Republic of Iraq
Ministry of Higher
Education and Scientific Research
University of Technology

New Trends in Flexible Pavement Design

Annual project Submitted to the Department of Building and Construction Engineering of the University of Technology in Partial Fulfillment of Requirements for the Degree of B.Sc. In Highway and Bridge Engineering

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2010 **1431**

بسم الله الرحمن الرحيم

(اقرأ باسمِ ربِّكَ الَّذي خلَق ۞ خلَقَ الإنسانَ من علَق ۞ اقرأ وربُّكَ الأكرم ۞ الَّذي علَّمَ بالقلم ۞ علَّم الإنسانَ ما لم يعلم۞)

صدق الله العظيم

أهداء

الى من اعطاه الله الهيبة والوقار.. الى من علمني العطاء بدون انتظار.. الى من أحمل اسمه بكل افتحار.. أعدك بأن تبقى كلماتك نجوم اهتدي بها اليوم وغدا والى الابد.

ابي العزيز

الى ملاكي في الحياة.. الى معنى الحب والحنان والتفاني.. الى بسمة الحياة.. الى من دعائها سر نجاحي وحنانها بلسم جراحي.

امي الغالية

الى من اعطوني القوة.. الى من علموني الحياة.. الى من ساعدوني وساندوني بكل خطواتي.

عائلتي الكريمة

الى من قضيت معهم أيام وأيام.. الى من تذوقت معهم أجمل اللحظات.. الى من سافتقدهم ولن انساهم واتمنى أن لا ينسوني.

زملائي وزميلاتي

أحمد سعد الامير عبد الامير

الى سيدي و حبيبي .... رسول الله (ص)

الى المعين الذي لم ينضب عطاؤه بكل ما ينبض من قلبه من حب وتسامح ....
لاجل تحقيق سعادتي و الذي كان في طريقي نورا و أملا .... **والدي العزيز**

الى التي زرعت في قلبي الآمال و سقتني من كأسها الحنان ....
و زرعت في نفسي روح الطموح والمثابرة .... **والدتي العزيزة**

الى أخي و أخواتي .... حبا و احتراما

الى من علمني الحرف و الكلمة .... **أساتذتي الافاضل**

الى كل من ساهم في بناء هذا الوطن الغالي.

اهدي جهدي المتواضع هذا.

محمد أسعد علي

New Trends in Flexible Pavement Design

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CHAPTER ONE

INTRODUCTION

In many civil engineering works, such as industrial structures, highway and airfields, the supporting soil is subjected to both monotonic and repeated external loadings, the supporting soil whether soft soil or loose sand will experience some kind of settlement which may exceed the tolerable settlement. There is always a need for improving the properties of these soils to increase their bearing capacity and control the expected generated settlement the major challenge with the available improving techniques is the cost benefit of these techniques and there is always a debate on what is the cheapest and more economical technique.

The present work is an attempt to investigate the bearing capacity of a model footing resting on abed of ballast layer of various thicknesses overlaying a layer of sand. The behavior of model footing was investigated under both monotonic and repeated loadings.

Two model tests were performed under monotonic loading with asphalt layer spread along the interface between this sand and the ballast layers, in other words along the interface between the two layers.

In each model tests in the monotonic series, the footing was subjected to stress increments up to failure. For each stress increment the corresponding generated settlement was recorded and presented as a ratio of the footing width. Failure was considered as the stress corresponding to 10% settlement of the footing width.

In the repeated model tests series, the applied stress represents a ratio of the stress at failure. Stress ratios 0.4, 0.6 and 0.8 were selected for each ballast thickness. Each stress ratio was applied at frequency of 1Hz and generated settlement was recorded with increasing number of cycles.

In spite limited number of test the model tests revealed some interesting results. There was a clear effect of the thickness of the ballast layer on the stress settlement relationship and on stress at failure.

The increase in failure stress was clearly pronounced due to the presence of the asphalt layer. The results are encouraging and further investigation is required for more fruitful results to be obtained at repeated loading.

The repeated model tests shed the light about required safety needed and gradual degradation of stiffness.

