BITUMINOUS STABILIZATION OF SILTY SAND

BY

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DECLARATION

I hereby declare that this thesis has been composed by myself and that it is a record of my own research. It has not been accepted in any previous application for a higher degree.

All quotations are indicated and sources of information are specifically acknowledged by means of references.

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1991.

CERTIFICATION

This thesis entitled " BITUMINOUS STABILIZATION OF SILTY SAND" by ATUEGBU, FRANK 'KUDO meets the regulations governing the award of the degree of Master of Science (Civil Engineering Construction Materials) of Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This thesis is dedicated to my late Parents, Brothers and Sisters for their moral and financial buttress over the period.

ACKNOWLEDGEMENTS

This work will not be complete without giving due acknowledgement to the following.

I wish to express my profound gratitude to my main Supervisor Mr. B. K. Yanney of Department of Civil Engineering, Ahmadu Bello University, Zaria for his valuable suggestions, criticisms, encouragement and his easy accessibility at all times to bring this thesis to a logical and suceesful end; and whose academic initiative is my source of inspiration towards greater academic pursuits. The same gratitude also goes to my second Supervisor Dr. K. J. Osinubi lecturer, Department of Civil Engineering, Ahmadu Bello University, Zaria for his very useful suggestions and also for taking his very valuable time to read and fully criticise the write-up. Also to my Head of Department, Professor O. ADEBISI for suggestions at all times.

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ABSTRACT

Bituminous Stabilization of S1lty Sand is one method of improving the engineering properties of the Soil so that it can be used as fill. Sub-base and base materials for construction. In order to improve these properties, the following tests were carried out in the laboratory, liquid limit, moisture content, specific gravity, relationship between dry density and moisture content, C.B.R, Triaxial, Absorption, Marshall Stability flow and volume stability, using various percentages of bitumen, lime and cement.

Different methods of obtaining bituminous stabilization strength were used to compare with those of other stabilization methods (Lime and Cement).

The results obtained show that under soaked condition, *4%* bitumen was economically suitable for fill material, while *2%* cement was good for fill, Sub-base and base materials for light and medium traffic roads. The lime stabilized Soil easily disintegrated into a loose granular mass on touching. For the air cured condition, *4%* bitumen was adequate for use in fill, Sub-base and base material while *2%* cement were equally adequate.

The project will throw more light on the use of bituminous stabilization for pavement construction.

TABLE OF CONTENT

CONTENT	PAGE
TITLE	i
DECLARATION	ii
CERTIFICATION	iii
DEDICATION	iv
ACKNOWLEDGEMENTS	v
ABSTRACT	vii
TABLE OF CONTENTS	viii
LIST OF TABLES	xi
LIST OF FIGURES	xii
LIST OF APPENDICES	xiii
ABREVIATIONS	xiv
NOTATION	xv
CHAPTER 1	
1.0 Introduction	1
1.1 Objectives	3
1.2 Need for Research	4
CHAPTER 2	
2.0 Literature Review	7
CHAPTER 3	
3.0 Description of the basic Soil Sample	12
3.1 Methodology	12
3.2 Techniques of Soil Stabilization	13

CHAPTER 4

4.0 Experimental procedures and results 16

4.1 Determination of moisture content and specific gravity 16

4.2 Preliminary identification tests 17

4.3 Determination of the particle size distribution of soil 17

4.4 Determination of the Dry density/moisture content(using the modified AASHTO compaction test) 22

4.5 The California Bearing Ratio (CBR) test 30

4.6 Triaxial test 32

4.7 Absorption test for bitumen stabilized soil 42

4.8 Stability and flow tests 42

4.9 Volume stability 44

4.10 Weighing out the bitumen and mixing 46

CHAPTER 5

5.0 Analysis of Results 48

5.1 Preliminary tests on bitumen binder 48

5.2 Grading Analysis 48

5.3 Dry Density/moisture content Relationship 49

5.3.1 Bitumen - Stabilizer 49

5.3.2 Lime - Stabilizer 49

5.3.3 Cement - Stabilizer 50

5.4 California Bearing Ratio (CBR) Test 50

5.4.1 Bitumen - Stabilizer 50

5.4.2 Lime - Stabilizer 51

5.4.3	Cement - Stabilizer	51
5.5	Triaxial test	52
5.5.1	Bitumen - Stabilizer	52
5.5.2	Lime - Stabilizer	53
5.5.3	Cement - Stabilizer	53
5.6	Absorption test	53
5.7	Effect of bitumen Stabilizer on stability, flow and volume stability	54

CHAPTER 6

6.0	Conclusion and Recommendation	56
6.1	Conclusion	56
6.2	Recommendation	57

REFERENCES	59
Appendix A	61
Appendix B	67
Appendix C	84
Appendix D	133

LIST OF TABLES

TITLE		PAGE
4.1.	Preliminary test results on the bitumen binder and Recommended values from the specification	17
4.2	Properties of the Soil used	21
4.3	Effects of bitumen on Compaction	23
4.4	Effects of lime on Compaction	23
4.5	Effects of cement on Compaction	26
4.6	Results of Average CBR(%), Air Cured for 1day	31
4.7	Results of Average CBR(%), Air Cured for 7days	31
4.8	Results of Average CBR(%), Soaked for 7days	32
4.9	Results of the effect of 7days air curing, on the strength of stabilized Soil.	37
4.10	Results of the effect of 7days air curing, and 7days soaking on the strength of stabilized Soil.	37
4.11	Results of Water absorption test	42
4.12	Results of bituminous Stabilization on Marshall Stability and flow tests	44
4.13	Preliminary test Results on the basic Soil Sample and the Recommended values from the specification	48

LIST OF FIGURES

	TITLE	PAGE
4.1	Particle size Distribution of Silty Sand	20
4.2	Effect of Bituminous Stabilizer on optimum moisture content	24
4.3	Effect on Bituminous stabilizer on Maximum dry density	25
4.4	Variation in CBR(%), with Stabilized Soil (Air cured for 1day)	33
4.5	Variation in CBR(%), with Stabilized Soil (Air cured for 7day7)	34
4.6	CBR values (%), Soaked for 7days Vs Stabilizer content	35
4.7	Effect of bearing capacity parameter on Stabilized Soil (Air cured for 7days)	38
4.8	Effect of bearing capacity parameter on Stabilized Soil (Air cured for 7days)	39
4.9	Effect of bearing capacity parameter on Stabilized Soil (Air cured for 7days and 7days soaked)	40
4.10	Effect of bearing capacity parameter on Stabilized Soil (Air cured for 7days and 7days soaked)	41
4.11	Water Absorption of Silty Sand Stabilized with bitumen	43
4.12	Effect of bituminous Stabilization on stability flow (0.25mm)	45

LIST OF APPENDICES

	TITLE	PAGE
A	Specific gravity of Soil particles and Bitumen Sieve Analysis Results and values of K for use in equation for computing Diameter of particle in Hydrometer Analysis	61
B	Results of modified AASHTO compaction test on the Soil - Stabilizers	67
C	CBR test results for both Soaked and unsoaked cases for the Soil-Stabilizers	84
D	Triaxial test results for the Soil-Stabilizers result of absorption test and result of marshal Stability/flow test.	133

ABREVIATIONS

B.S	British Standard
C.B.R.	California Bearing Ratio
M.D.D	Maximum Dry Density
O.M.C.	Optimum Moisture Content
P.I	Plasticity Index
P.L	Plastic Limit
L.L	Liquid Limit
N.P	Non Plastic
AASHTO	American Association of State Highway and Transportation Officials
T.R.R.L	Transport and Road Research Laboratory
ASTM	American Society for Testing and Materials.

NOTATION

R_c = Correct hydrometer reading

Rn = Reading at the top of menniscus

C_m = Meniscus correction

X = Dispensing agent correction

C_w = Water density correction

G_s = Specicify gravity of the Solid Soil

W = Oven dry mass of sedimentation Simple

P = The friction of particle finer than O

a = Constant that depend on specific gravity

M_t = Temperature correction

D = Particle diameter

C_u = Coefficient of uniformity

C_c = Coeffient of curvature

γ_b = Bulk density of the soil

γ_d = Dry density of the soil

w = Moisture content of soil

V = Volume of mould.

CHAPTER 1

1.0 INTRODUCTION

Natural soil is one of the most universally available and low cost construction materials. The rapid growth in road traffic after the end of the second World War produced a demand for more bitumen surfaced roads all over Africa.

Not uncommonly, however, the soil at any particular locality is unsuitable, wholly or partially, to the requirements of the construction engineer. A basic decision must therefore be made, whether to:

1. accept the site material as it is, and design to standards sufficient to meet the restrictions imposed by its existing quality; or

2. remove the site material and replace it with a superior material; or

3. alter the properties of the existing soil so as to create a new site material capable of meeting the requirements.

The latter choice, the alteration of soil properties to meet specific engineering requirements is known as Soil Stabilization. The properties of a soil may be altered in many ways by methods which include

chemical, thermal, mechanical and other means. Additives are mixed into the soil in pre-determined economical proportions to achieve favourable modifications of soil properties. The choice of a stabilizer is often governed by its "response spectrum", that is, the number and type of soils in which it has been found effective.

The chief properties of a soil with which the construction engineer is concerned are volume stability, strength, permeability and durability. The need for these studies, stems from the fact that most soils in their states are at best suitable for fill or sub-base, but not for standard pavement base construction material where roads are expected to carry heavier wheel loads all the year, thus the road material needs to be improved to contain the increased stress. If the base is not well sealed, water will soften the subgrade below and thus must be prevented.

Bituminous stabilization process is more acceptable with non-cohesive granular materials where the bitumen adds cohesive strength, and with cohesive materials - where the bitumen "waterproofs" the soil thus reducing loss of strength with increase in moisture content. Both effects stem partly from the formation of films around the soil particles, which stick them together and prevent the absorption of water and simple blocking of the pores preventing water from entering the soil mass.

