Effect of Soaking on the CBR-Value of Subbase Soil

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Received on: 1/2/ 2011
Accepted on: 7/4/2011

Abstract

The effect of soaking on the top and bottom CBR value of a sub-base is studied in this paper.

Fourteen CBR samples were prepared at 95% relative modified AASHTO compaction .Two CBR samples were prepared for each soaking period of 0,4,7,14,30 and 60 days. These samples were prepared and compacted mechanically in the laboratory. The first group was tested in case of unsoaked while the second group was tested in case of soaking.

The results showed that, a significant drop in the CBR for top and bottom due to the soaking was observed compared with natural case due to softening of soil particles Which means that the bearing capacity of subbase soil decrease with increase of soaking time. Most of decrease in soaked CBR value is pronounced inthe first days for top and bottom CBR, respectively. And it dropped to 20% and23%value for top and bottom after 60 days soaking period and this drop is in full of weakness of soil with soaking.

Keywords: Subbase , Soil, CBR, Top and Bottom, Soaking.

تاثير الغمر على قيمة التحمل الكاليفورني لتربة تحت الاساس

الخلاصة

يقدم هذا البحث دراسة لتأثير فترات الغمر على نسبة التحمل الكاليفورني للسطح و القاعدة بالنسبة لل sub-base المستخدم لاغراض الطرق.

لدراسة تأثير فترة الغمر على نسبة التحمل الكاليفورني تم غمر 14نموذج بنسبة رص قدرها 95% من رص الاشتو المعدل و قد تم تحضير نموذجين لكل فترة غمر و ان هذه الفترات هي (0و4و7و14و30,و 60 يوم). وان هذة النماذج تم تحضيرها و رصها ميكانيكيا في المختبر و تم فحص مجموعة منها بالحالة الاولى ,غير المغمورة والمجموعة الثانية و ضعت بالماء اعتمادا على فترات الغمرو قد لوحظ انخفاض واضح في نسبة التحمل الكاليفورني لكل من السطح والقاعدةمما يعني ان قابلية التحمل لتربة تحت الاساس قد قلت بزيادة فترات الغمر و معظم النقصان قد حدث في الايام الاولى للغمر لكل من السطح والقاعدة . فقد انخفضت نسبة التحمل الى 20% و 23% لكل من السطح و القاعدة بعد مرور 60 يوم مغمورة بالماء. هذا الانخفاض يعود الى ضعف التربة نتيجة غمرها لفترات في الماء.

Introduction

Soil is the foundation material for all highways, wherever it is in the form of undisturbed in situ sub grade materials or transported and reworked embankment materials (O Flaherty 1988).

Most structures of all types rest either directly upon the soil or backfilled granular soil (subbase) and proper analysis of the soil and design of the foundation of the structures are necessary to ensure a safe structure

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Free of undue setting and /or collapse (Cheng and Evett, 1981).

The purpose of this study is to investigate the behaviour of top and

Sub-Base layer

This layer or layers of specified or selected materials of designed thickness is placed on a sub grade to support a base course (Binder, 1977).

The purpose of a sub-base is to permit the building of relatively thick pavement at a low cost. Economy is the essential item in the design of sub-base course. The greatest possible use should be made of locally available material. They may consist of selected materials such as natural gravels, which are stable but are not completely suitable as base course borrow. This may also, consist of stabilized soil or merely selected borrow. Thus, the quality of sub-base can vary within wide limits, as long as When using soil as a material in highway embankment, earth dams and backfill for a various types of construction, the quality of the earth construction is controlled mainly by compaction requirements. The compaction test is the most common field test for soils during construction (Athins, 1980).

Compaction of soil is the process whereby soil particles are constrained to pack more closely together through a reduction in air void, generally by mechanical means. The object in compacting soil is to improve its properties, and in particular to increase its strength and bearing capacity, reduce its compressibility and decrease its ability to absorb water due to reduction in volume of voids. Due to above reason tendencies for volume change more shrinkage and swell are reduced and the soil mass becomes

exists for each soil, a moisture content at which a maximum dry

Bottom CBR of soilunder soaking. Therefore, the value of CBR will be evaluated at different periods of soaking.

the thickness design criteria are fulfilled for flexible pavement.