CHAPTER TWO

EXPERIMENTAL WORK

2.1: Introduction:

Model tests were performed on untreated and treated beds of ballast overlying a sand layer. The physical properties of the materials are outlined below

2.2: Materials Used:

2.2.1: Sand:

The first step was to perform grain size distribution for the sand layer. The test was carried out according to British Specifications BS 882/1992 and the results are presented in table (1).

Table (1)

Sieve No. (mm)	Passing (%)
9.5	100
4.75	94.2
2.36	80
1.18	72.4
0.6	33.3
0.3	21.7
0.15	7.3

2.2.2: Ballast:

The ballast material are particles used as supporting layer to truck rails. Grain size distribution revealed the size outlined in table (2).

Table (2)

Sieve Dai.	Retaining Wt. (gm)	Retaining %	Passing %
8 mm	6.5	0.65	99.35
6.7 mm	31.1	3.11	96.24
5.6 mm	293	29.3	66.94
4.75 mm	147.7	14.77	52.17
2 mm	513.8	51.38	0.79
1 mm	6.3	0.63	0.16

2.2.3: Asphalt:

The physical properties of the asphalt used as a stabilizing layer is shown in table 3. Four tests were performed indicating the suitability of the specified asphalt as a stabilizing material.

Table (3)

Asphalt Properties	
Grade	48 mm
Durability	110 cm
Softening Point	58 ^{o}c
Flash Point	300 ^{o}c

2.3: Experimental Setup:

An experimental set up was designed and manufactured previously, simulating approximate one tenth of the general rail track in engineering practice. Track with tie lengths of 2000 mm interacting to form a continuous footing was modeled by a plane strain 200 mm wide footing.

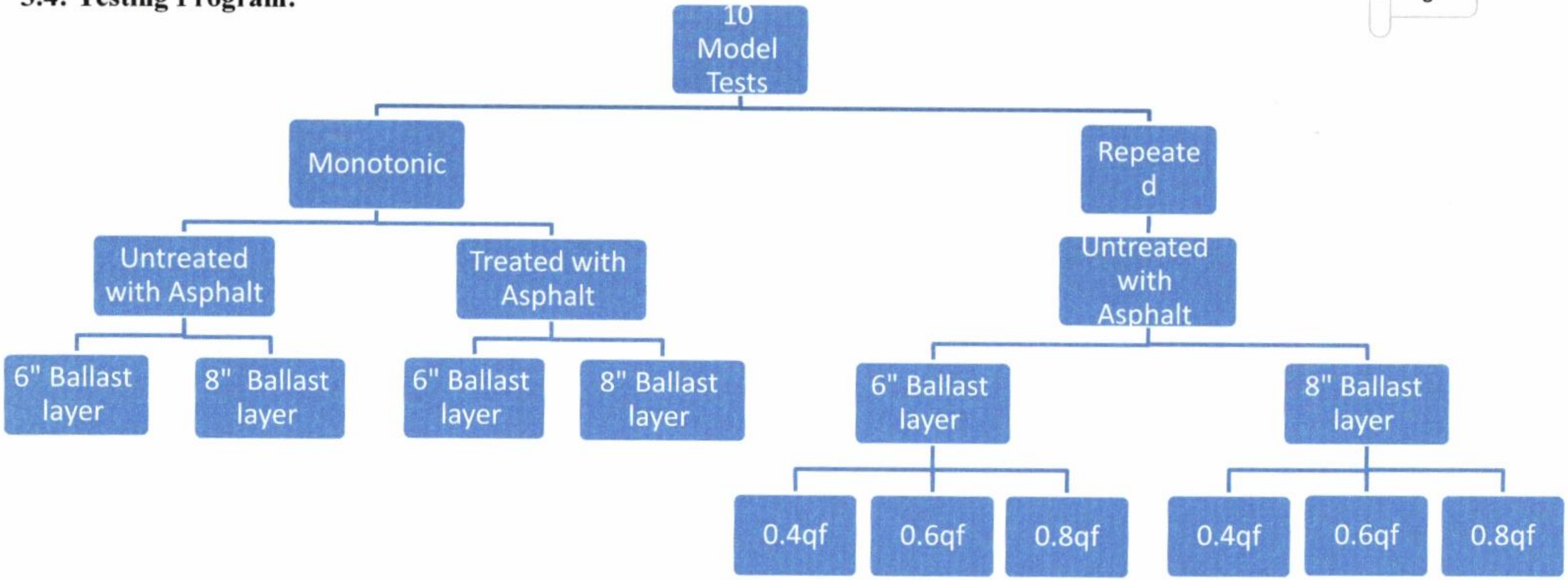
The general view of the apparatus is shown in Figure 1. The apparatus consists of the following:

1. Loading frame.
2. Axial loading system.
3. Hydraulic pressure system.
4. Model footing.
5. Data acquisition.
6. Steel containers and rails.
7. Electric control board.