The method to be adopted depends upon the properties

to be improved and on the type of soil, for example in order to reduce permeability, it would suffice to ensure that seepage paths are penetrated and sealed in site by the stabilizer. Cement stabilization is most commonly used. However in cases of fine uniformly graded and round sand which occurs mostly in arid and semi-arid areas, lime stabilization has not proved very successful, e.g. in Europe and far East. Therefore the purpose of this research is to prove that bitumen stabilizer can be used for stabilizing silty sand.

Although several studies have been carried out on the use of other stabilizers (cement and lime in particular), these studies are not highlighted on the performance of bitumen as stabilizer for some soils like silty sand.

1.1 OBJECTIVES

The study is essentially aimed at improving the strength and other properties of silty sand using bitumen. By so doing, it is hoped to achieve the following objectives:-

a) Find out the range of percentage of bitumen to be used in stabilizing given type of the soils to meet fill, sub-base and base specifications.

b) To find out the extent to which various

percentages of the additives within economical ranges, improve the characteristics of the chosen soil towards meeting the specifications for fill, sub-base and base materials.

c) To try and compare its strength with that of soils stabilized with cement and lime.

1.2 NEED FOR RESEARCH

In many countries, the natural road building materials traditionally used for unsurfaced roads were found to be unsuitable for constructing bituminous surfaced roads. For example the widely occurring lateritic gravels which make excellent gravel roads proved to be too plastic and too variable to provide a satisfactory road base under a bituminous surfacing. This results in locating borrow pits with large haulage distances and hence heavy transport costs.

Highway engineers soon found that they could make excellent and cheap roads by stabilizing the natural materials with cement, lime or bitumen to form the road, sub-base and base by improving the soil strength and stability. The principles of soil stabilization are:

i. evaluation of the properties of the available soil,

ii. estimating the lacking property in the available soil,

iii. devising the method of adding the lacking property, through economical method of stabilization,

iv. compaction of the designed soil.

Soil stabilization may bring any one or more of the following changes:-

a) Chemical properties may be modified.

b) Physical properties like density, expansion, shrinkage, stability, etc. may be changed.

c) Retention of some minimum strength properties due to water proofing measures.

Different types of stabilizers are currently in use all over the world, depending on their availability. Such stabilizers include cement, lime, bitumen, some chemicals like calcium chloride, sodium silicate and some industrial by-products, namely billet-scales, fly ash, rice husk etc.

Northern Nigeria and countries surrounding the Sahara have non-plastic sandy soil to which bitumen can be applied successfully as stabilizing agent. Nigeria being a petroleum producing country, has surplus bitumen as a by-product and they are less expensive. Its use is not popular when compared with other stabilizers. Most

of the information available pertain to soils of the temperate zones where bituminous stabilization is not widely employed because the soils have a relatively high moisture content. Hence the need for this research.

CHAPTER 2

LITERATURE REVIEW

The base course of a pavement consists of gravel or crushed stone. In most parts of Africa and other developing nations, there is either a shortage of stone chipping or stone production is expensive, but there is an abundant supply of sand. Under these circumstances, it is more economical to improve the properties of the local sand or laterite than to haul gravel or crushed stone over large distances. Besides its abundant use, interest has been shown in the materials because of the frequently occurring functional and structural failures of local pavement structure of our highways and airfields. For these reasons more investigations in different countries over the years leading to the concept of soil stabilization have been made. The need for these studies stems from the fact that most soils in their natural states are at best suitable for sub-base but not for standard pavement base, construction material (Nanda and Kashamachare, 1958; Arulahanden and Tundridge, 1969).

According to the Highway Research Board (HRB), 1946; bituminous soil stabilization is the name given to those methods of construction in which bituminous materials are incorporated into the soil or soil aggregate mixture to provide base courses.

In developing countries, the road engineer sometimes needs to construct a road base using cohesionless materials and bitumen can be used for the stabilization, particularly in an oil producing country. A number of bituminous materials including cut-back bitumens, bitumen emulsion, etc have been used effectively in roads as stabilizing agent (Voder,1957). These materials increase the strength of the soil by binding the particles together and also act as a waterproofing agent, preventing the absorption of water and so maintaining the strength of the stabilized materials.

In general, a clean well-graded material is required in stabilization such as non-plastic soil even though they can be stabilized with cement, but with less efficiency. But "single size" sand with coefficient of uniformity less than 3 present a special problem because of their inherent lack of internal friction or cohesion. For such materials generally a more satisfactory solution will be found by stabilizing them with bitumen than with cement (Winterkorn and Chandrasekhakan, 1951; Clare, 1960). Harris *et al.*, 1983; Morais and Fraeme, 1977 as reported in TRRL, 1987 have found out that bitumen is particularly suitable for stabilizing cohesionless sands which would otherwise pose problems if stabilized with cement. The survey of criteria together with data published by the U.S Armed Forces suggested a limit of 20 percent passing NO.200 Sieve, a

plasticity index less than 6 and the product of plasticity index and the minus NO.200 materials less than 60 have been ultilized for selecting soils suitable for stabilization with bitumen.

The choice of a particular stabilizing agent in a particular situation depends on the use for which it is intended. The quantity of stabilizer required for a particular stabilization project is generally determined by means of arbitrary laboratory tests which to a great extent simulate field conditions of weather and other durability processes. The soil type and its composition have been known to influence the results of stabilization. Moh *et al.*, 1967, obtained satisfactory stabilization results for significantly different genetic soils with variable composition and concluded that all laterite soil could be stabilized using 4 to 7% cement for base construction. To improve poorly graded sub-base materials (M. D. Gidigasu, 1976), suggested 1 - 3% bitumen, 1/2 - 4% cement or lime as modifiers and 4 - 6% bitumen as a waterproofing agent.

The triaxial test has been used extensively for evaluating the shear strength characteristics of various genetic types of tropically weathered laterite soils and gravels (Florentin *et al.*, 1957; Lumb, 1962; Ruddock, 1967; Cruz, 1967; De Graft-Johnson *et al.*, 1972). The conclusions reached appear to suggest that the triaxial test may be used for evaluating the shear strength characteristics of almost all soils. Millard (1961),

suggested that tropical gravel soil which are generally clayey having liquid limits normally ranging between 20 and 60% may generally be stabilized to make adequate road bases by the incorporation of 4% by weight of either cement or hydrated lime. He further said that where there are facilities for the thorough mixing of gravels and are not excessively clayey less stabilizer may be used.

Immersion of specimens prepared over a range of moisture contents enables an optimum moisture content selected from the given maximum dry and wet strengths. The Practicability of using this moisture content in the field must then be judged.

The principal problem in the bituminous stabilization is the excess fluids that are not present in the work at the time of compaction, i.e. the soil to be treated must not be too moist. In this respect, practical difficulties have occurred in areas subjected to frequent, high or irregular rainfall. The work must be carefully protected until curing has been effected, and the bitumens chosen to be of a suitable viscosity grade for the environmental conditions of service (hot or cold). It is sufficient here to note that the principal criteria applied for bituminous stabilization are those designed to ensure resistance to soaking, provision of cohesion, resistance to swell and the ability to penetrate and adhere to the soil (Lee, I. K., 1974). He

further suggested that sands should be stabilized using clay loam for mechanical stability, cement for density and cohesion while bitumen for cohesion. Ingles and Metcalf did not recommend lime for use in stabilizing sand, instead they suggested the use of bitumen stabilization for promoting adhesion or cement may be used in the soil along with bitumen to improve the stability of the mixture.

The basic soil sample particles may be rounded or angular. The shape of the particles influence the characteristics of coarse grained soil like sand, gravel etc. But the shape of the particles in case of fine grained soils does not have remarkable effect on the soil behaviour.

Internal frictional resistance is the resistance of the soil particles to slide over each other. Rough angular and large particles have higher internal friction than smooth, rounded and smaller particles. Well graded compacted soils also exhibit larger internal friction than loose ungraded soil mixtures.

The research will highlight on the amount of bitumen to be added to the silty sand in order to improve the strength property of the soil.

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CHAPTER 3

3.0 DESCRIPTION OF THE BASIC SOIL SAMPLE

The soil sample used in this thesis was collected from the bank of a seasonal river at the back of Dan Fadio Hostel, Ahmadu Bello University, Samaru-Zaria. It was a disturbed sample obtained at the depth of 1m below the ground surface in order to avoid organic matters. The sample is to be tested and see if it is suitable in it's natural state for use as sub-base and base materials.

3.1 METHODOLOGY

The basic soil sample was taken to the laboratory and was subjected to various tests to determine its physical and engineering properties. These laboratory tests were performed in accordance with British Standard (BS) or American Society for Testing and Materials (ASTM) Standards.

The following tests were carried out,

1. Liquid limit,
2. Moisture content and specific gravity,
3. Compaction to determine the relationship between dry density and moisture content,
4. C.B.R. both soaked and unsoaked,
5. Absorption test,
6. Stability and flow tests,

7. Volume stability, and

8. Triaxial test.

The percentages of the stabilizers used were 2, 4, 6, 8 and 10. Any of the soil-stabilized sample which needed compaction were compacted at optimum moisture content using the modified AASHTO Standard Method of Compaction.

Any material of which more than 35% passes the NO.200 B.S. Sieve may be rejected.

3.2 TECHNIQUE OF SOIL STABILIZATION

There are various methods of soil stabilization the particular method to be employed depend upon the results achieved by various stabilization techniques. Generally the methods can be grouped under the following headings.

1. Proportion:

In this method various soils were proportioned to give the desired results after compaction.

2. Modifying Agents:

Lime and cement are the main modifying agents. When small amount of modifier is added to the soil to be stabilized, it brings about a lot of improvement in the performance of the soil.

3. **Cementing Agents:**

Addition of cement materials like lime, fly ash or cement, considerably enhance the strength and stability of the stabilized soils. Bituminous materials impart binding properties to non-cohesive soils like pure sand.