The purpose of sub-base is to serve one or more of the following (Sharma, 1985):

1) Increase the structural support for the base and surface courses.
2) Improve drainage.
3) Eliminate frost heave and salt heave.
4) Prevent the base and surface course from being affected detrimentally by the poor qualities of the underlying soil.

The sub-base may be continuous or intermitted and its depth may vary considerably on different sections of the road.

Compaction Characteristics

more uniform and less susceptible to differential settlement. Due to compaction, resistance to frost action is generally increased since heat and moisture transfers are retarded.

Compaction is measured quantitatively in term of dry density of the soil , weight of soil per cubic meter of the soil in bulk. The moisture content of the soil is the weight of moisture present expressed as a percentage of the weight of dry soil, and dry density is thus determined from the bulk density of the soil by deducting the weight of the moisture present.

Important factors which influence the increase in the dry density of soil produced by compaction are moisture content and the amount as well as method of application of the compactive effort. With a given amount of compactive effort there density is obtained. This moisture content is known as optimum moisture content (Sharma, 1985).

California Bearing Ratio (CBR):

The CBR test was developed by the California division of highway in 1929 to predict behaviour of materials of the pavement and the sub grade.CBR test is simple and can be performed both in the laboratory and in the field. It is necessary that the standard test procedure should be strictly adhered to (Binder, 1977).

According to O Flaherty (1988), the CBR test is an empirical test and depends upon the condition of the soil at the time of testing. This requires that the soil must be tested in a condition that is critical to the designer.

The sample with the surcharge imposed on it is subjected to penetration by piston 1.95 in (49.6mm) in diameter moving at a speed of 0.05 in/min (1.27mm/min).

The ASTM D1883-87 specification will be adopted to carry out the CBR test in this study because of the contradiction in the state commission of road and bridges SCRB (formerly SORB) specification (1999) in which the AASHTO T193-81 (i.e. standard Proctor compaction)is used to carry out the CBR test. However, the SORB specification requires that the compaction should be carried out in accordance with the modified AASHTO compaction.

For this reason and to avoid such contradiction, Subhi (1987), Razouki and EL-Rawi (1997), Kutta (2000), Jassim (2001) were recommending the use of ASTM D1883-87 for carrying out the CBR test. This is because ASTM D 1883-87 allows the compaction (Salem, 2006).

El- Janabi (1995) studied experimentally the effect of long-term soaking on the strength of Tikrit granular gypsiferous soil [A-3(0) soil group with 64% gypsum content].He prepared CBR samples at 95% relative modified AASHTo compaction. After soaking the sample it found that the reduction in CBR value after four days of soaking was about (32%) of the original unsoaked CBR. However, at the end of days soaking period the loss in CBR value was about (84%) relative to the initial unsoaked CBR value.

Razouki and El-Janabi (1999) pointed out that, there is a serious decrease in gypsiferous soil strength in terms of CBR during long-term soaking.

Kuttah (2000) reported that the CBR of a clayey gypsiferous soil [A-7-6 (42) soil after AASHTO and CH soil after the Unified Soil Classification System] having TSS of 34.5 % and 33% gypsum content decreased sharply at the first 15 days of soaking under a surcharge load of each of 10, 40 and 70 Ibs (44.5, 178 and 311.5 N) suitable for highway sub-grades. After 180 days soaking period, the CBR dropped from 18.59, 20.6 and 22.1% (unsoaked CBR) to 0.999, 2.89 and 4.35% for 10, 40 and 70 Ibs surcharge load respectively.

Jassim (2001) tested a clayey gypsiferous soil [A-7-5 (45) having 15.9% T.S.S. and 14.84% gypsum content] under surcharge loads of 70, 140 and 210 Ibs (312, 623, and 935N) suitable for airport subgrades. A sharp decrease in CBR values was noticed at the first 30 days of soaking, thereafter the loss in CBR took place at a smaller rate so that the soil strength became almost constant after six months of soaking.

This loss in CBR was attributed to the dissolution of salts present in the soil tested.