Fig. (1) The Apparatus

The main objective of the apparatus is to apply axial loading (Monotonic and Repeated) on the model and determine its vertical displacement. The pressure applied on the model is controlled by a pressure transducer connected to the main line of the hydraulic pressure system. The displacement of the model is measured by two linear position displacement transducers (LPDTs). The output signals from the pressure transducer and LPDTs pass through the conditioning unit and are finally recorded at selected intervals in a data file in the computer. The entire testing process is run with the aid of computer software.

3.4: Testing Program:



A total number of 10 model tests represent 2 series carried out

The first series consists of 4 models , two model tests were performed by using a constant thickness of sand layer (400 mm) for both of them but we used a variable thickness (H) of ballast layer (6" = 152.4 mm) , (8" = 203.2 mm) , these two model tests were performed under monotonic load on untreated bed of ballast , these two models were taken as a performance base of comparison with all other models , the other two models in this series were performed under monotonic load on treated bed of ballast , the second series consists of 2 models by using a constant thickness of sand layer (400 mm) for both of them but we used a variable thickness (H) of ballast layer (6" = 152.4 mm) , (8" = 203.2 mm) of untreated ballast layer , each on of these 2 models was tested repetitively with applied stress 0.4 ,0.6 and 0.8 of the ultimate monotonic value.

3.4.1: Monotonic (Untreated Soil) and Repeated Tests:

6 " Ballast layer (without) treatment :

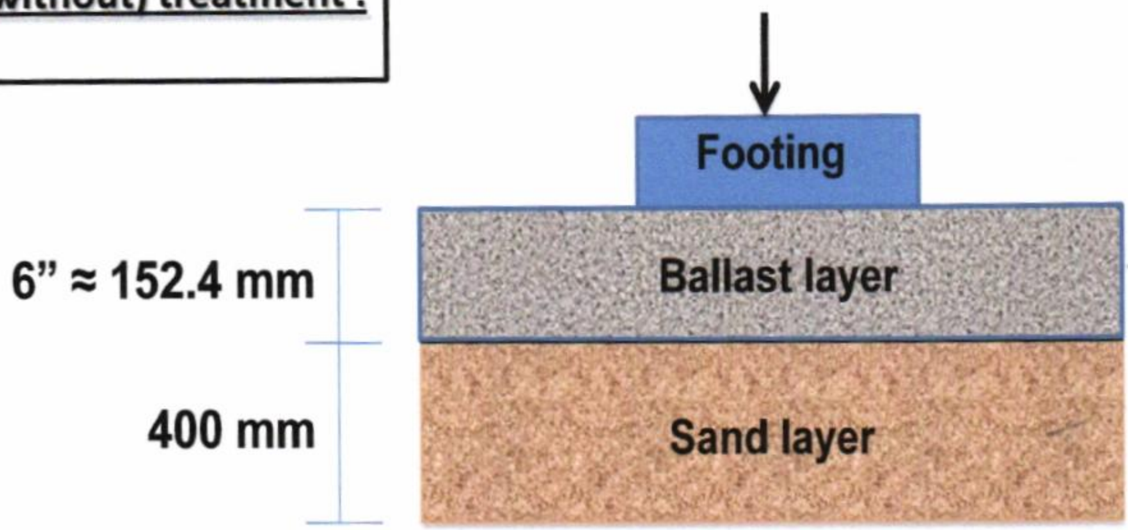


Fig. (2) Monotonic Untreated Soil and Repeated Tests for Ballast Thickness 6"

8 " Ballast layer (without) treatment :