4. **Water Proofing and Repelling Agents:**

A good stable soil may become soft and weak if water infiltrates into it. If entrance of water into such soil is stopped or minimized by using water proofing agents, its strength properties can be preserved and the soil may continue to perform effectively. Bituminous materials are the most commonly adopted water proofing materials. When repelling agent like vinsol resin is added to the materials to be stabilized, render stabilized soil water proof. This agent does not allow water to come into contact with the stabilized soil as they coat soil particles and prevent absorption of water.

5. **Water Retaining Agents:**

Some of the non-cohesive soil maintain sufficient stability and strength when their layers posses certain minimum amount of moisture. These soils become loose and less stable, if moisture content is less than this minimum amount. Calcium chloride is one of such compounds which if added to the

stabilized soil will continue to absorb moisture from the atmosphere and will maintain optimum moisture content in the soil. Treatment with calcium chloride will also reduce dust nuisance on the laterite roads.

In addition to the above mentioned measures, heat treatment and chemical treatment of the soils may also be adopted if conditions warrant. Heat treatment is useful for treatment of clayey soils. In all the measures discussed, earlier effective compaction of the soil is very essential for achieving the desired results.

CHAPTER 4

4.0 EXPERIMENTAL PROCEDURES AND RESULTS

The main essence of the research work as stated in Chapter one is to examine the possibility of using the technique of bituminous stabilization to improve the qualities of either a sub-base material to suit the properties (e.g. CBR) of a good base materials or may even be used to improve the properties of ordinary fill material to suit the properties of sub-base material. Then the results obtained in this research work can be ultilized for any road construction project in the vicinity. Also the result will help in using bitumen as a substitute to the more convention stabilizers (lime and cement).

When the basic soil was found to be unsuitable, different percentages of the stabilizers each was added and thoroughly mixed. Compaction, CBR triaxial, Absorption, Stability and Flow tests were carried out. The results were presented in both tabular and graphical forms.

4.1 DETERMINATION OF MOISTURE CONTENT AND SPECIFIC GRAVITY

The initial moisture content of the soil sample as well as the specific gravity were calculated and the averaged values are presented in data sheet tables 1 and 2 respectively (see Appendix A). For detail procedures

see B.S 1377: 1975, Test 1 (A) and Test 2 (B) or reference No. 10.

4.2 PRELIMINARY IDENTIFICATION TESTS

The procedure for the tests can be found in reference No. 20. Bitumen tests were carried out on the properties of the binder used. The following results were obtained in the laboratory. These are given in Table 4.1. The binder labelled MCO was supplied by a reputable petroleum company.

Table 4.1: **Preliminary test results on the bitumen binder and recommended values from the specification**

Test carried out	Results	Specification
Flash point (^{o}C)	68	38(min)
Viscosity at 25^{o}C (secs)	0.8	1/2-2
Solubility in CCl_4 (%)	99	99
Specific gravity	1.02	0.97-1.04

4.3 DETERMINATION OF THE PARTICLE SIZE DISTRIBUTION OF THE SOIL

The particle size distribution of the soil was found by particle size analysis. An analysis of this kind quantitatively expresses the proportions by weight of various sizes of particles present in the soil. It is of great significance in collaborating the properties of

soil, e.g. concrete mixes, highway sub-base and base, design of impermeable layers behind earth dams and water well etc.

In order to analyse the soil, the combined sieve analysis was used. The particle size distribution of the coarse friction was determined using B.S Sieves. The fine fraction was also evaluated using the Sedimentation analysis. See reference No. 10 or BS 1377: 1975, Test 7 (D) for the procedures.

The result of sieve analysis is recorded in data sheet 3 and the calculated particle size and the friction finer (P) of particle finer than D is presented in data sheet 4 and the results of drying sieving and sedimentation analysis were combined in Data Sheet 5 all in Appendix A. To calculate the particle diameter D(mm) at a given time t(min). Stoke's law was used as follows:

$$D = K\left(\frac{L}{t}\right)^{1/2} \quad \ldots\ldots\ldots\ldots\ldots 4.1$$

where $K = \frac{18\eta}{\gamma s - \gamma w}$ 4.2

K can be obtained from Data Sheet 2. η is the viscosity of the suspending medium γ_s and γw are the unit weights of the soil solids and water respectively.

D = particle size diameter

$$P = \frac{aRc}{W} \quad \ldots\ldots\ldots\ldots\ldots 4.3$$

$$a = 1.53 - 0.2Gs \quad \ldots\ldots\ldots\ldots\ldots 4.4$$

$$Rc = Ra + Cm + Mt - X + Cw \quad \ldots\ldots\ldots\ldots 4.5$$

Using Mt = 0.5

X = 4.0

Cw = 1.8

Cm = 0

These data were obtained from the hydrometer No. 773122.

Where Rc = Corrected hydrometer reading

Ra = Reading at the top of meniscus

Cm = Meniscus correction

X = Dispersing agent corection

Cw = Water density correction

Gs = Specific gravity of the solid soil

W = Oven dry mass of sedimentation sample

P = The fraction of particle finer than D

U = Constant that depend on specific gravity

Mt = Temperature correction

From equation 4.5

$$Rc = Ra - 1.7 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad 4.6$$

fraction passing the 2mm sieve = $\frac{M_1}{M_o}$

where M_o = Gross mass of soil

M_1 = Mass passing 2mm sieve

M_2 = Mass used in sedimentation analysis

The results of sieve analysis on material retained on .2mm sieve is given as:

PARTICLE SIZE DISTRIBUTION

LOCATION NO———— BORE HOLE No———— SAMPLE No———— PRETREATMENT DETAILS————

DATE OF TEST———— DESCRIPTION————

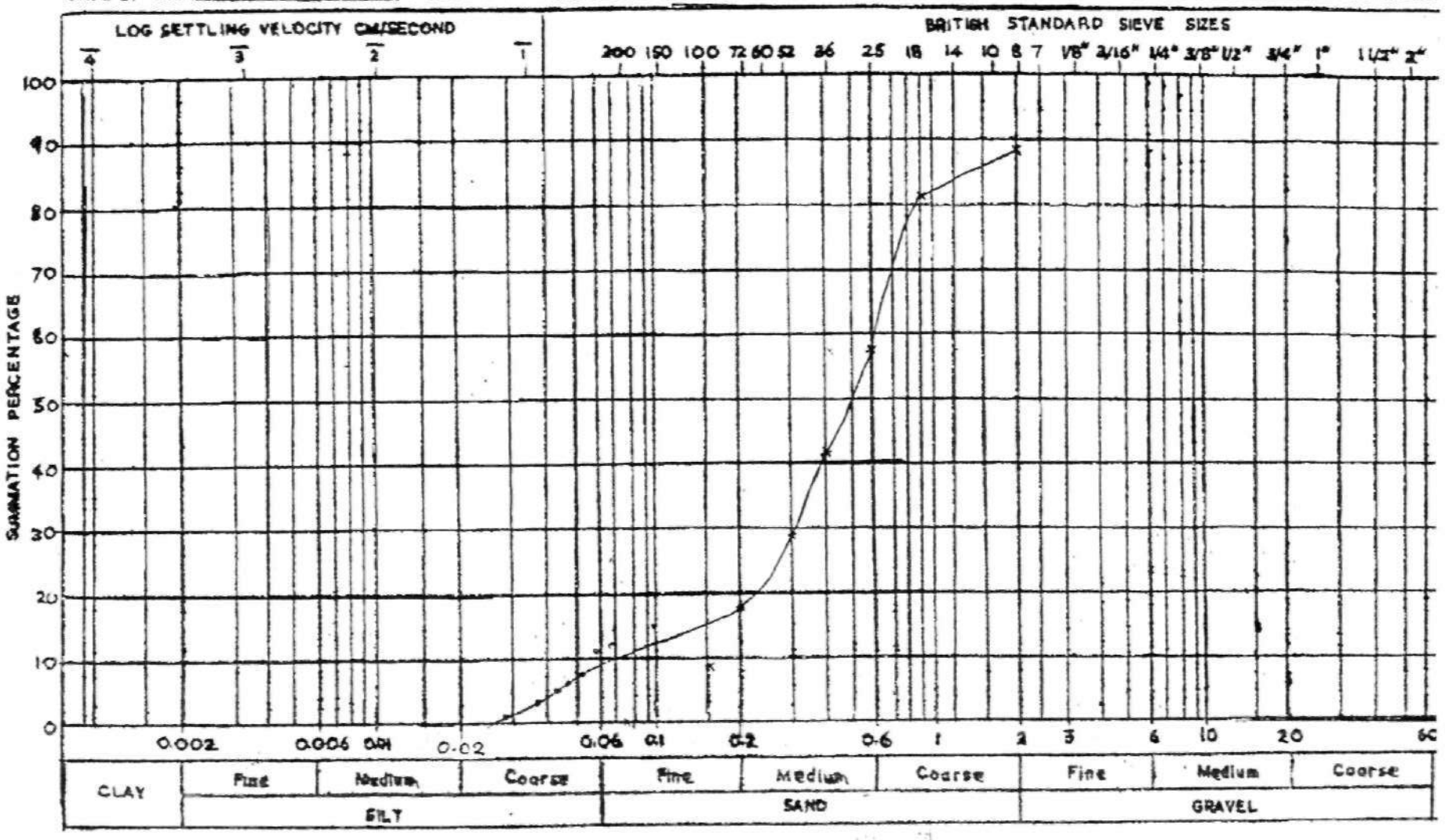


Figure 4.1

$$\text{Fraction retained} = \frac{\text{mass retained on sieve}}{M_o}$$

Fraction finer = 1.0 - cummulative fraction retained.