Effect of Soaking on the Number of Blows and Compaction Requirement

According to the state commission of roads and bridges SCRB (1999) specification the CBR must correspond to 95 % of the maximum dry density of the modified AASHTO compaction as determined by ASTM D1557-02.

The number of blows per layer required to achieve the 95% relative compaction may be affected by the condition of the sample whether it is soaked or unsoaked. For this purpose,unsoaked and soaked CBR samples were prepared and tested in this study.

After testing the subbase in thelaboratory and according to the AASHTO T180, the subbase used was type B and the specifications of this type are listed in Table (1).

The sieve analysis of soil study is drawn in Fiqure (1) . It can be seen that the soil used in this study is meeting therequirements of type Bsubbase.

The surcharge weights, in the form of annular steel rings each of 5lb mass, are usually placed on the top surface of the prepared specimen during soaking and penetration.

According to AASHTO (T 193- 81) Head (1988), and ASTM (1883- 99)**,** sufficient annular surcharge weights equal to the mass of the base courses and surfacing above.

The testingloads of subgrade must be applied on the soil sample throughout the soaking period and penetration test. In no case shall the mass be less than 10 lb.O'Flaherty (1988)reported that a surcharge load of 5lb is considered equivalent to 2.5 in (63.5mm) pavement thickness.

In order to obtain the moisture-density relations for the standard and modified AASHTO compaction test, a mold of 6 in (152.4 mm) internal diameter and 4.584 in (116.43 mm) height is used. For carrying out the standard AASHTO compaction (AASHTO T99-86, method D), a hammer of (24.42 N) falling from a height of 12 in was used to compact the soil sample in three approximately equal layers with 56 blows per layer. Following AASHTO specification (T180-86,method D), the modified AASHTO compaction was carried out using (44.537 N) falling hammer with 18 in drop (Abood,2004).

Preparation of Soil Study:

The maximum dry unit weight of the soil used in this work was found to be (22)kN/m^3 at the optimum moisture content of 5%.To study the effect of soaking on the number of blows per layer required to achieve 95% relative compaction , two set of sample were prepared. The first was prepared for un-soaked CBR test and the second set for soaked CBR test. The surcharge load was placed first on the top of CBR sample for the case of the top CBR and the **penetration test was performed.** Thereafter, the sample was inverted and the surcharge load was placed on the inverted base of the sample to determine the base CBR and each specimen was then subjected to the penetration test. The values of CBR were calculated using equation (1) and (2) to the top and bottom.

$$CBR_{0.1} = \frac{\mathrm{P}_{0.1}}{\mathrm{P}_{S0.1}} \times 100 = \frac{P_{0.1}}{P_{S0.1}} \times 100 \quad \text{....(1)}$$

$$CBR_{0.2} = \frac{\mathrm{P}_{0.2}}{\mathrm{P}_{S0.2}} \times 100 = \frac{P_{0.2}}{P_{S0.2}} \times 100 \quad \text{....(2)}$$

where:-

$P_{0.1}, P_{0.2}$ =load required to force a standard piston 0.1″ and 0.2″ into the soil, respectively

Soaking on CBR Value:

To reveal the effect of soaking on the strength of the top and bottom of the tested soil, a number of CBR samples were prepared at 95% relative AASHTO for compaction and then soaking periods of for 4, 7, 14,30and 60days.

1- **Effect of Soaking on the Top CBR Value**:

Figure (2) shows the relationship between the load and penetration for the case of top CBR value. It can be seen that the load decreases with increase of soaking period due to softening soil particles.

Figure (3) showsthe influence of soaking on the top CBR value. A significant effect of soaking on CBR- value can be concluded from this figure compared with origin.

Figure (4) shows the result origin ofunsoaked top CBR value. Figure (5) shows degree of variation in CBR value which calculate according to the equation (3) below.

$$\Delta CBR\% = \frac{CBR_o - CBR_{t\ or\ b}}{CBR_o} \times 100 \cdots (3)$$

Where:

Δ CBR %= Degree in Variation CBR Value

CBR_o=CBR Origin

$CBR_{tor\ b}$= CBR Top or Bottom

It is noticed that a decrease in the top CBR of about (67%) takes place within 60 days soaking.