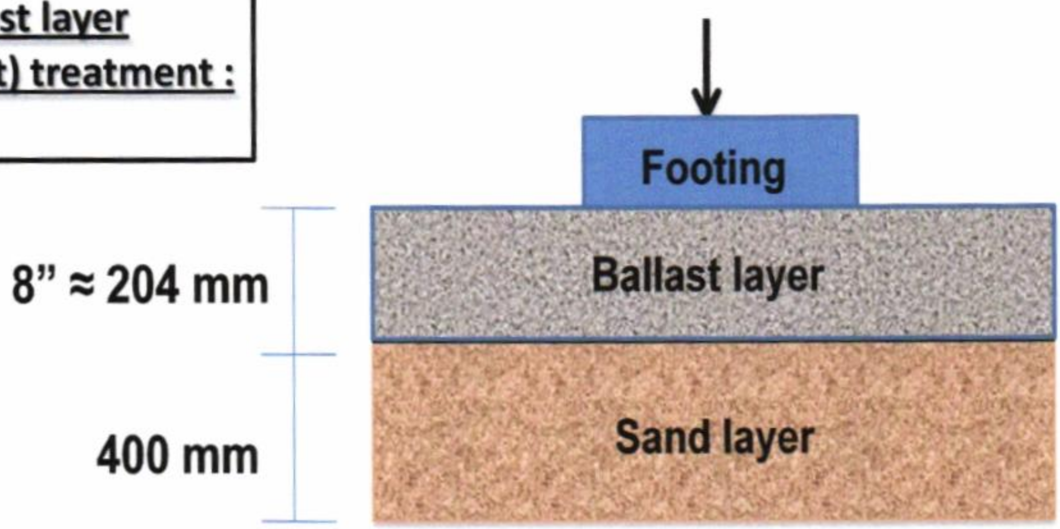


Fig. (3) Monotonic Untreated Soil and Repeated Tests for Ballast thickness 8"

3.4.2: Monotonic (Treated Soil) Tests:

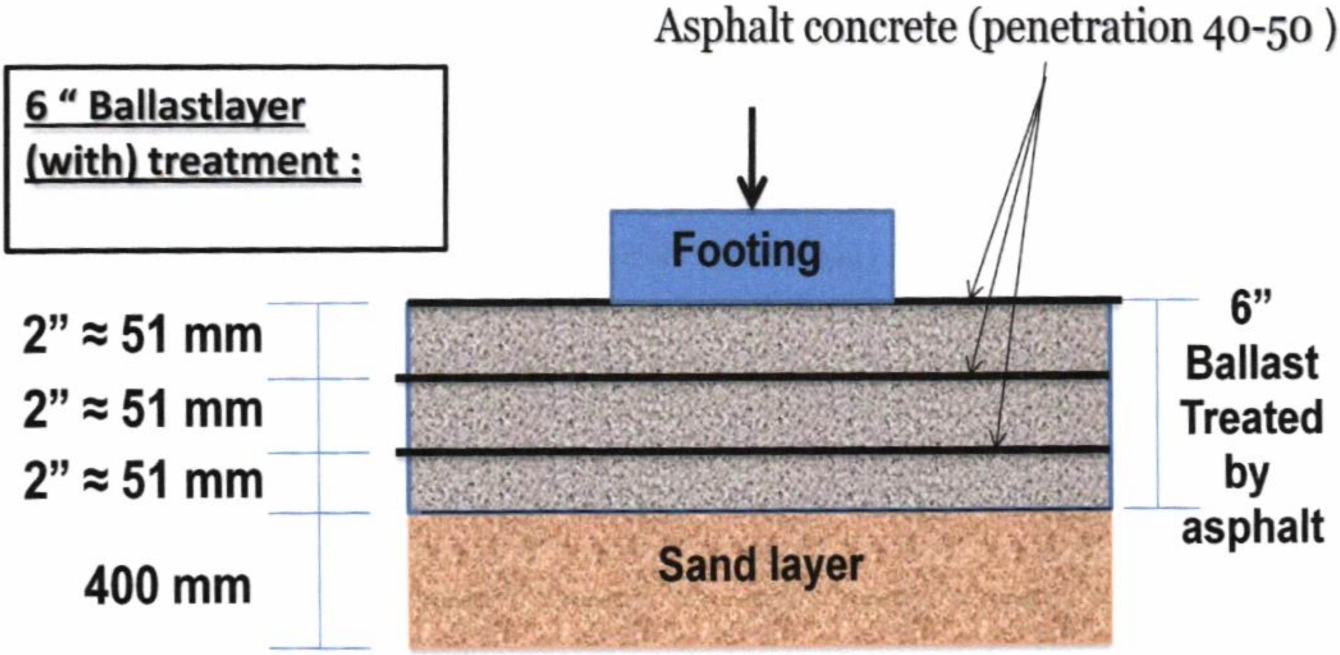


Fig. (4) Monotonic Treated Soil for Ballast Thickness 6"