Results of sieve analysis of soil used for sedimentation analysis (passing 2mm sieve) is given as:

$$\text{Fraction Retained} = \frac{\text{mass retained on sieve}}{M_2}$$

Fraction finer (of total sample) =

$$(1 - \text{cummulative fraction retained}) = \frac{M_1}{M_o}$$

Result of sedimentation analysis is given as;

$$\text{Fraction finer (of total sample)} = P\ \frac{M_1}{M_o}$$

$$\text{Uniformity coefficent } (C_u) = \frac{D_{60}}{D_{10}} \quad \ldots\ldots 4.7$$

$$\text{Coefficient of curvature } (C_c) = \frac{(D_{30})^2}{D_{60} \times D_{10}} \quad \ldots\ldots 4.8$$

where

D_{10} = maximum particle size of the smallest 10% (by weight) of the sample (effective size)

D_{30} = maximum particle size of the smallest 30%

D_{60} = maximum particle size of the smallest 60%

Table 4.2: Properties of the soil used

Test	Result
Unformity coefficent (C_u)	8.7
Coefficient of curvature (C_c)	2.6
Liquid and plastic limits	N.P.
Colour	Dark brown
Specific Gravity (G_s)	2.48

4.4 DETERMINATION OF THE DRY DENSITY/MOISTURE CONTENT (Using the Modified AASHTO Compaction test)

For the test procedure see BS 1377: 1975, Test 13 or see Reference No. 10. The relationships between W, γd and γb are given as follows:-

$$b = \frac{Ww + Ws}{V} \quad \ldots\ldots\ldots 4.9$$

$$d = \frac{Ws}{V} \quad \ldots\ldots\ldots\ldots 4.10$$

$$w = \frac{Ww}{Ws} \quad \ldots\ldots\ldots\ldots 4.11$$

from equation 4.11

$$Ww = WWs$$

substituting in equation 4.9

$$\gamma b = \frac{Ws}{V}(1 + w)$$

$$\gamma d = \frac{\gamma b}{1 + W} \quad \ldots\ldots\ldots\ldots 4.12$$

where

Ww = weight of water in soil

Ws = weight of dry soil

V = volume of mould or soil in the mould

W = moisture content of the soil

γb = bulk density of the soil

γd = dry density of the soil.

The graphs of dry density plotted against moisture content are shown in Appendix B. The results of the AASHTO compaction of the soil with bitumen, lime and cement are summarized in Tables 4.3 - 4.5.

Table 4.3: Effects of bitumen on Compaction

% of Stabilizer	OMC %	MDD (KN/m^3
0	8.8	20.1
2	8.14	20.3
4	8.5	20.2
6	7.98	19.9
8	7.38	19.4
10	7.28	18.6

Table 4.4: Effects of lime on Compaction

% of Stabilizer	OMC %	MDD (KN/m^3
0	8.8	20.1
2	7.7	20.2
4	7.3	20.0
6	7.5	20.6
8	9.6	20.1
10	9.8	20.2

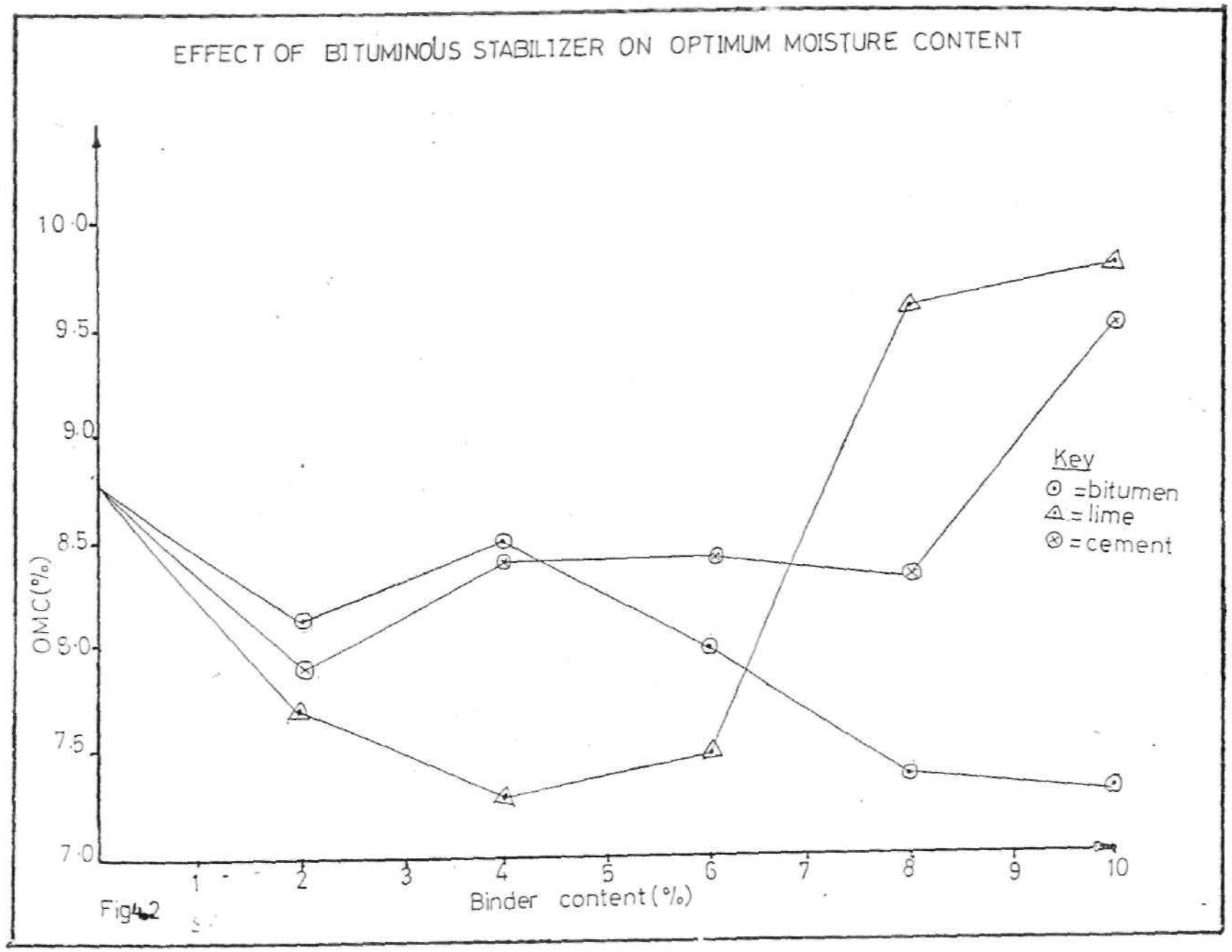

EFFECT OF BITUMINOUS STABILIZER ON OPTIMUM MOISTURE CONTENT
10·0
9·5
9·0
8·5
8·0
7·5
7·0
OMC(%)
1
2
3
4
5
6
7
8
9
10
Binder content (%)
Key
⊙ =bitumen
△ =lime
⊗ =cement

Fig4.2

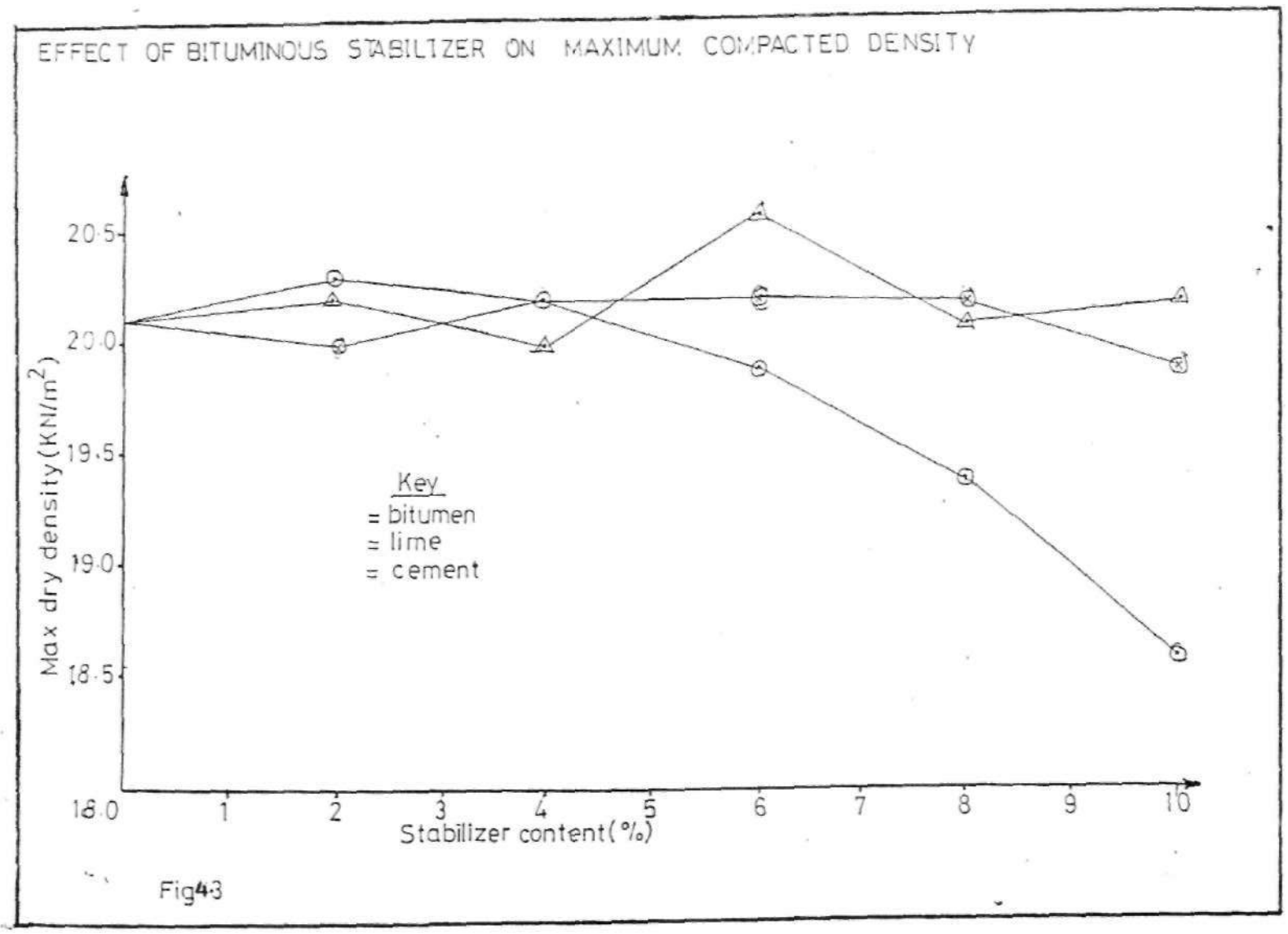

EFFECT OF BITUMINOUS STABILIZER ON MAXIMUM COMPACTED DENSITY
Max dry density(KN/m²)
20·5
20·0
19·5
19·0
18·5
18·0
1
2
3
4
5
6
7
8
9
10
Stabilizer content(%)
Key
= bitumen
= lime
= cement

Fig4·3

Table 4.5: Effects of cement on Compaction

% of Stabilizer	OMC %	MDD (KN/m^3)
0	8.8	20.1
2	7.9	20.0
4	8.4	20.2
6	8.4	20.2
8	8.3	20.2
10	9.5	19.9

Optimum moisture content (OMC) and maximum dry density (MDD) can also be obtained mathematically. The shape of the graph of MDD against moisture content has a shape of parabola.