2- Effects Soaking on the Bottom CBR Value:

Figure (6) shows the relationship between the load and penetration for the case of bottom CBR value. It can be seen that the load decreases with increase of soaking period due to softening soil particles.

And Figure (7) shows the results of CBR test indication the significant effect of soaking on bottom CBR value for the test. From compared the top CBR value with the origin unsoake CBR there is a significant decrease in the bottom CBR value is caused by increasing soaking period .Figure (8) shows the resultsof in origin unsoaked CBR value. Figure (9) shows degree of variation. It is noticed that a decrease in the bottom CBR of about (69%) takes place within 60 days soaking.

Conclusions

From the results of the testing conducted in this study on the effect of soaking period on top and bottom subbase for highway purpose , it is conclude that the load applied on the subbase layer decreases with increase of period soaking.Which means that the bearing capacity of subbase soil decreases with increase of soaking time. Most of decrease in soaked CBR value is pronounced inthe first days for top and bottom CBR, respectively and the decrease in CBR value at the bottom is less than the top for all soaking periods. The degree of decrease due to soaking is about (67% in top for 60 days and about 69% in bottom for 60 days). For the case of continuous soaking, there is a decrease in strength with increase of soaking time.

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Table (1 the specification requirements of subbase type B.

Sieve size mm	Alternative	Percent passing by weight Type B
75	3 in	
50	2 in	100
25	1 in	75-95
9.5	3/8 in	40-75
4.75	No.4	30-60
2.36	No. 8	21-47
0.3	No. 50	14-28
0.075	No. 200	5-15

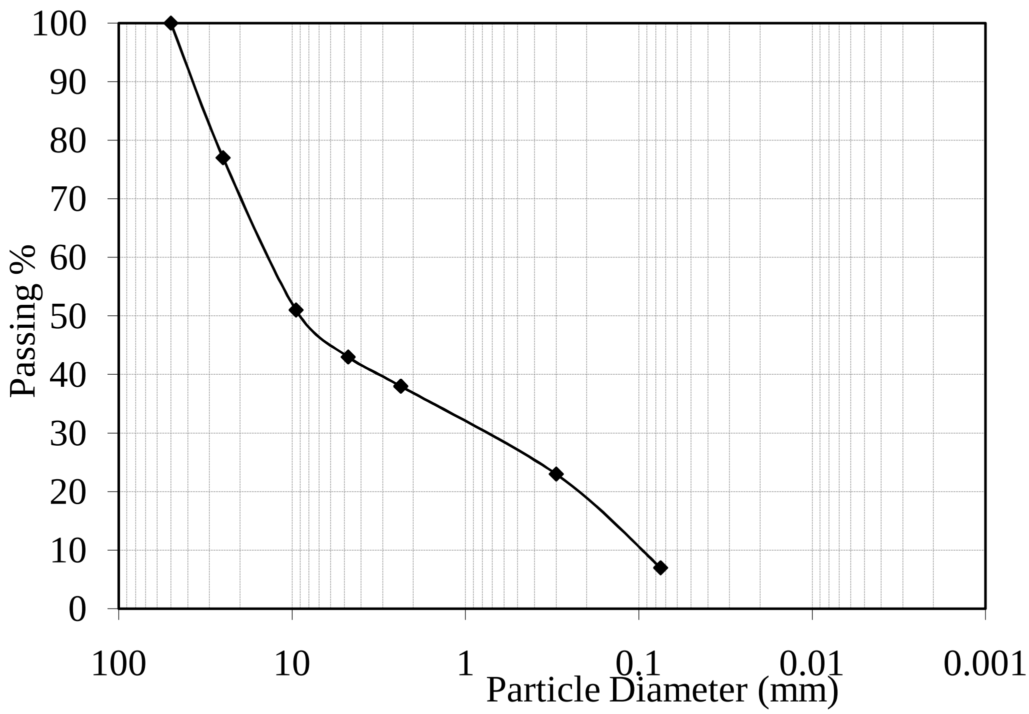

Figure (1) grain size distribution of Soil used in study.

