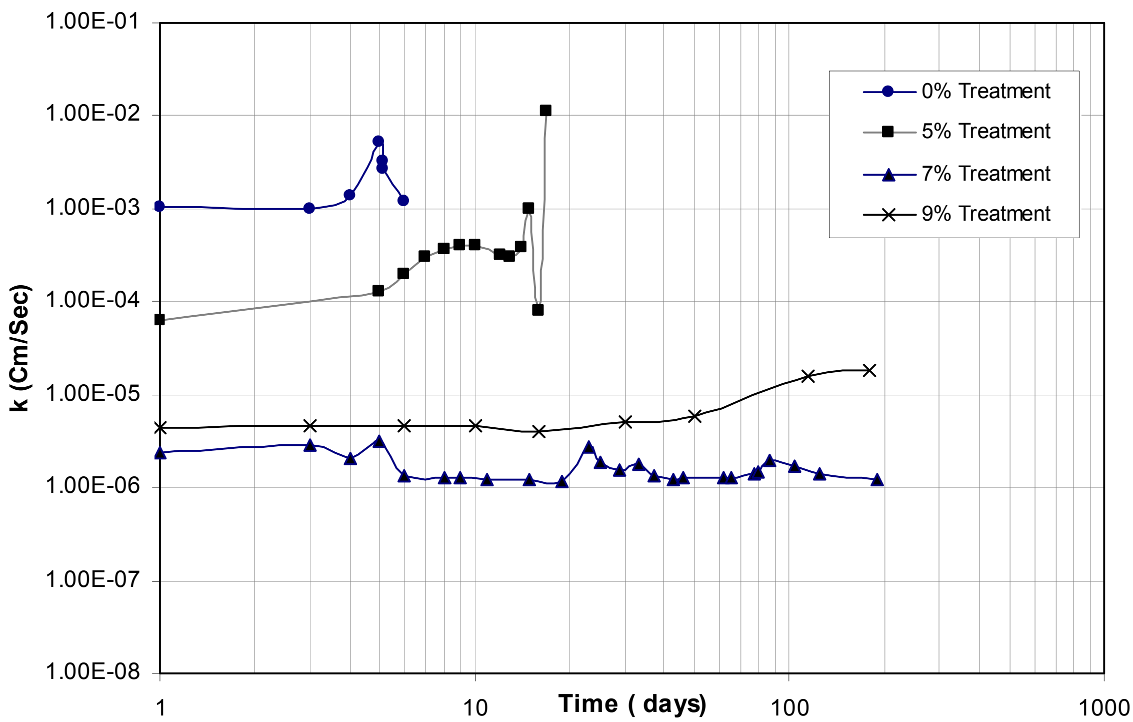


Figure (8): Permeability- Time Relationship for CPLT (Log-Log Scale)