Equation of parabola is

$$Y = aX^2 + bX + c \quad \ldots\ldots\ldots\ldots \quad 4.13$$

Where

Y = dry density

X = moisture content

$$\frac{dy}{dX} = 2aX + b \quad \ldots\ldots\ldots\ldots \quad 4.14$$

When $\frac{dy}{dX} = 0$

$$\text{then } X = \frac{-b}{2a} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad 4.15$$

where $\frac{-b}{2a}$ is the optimum moisture content

substituting equation 4.15 into 4.13

$$Ymax = \frac{-b^2}{4a} + c \quad \text{..... 4.16}$$

where Ymax = maximum dry density

With 3 - equations, the 3- unknowns a, b and c can be obtained from the data collected (any of the 3 columns of dry densities and corresponding moisture contents) can be used. Example using data collected for natural soil (no stabilizer used), (See Appendix B).

Average moisture (%) 1.06 3.57 6.86 14.02 19.03

Dry density (Kn/m^3) 17.72 18.72 19.76 18.00 14.64

using equation 3.13

$$18.72 = 3.57^2a + 3.57b + c$$

$$19.76 = 6.86^2a + 6.86b + c$$

$$18.00 = 14.02^2a + 14.02b + c$$

use Cramer's rule to solve the system.

$$\begin{bmatrix} 12.74 & 3.57 & 1 \\ 47.06 & 6.86 & 1 \\ 196.56 & 14.02 & 1 \end{bmatrix} \begin{bmatrix} a \\ b \\ c \end{bmatrix} = \begin{bmatrix} 18.72 \\ 19.7 \\ 18.00 \end{bmatrix}$$

$$\text{determinant} \quad (\Delta) = \begin{bmatrix} 12.74 & 3.57 & 1 \\ 47.06 & 6.86 & 1 \\ 196.56 & 14.02 & 1 \end{bmatrix}$$

$$= 12.72\,(6.86 - 14.02) - 3.57\,(47.06 - 196.56) + 1\,(47.06 \times 14.02 - 6.86 \times 196.56)$$

$$= -91.22 + 533.72 - 688.62$$

$$= -246.12$$

$$\Delta a = \begin{vmatrix} 18.72 & 3.57 & 1 \\ 19.76 & 6.86 & 1 \\ 18.00 & 14.02 & 1 \end{vmatrix}$$

$$\Delta a = 18.72\ (6.86 - 14.02) - 3.57\ (19.76 - 18)$$
$$+ 1\ (19.76 \times 14.02 - 6.86 \times 18)$$
$$= -134.04 - 6.28 + 153.56$$
$$= 13.24$$

$$\Delta b = \begin{vmatrix} 12.74 & 18.72 & 1 \\ 47.06 & 19.76 & 1 \\ 196.56 & 18.00 & 1 \end{vmatrix}$$

$$\Delta b = 12.72\ (19.86 - 18) - 18.72\ (47.06 - 196.56)$$
$$+ 1\ (47.06 \times 18 - 19.76 \times 196.56)$$
$$= 22.42 + 279.64 - 3036.96$$
$$= -215.89$$

$$\Delta c = \begin{vmatrix} 12.74 & 3.57 & 18.72 \\ 47.06 & 6.86 & 19.76 \\ 196.56 & 14.02 & 18.00 \end{vmatrix}$$

$$\Delta c = 12.74\ (6.86 \times 18 - 14.02 \times 19.76)$$
$$-3.57\ (18 \times 47.06 - 19.76 \times 196.56)$$
$$+ 18.72\ (14.02 \times 47.06 - 6.86 \times 196.56)$$
$$= -1956.29 + 10841.90 - 12890.97$$
$$= -4005.36$$

$$a = \frac{\Delta a}{\Delta} = \frac{-13.24}{246.12} = -0.05$$

$$b = \frac{\Delta b}{\Delta} = \frac{215.89}{246.12} = 0.88$$

4.5 THE CALIFORNIA BEARING RATIO (CBR) TEST

The California Bearing Ratio (CBR) test is an ad hoc penetration test developed by the California State Highway Department for the evaluation of subgrade strengths and later extend to fill, sub-base and base materials. The load required to cause a plunger of standard size to penetrate a specimen of soil at a standard rate is measured either before or after the specimen has been soaked for some days. Therefore, CBR is a measure of the shearing resistance of soil under carefully controlled density and moisture conditions and is used with empirical curves for designing flexible pavements. It is expressed as a percentage of the unit required to force a piston into the soil divided by the unit load required to force the same piston to the depth into a standard sample of crushed stone.

For test procedure, see BS 1377: 1975, Test 16 or reference No.10. The soaking was done in order to stimulate the soil or stabilized soil to the worst condition which exist subsequent to construction. Therefore the soaking is done to assess, if the soil will resist see page and upholds its strength whether it will withstand water that lasts for hours or even days.

The results of the CBR test are presented in Tables 4.6 -4.8 and the result were also graphically represented as shown in Figs. 4.4 - 4.6 for soaked and unsoaked conditions.

Table 4.6: Results of Average CBR (%), air cured for 1 day

% of Stabilizer	Bitumen	Lime	Cement
0	15	15	15
2	13	65	20
4	31	83	23
6	20	44	23
8	19	56	18
10	4	93	23

Table 4.7: Results of Average CBR (%), air cured for 7 day

% of Stabilizer	Bitumen	Lime	Cement
0	47	47	47
2	48	76	56
4	83	122	63
6	44	152	82
8	27	119	124
10	18	100	96

Table 4.8: Results of Average CBR (%), soaked 7 day

% of Stabilizer	Bitumen	Lime	Cement
0	9	9	9
2	10	43	102
4	14	53	162
6	10	38	201
8	9	36	214
10	5	27	202

4.6 TRIAXIAL TEST

The undrained test on partly saturated cohesive soils method was used, that means no drainage and hence no dissipation of pore pressure was permitted during the application of the all-round stress. The procedure to carried out the test can be seen in the B.S 1377: 1975 test 21 or see reference No.s 3, 11, 13 or 16.

The results of the triaxial test are presented in Table 4.9 - 4.10 and the results were also graphically represented as in Figs. 4.7 - 4.10. Air cured for 7 days and the Air cured for 7 days, then 7 days soaked.