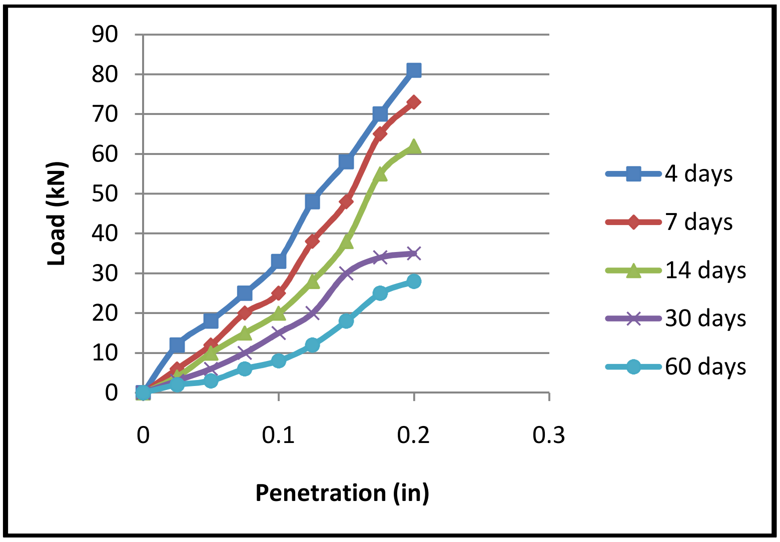

Figure (2) Load- Penetration Curves for the Top CBR Value

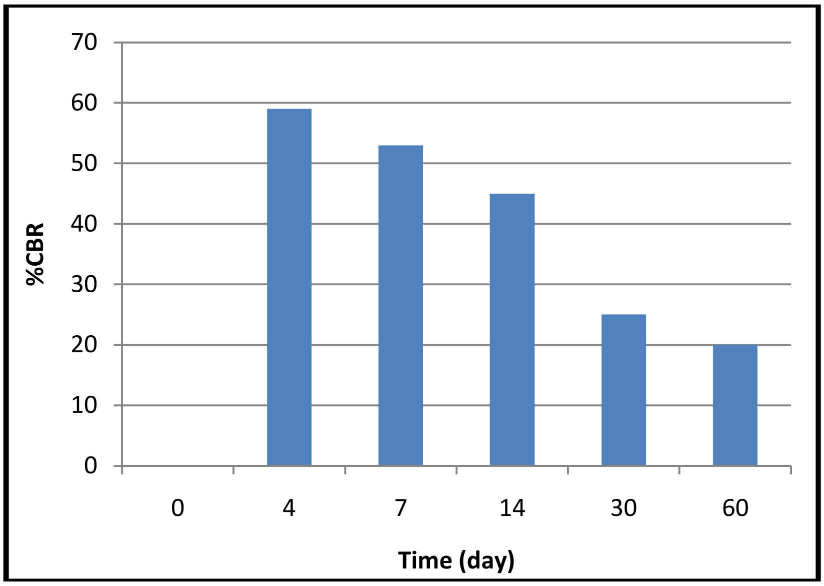

Figure (3) Effect of Soaking Time on CBR Value.

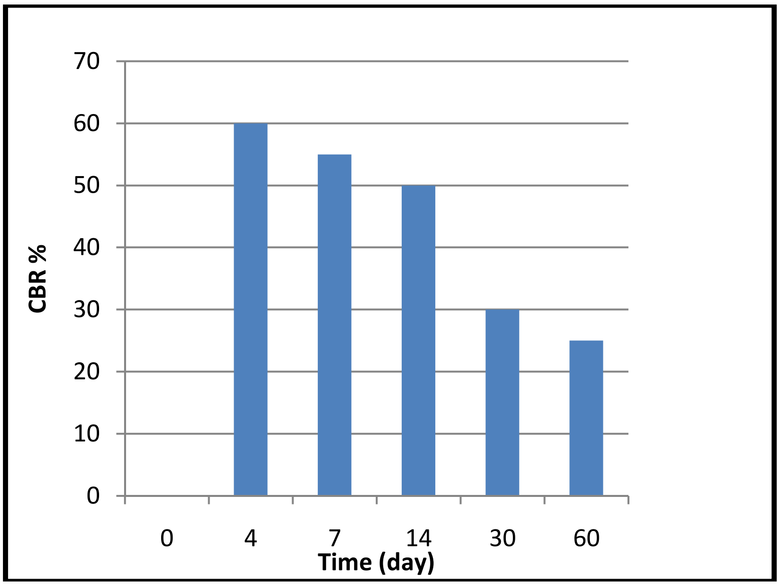

Figure (4) Relationship between OriginCBR Top Value with Time.