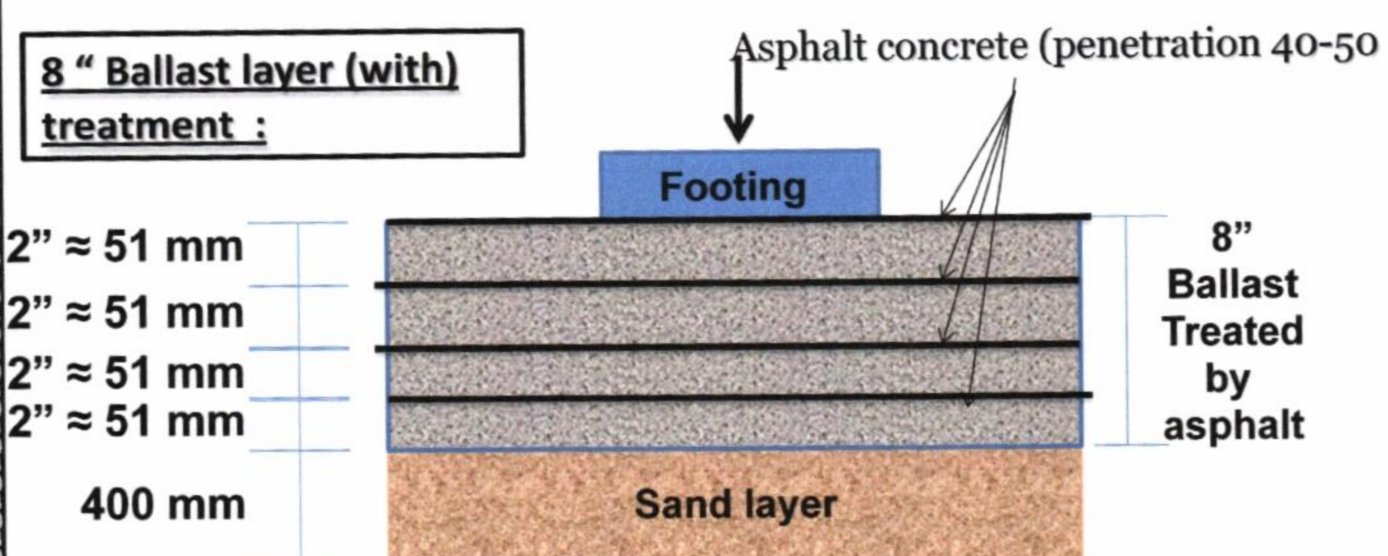


Fig. (5) Monotonic Treated Soil for Ballast Thickness 8"