The change of specimen length, , is found from equation

$$= a - b \quad \text{..... 4.17}$$

where a = movement of the top of the proving

= K(in millimeter per revolution) x number

ZARIA, NIGERIA
Ahmadu Bello University

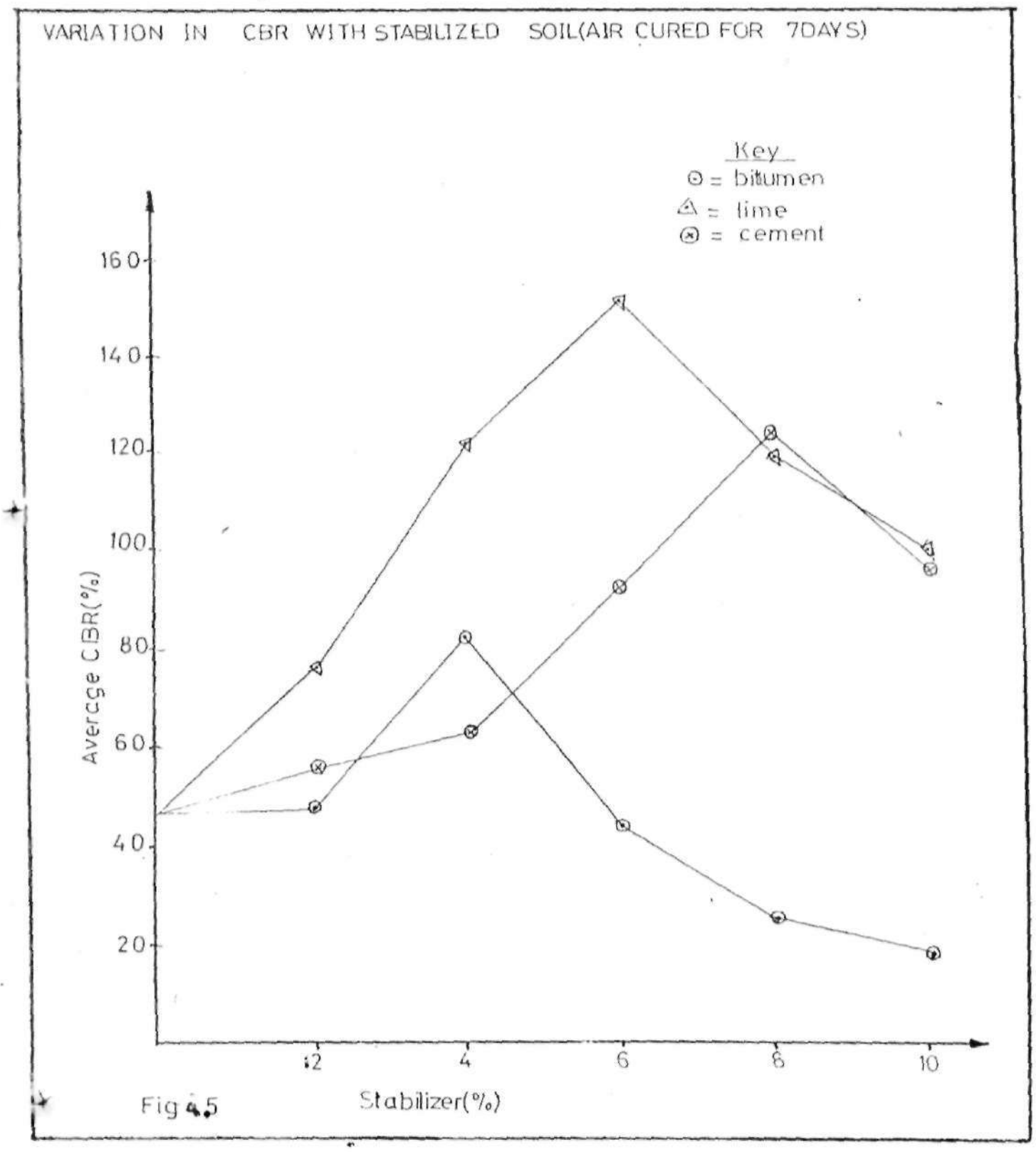


Fig 4.5

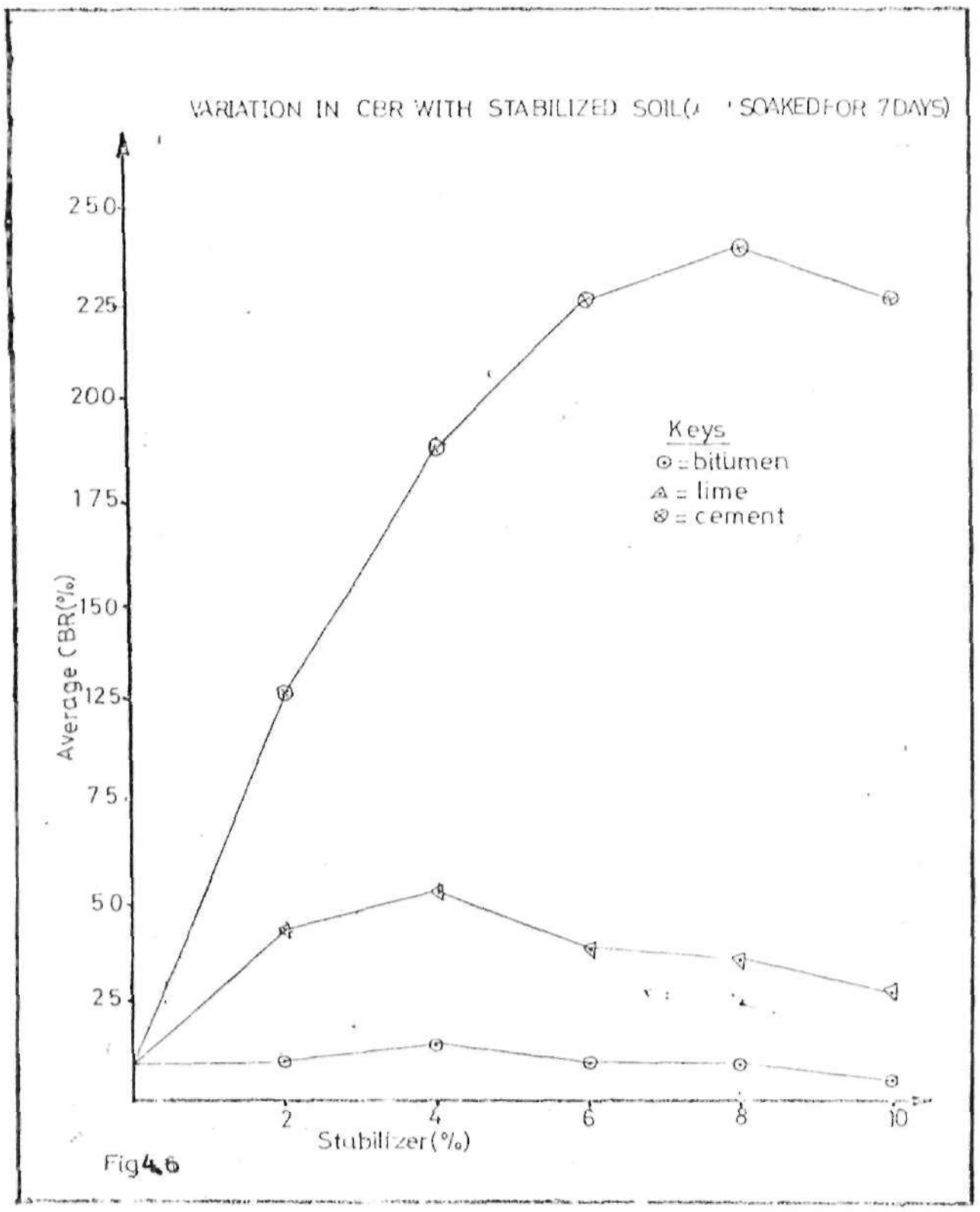

VARIATION IN CBR WITH STABILIZED SOIL(' SOAKED FOR 7DAYS)
Average CBR(%)
250
225
200
175
150
125
75
50
25
Keys
⊙ = bitumen
A = lime
⊗ = cement
2
4
6
8
10
Stubilizer (%)

Fig 4.6

of revolution..,

K is a property of the gear box, and is found by calibration

b = compression of proving ring

= proving ring dial reading in mm - initial proving ring dial reading in mm.

The axial strain, ε, at any time is found from

$$\varepsilon = \frac{l}{lo} \quad \text{..... 4.18}$$

where lo = the initial specimen length (76.2mm)

Note that l is given in the table as strain dial gauge in millimeter.

The average cross-sectional area, A, at any time is from equation

$$A = \frac{A_o}{1-\varepsilon} \quad \text{..... 4.19}$$

Where A_o = the initial cross-sectional area of specimen with diameter (38.1mm)

$$\frac{\pi(38.1)^2}{4\ (1000)^2}$$

$$= 1.14 \times 10^{-3}\ m^2$$

$$\text{The applied stress} = \frac{P}{A} \quad \text{..... 4.20}$$

where P = applied force = (proving ring reading - initial proving reading) x ring calibration factor.

Table 4.9: Results of the effect of 7days air curing on the strength of stabilized Soil

Stabilizer %	Bitumen Friction Angle Qu (deg.)	Bitumen Cohesion Cu (KN/m²)	Lime Friction Angle Qu (deg.)	Lime Cohesion Cu (KN/m²)	Cement Friction angle Qu (deg.)	Cement Cohesion Cu (KN/m²)
0	19	45	19	45	19	45
2	29.5	50	27	80	15	20
4	35	80	33	105	18	50
6	30	75	28	98	23	80
8	28	65	25	90	28	160
10	26.5	50	21	82	31	185

Table 4.10: Results of the effect of 7days air curing and 7days soaking on the strength of stabilized Soil.

Stabilizer %	Bitumen Friction Angle Qu (deg.)	Bitumen Cohesion Cu (KN/m²)	Lime Friction angle Qu (deg.)	Lime Cohesion Cu (KN/m²)	Cement Friction angle Qu (deg.)	Cement Cohesion Cu (KN/m²)
0	-	-*	-	-	-	-
2	-	-	18	50	20	90
4	26	40	21.5	65	22.5	120
6	24	35	18	50	26.5	140
8	20.5	30	15	45	31	200
10	19	10	11	40	34	235

* The triaxial samples failed after 3 days of the 7 days soaking.