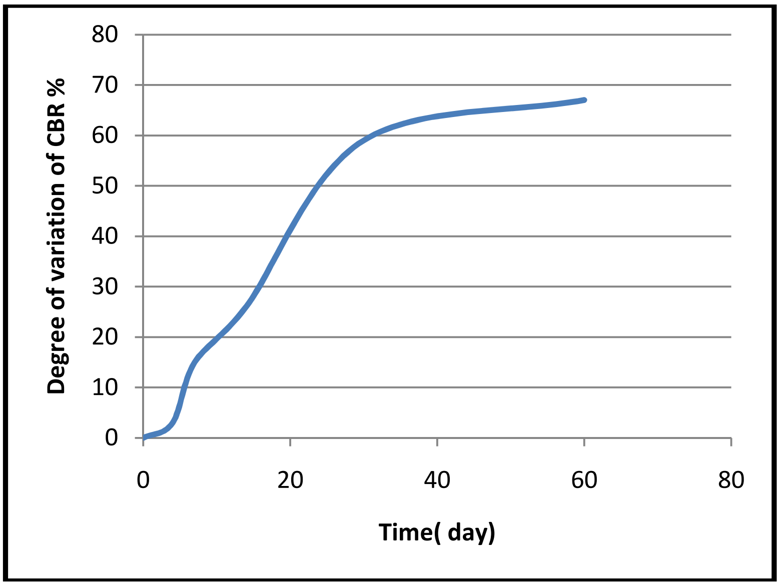

Figure (5) Degree of Variation in Top CBR Value due to Time Period.