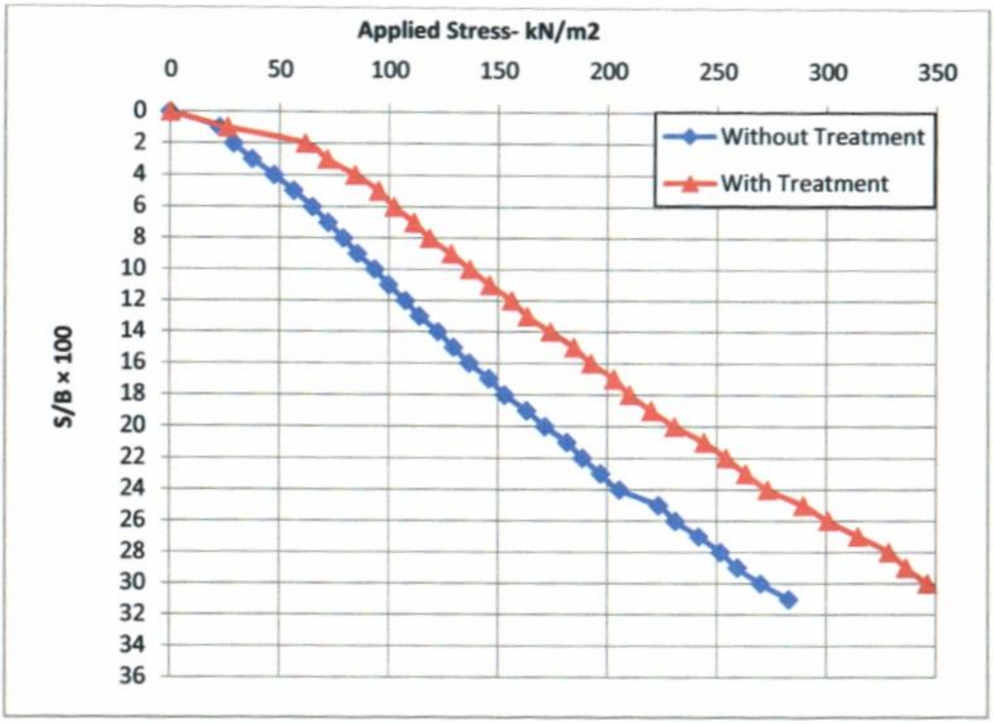


Fig (9) Applied Stress Versus Settlement Ratio (Bed Thickness 8" (203.2 mm))

3.4: Untreated Soil under Repeated Load:

In this series six model tests were performed, three at stress levels 0.4, 0.6 and 0.8 for each of the 6" and 8" thickness. The plots demonstrate the relationship between the number of cycles in a log scale and the generated settlement. The two figures (10) and (11) exhibited a similar trend of behavior where the settlement generated gradually with increasing number of cycles. It is obvious that the lowest stress level requires a higher number of cycles to reach any specified settlement ratio as compared to the two other stress levels. This argument is valid for the two thicknesses.

The number of cycles required to reach failure for the 6" model are 375, 8 and 4.4 for stress levels 0.4, 0.6 and 0.8 respectively. Similarly the numbers of cycles to reach failure for the 8" model are 78, 10 and 0.