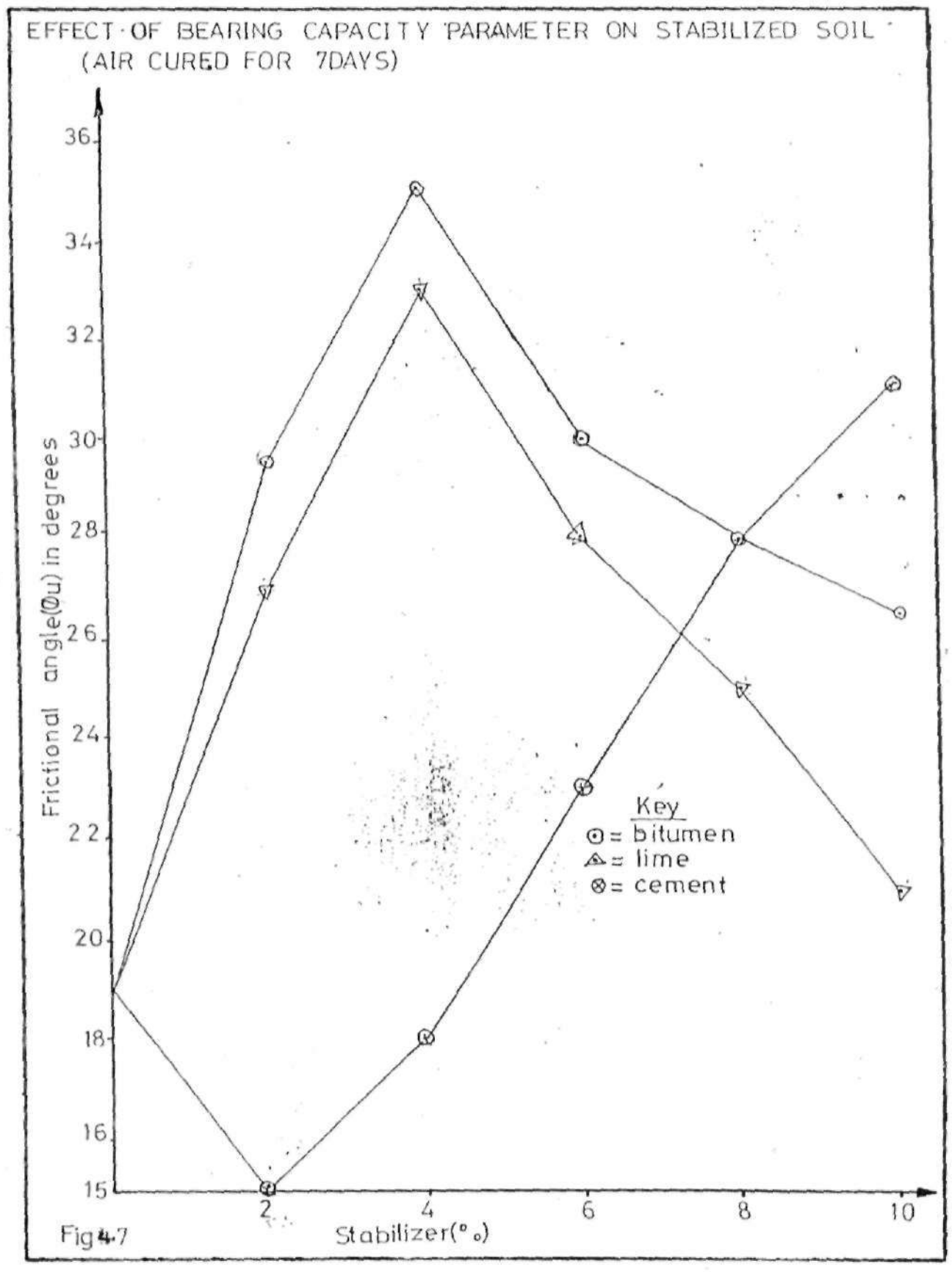

EFFECT OF BEARING CAPACITY PARAMETER ON STABILIZED SOIL
(AIR CURED FOR 7DAYS)
Frictional angle(Ø u) in degrees
36
34
32
30
28
26
24
22
20
18
16
15
2
4
6
8
10
Stabilizer(%)
Key
⊙ = bitumen
△ = lime
⊗ = cement

Fig 4.7

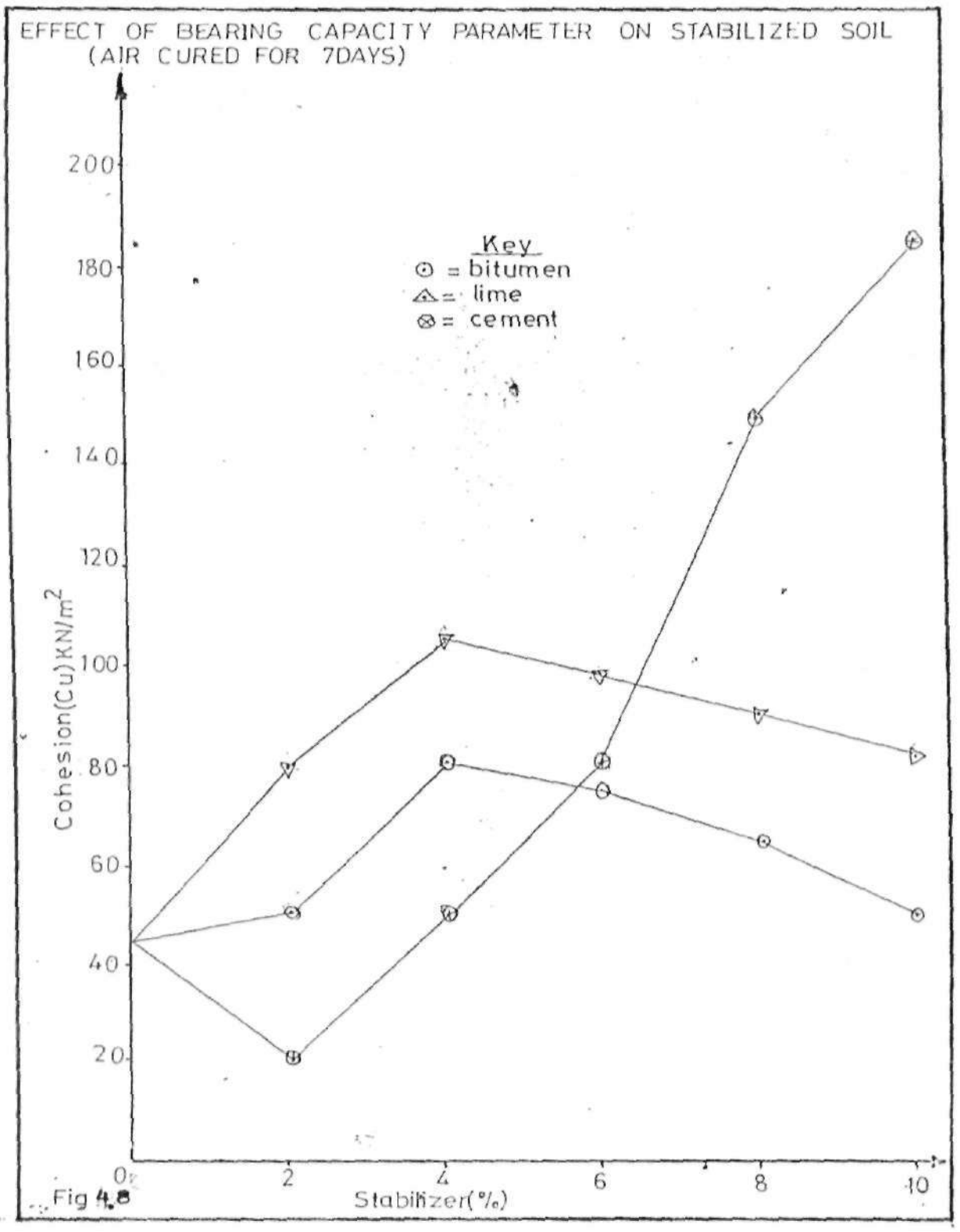

EFFECT OF BEARING CAPACITY PARAMETER ON STABILIZED SOIL
(AIR CURED FOR 7DAYS)
Key
⊙ = bitumen
△ = lime
⊗ = cement
Cohesion(Cu) KN/m²
200
180
160
140
120
100
80
60
40
20
0
2
4
6
8
10
Stabilizer(%)

Fig 4.8

EFFECT OF BEARING CAPACITY PARAMETER ON STABILIZED SOIL
(AIR CURED FOR 7DAYS AND 7DAYS SOAKED)

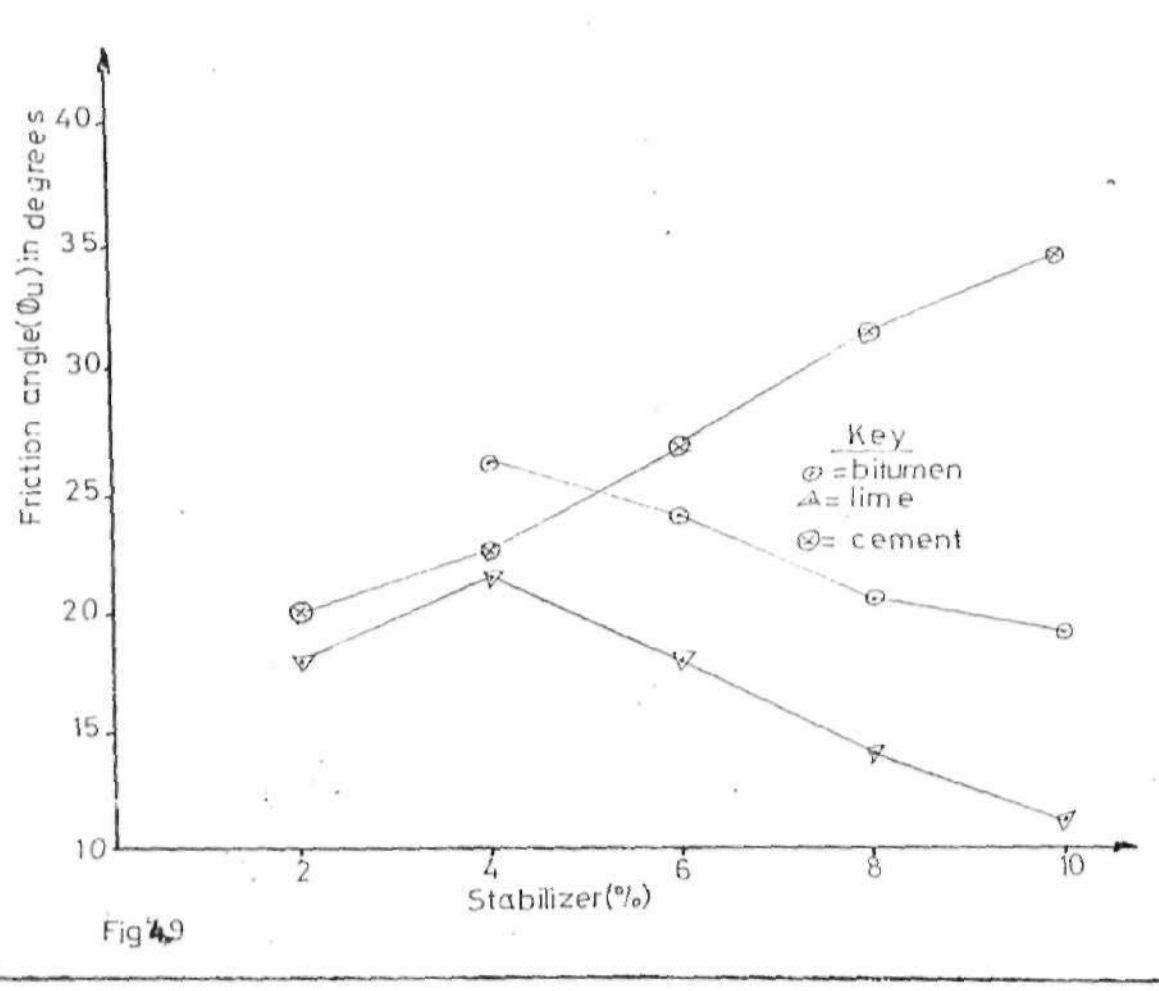


Fig 4.9

EFFECT OF BEARING CAPACITY PARAMETER ON STABILIZED SOIL
(AIR CURED FOR 7DAYS AND 7DAYS SOAKED) .