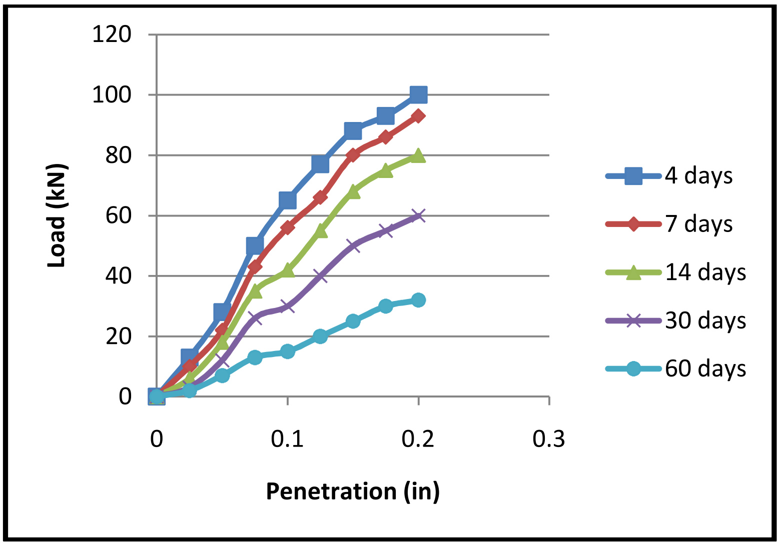

Figure (6) Load- Penetration Curves for the Bottom CBR Value

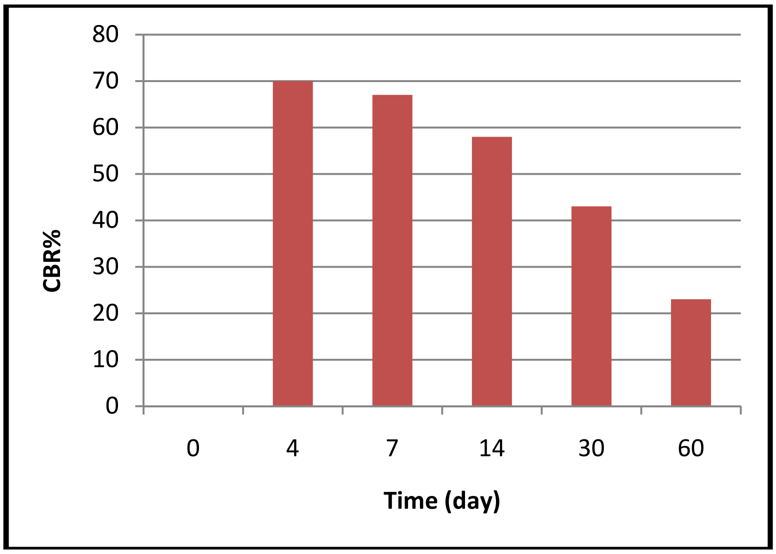

Figure (7) Effect of Soaking Time on Bottom CBR Value

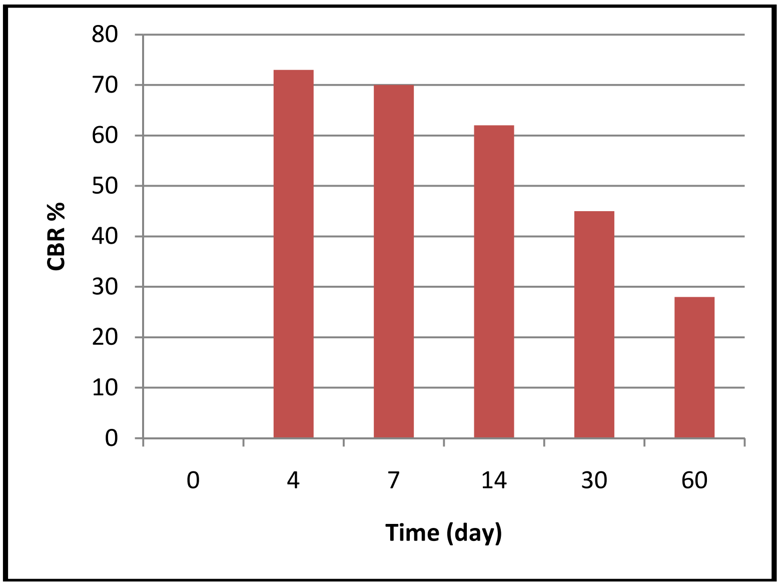

Figure (8) Relationship between Origin CBR Bottom Values with Time.

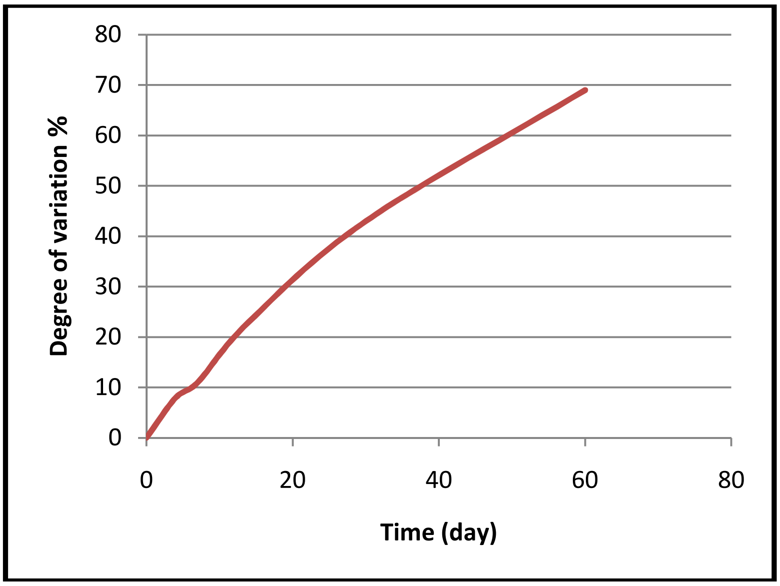

Figure (9) Degree of Variation in Bottom CBR Value due to Time Period