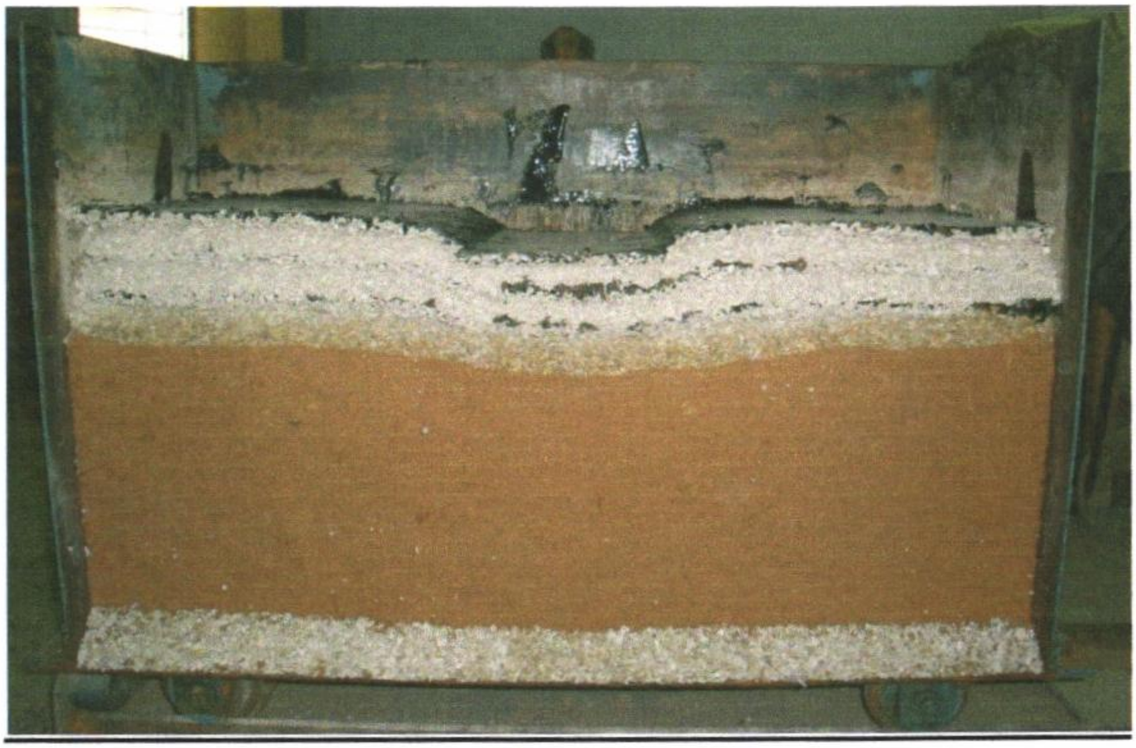


Fig. (12) The Model after the Test for 6''

Fig. (13) The Model after Test for 8''

With treatment (before and after test)

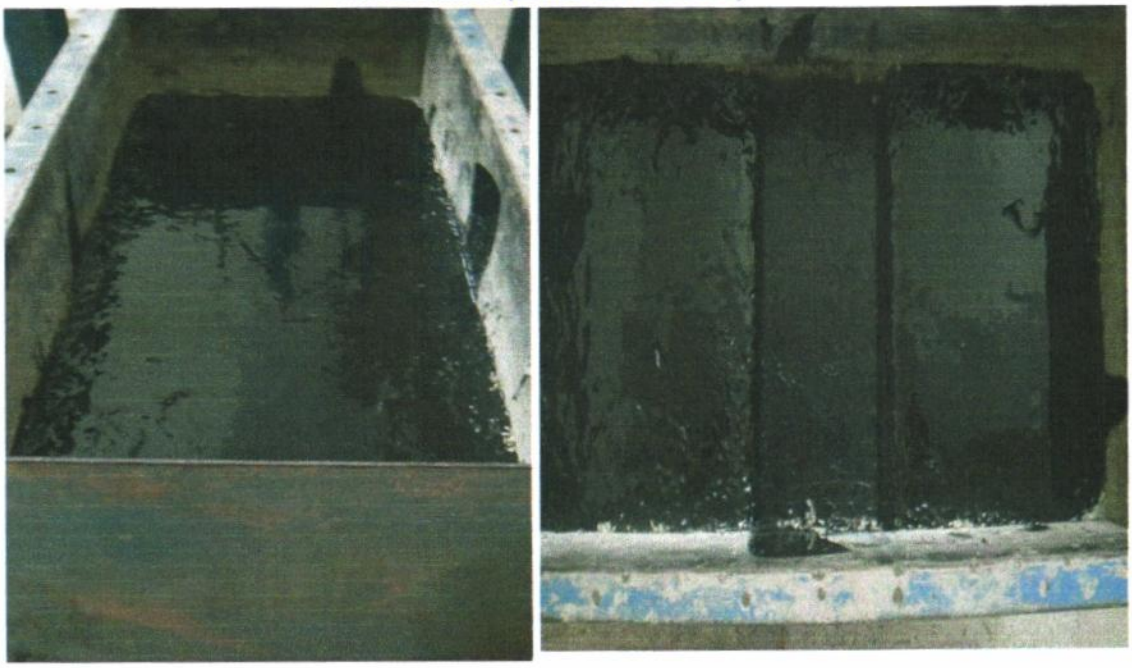


Fig. (14) Treated Model (before and after test)

Without treatment (before and after test)

Fig. (15) Untreated Model (before and after test)

CHAPTER FOUR

CONCLUSIONS

The following points are drawn from the model footing tests :

1- The bearing capacity from static model tests increased from 75 kN/m^2 to 98 kN/m^2 when the ballast thickness is increased from 6" to 8". In other words the percent increase is 30 % .

2- The presence of the asphalt layer along the interface provided a bearing capacity of 125 kN/m^2 and 140 kN/m^2 for the 6" and 8" thicknesses.

3- As comparing points 2 with 1 the percentages increase in bearing failure due to the presence of the Asphalt layer are 66 % and 42 % for the 6" and 8" thickness respectively.

4- The number of cycles required to reach failure depends on the applied stress level and the thickness of the ballast layer.