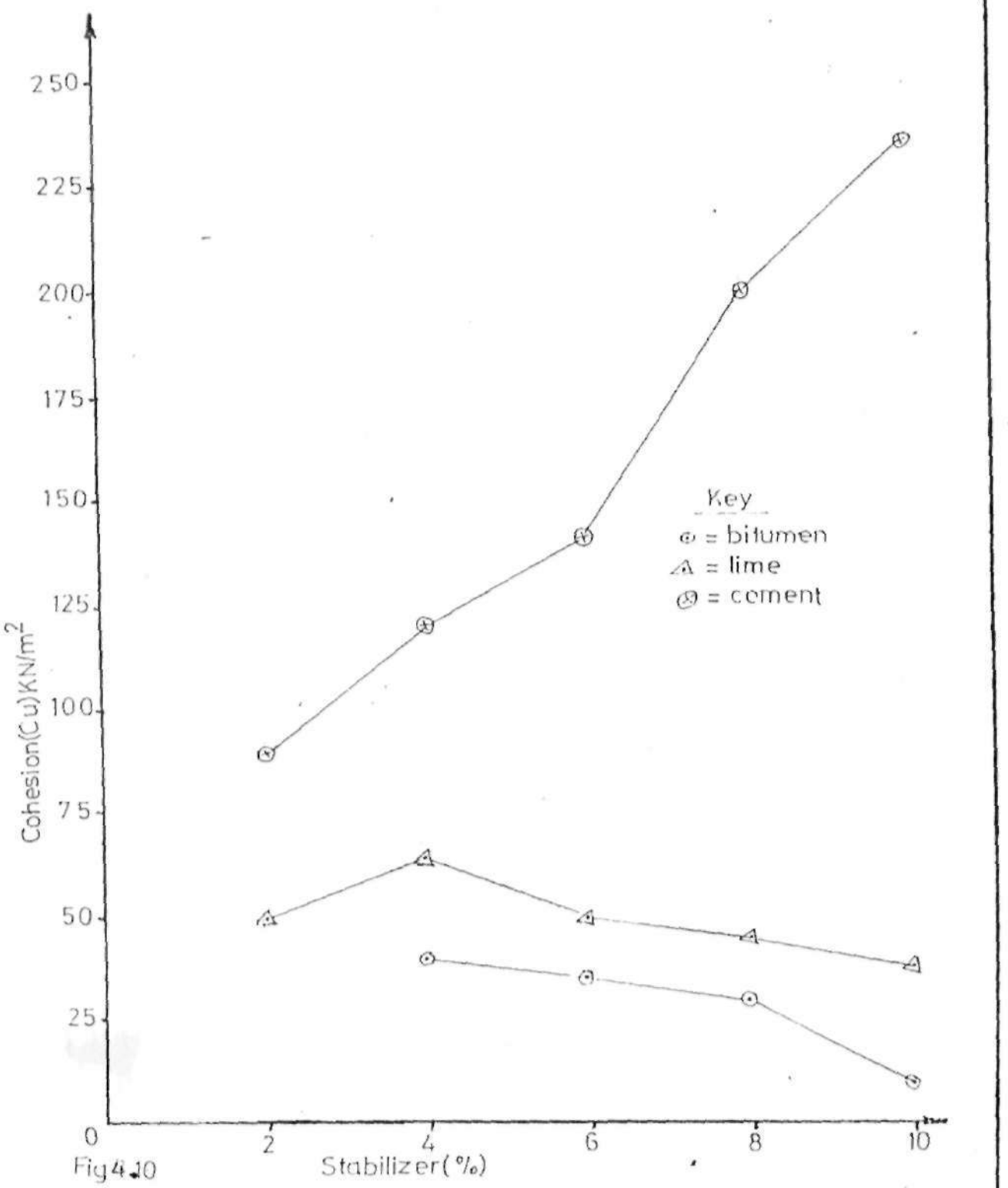


Fig 4.10

4.7 ABSORPTION TEST FOR BITUMEN STABILIZED SOIL

The capillary water absorption (C.W.A) test was devised at the Road Research Laboratory for testing the efficiency of water proofing stabilizers and was a development of the method standardized by the Institute of Petroleum.

The test procedure (see reference No. 7) and the results are presented in Table 4.11 and Fig. 4.11 for the graphical representation.

Table 4.11: **Result of Water Absorption Test**

Bitumen %	Water Absorbed in grammes				
	1 day	3 days	7 days	14 days	28 days
0	20.50	27.25	34.5	43.0	45.0
2	13.00	22.00	26.75	32.0	32.0
4	9.00	11.5	12.0	12.75	14.25
6	7.15	9.15	10.5	12.0	13.25
8	5.00	8.0	9.25	11.0	12.0
10	2.00	2.75	4.0	4.5	6.25

4.8 STABILITY AND FLOW TESTS

This test is used for laboratory design and field control of mixtures containing bitumen and aggregates (example asphalt concrete). It is essentially a type of unconfined compression strength test in which a cylindrical specimen (soil - bitumen) 101.6mm in

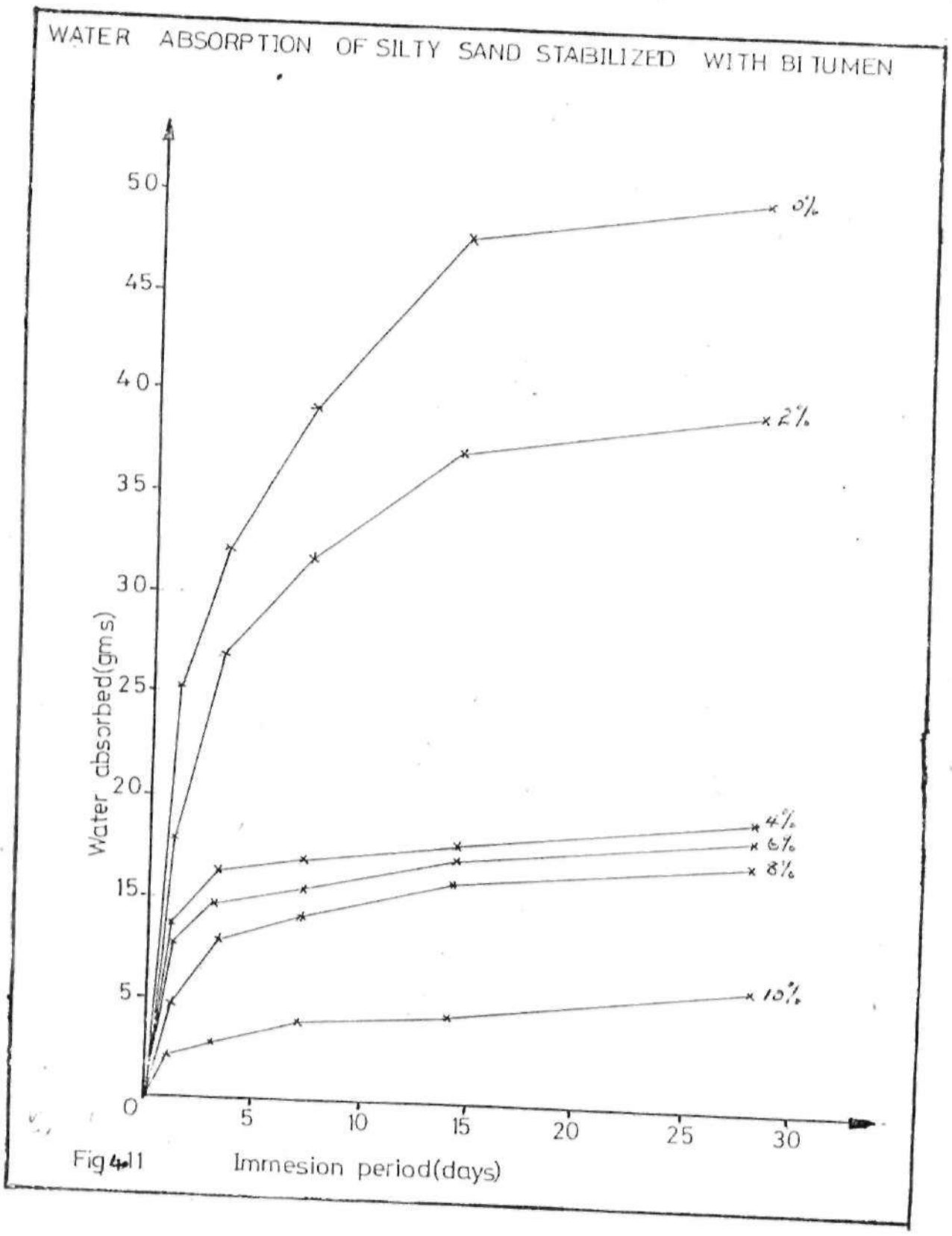

WATER ABSORPTION OF SILTY SAND STABILIZED WITH BITUMEN
Water absorbed(gms)
0
5
15
20
25
30
35
40
45
50
5
10
15
20
25
30
Immesion period(days)
0%
2%
4%
6%
8%
10%

Fig 4.11

diameter and 63.5mm high is compressed radially at a constant rate of strain of 50.8mm per min. The maximum load in kg which is sustained by the specimen is recorded as the marshall stability value and the deformation at failure in unit of 0.25mm is recorded as the marshall flow value.

For the test procedure (see reference Nos. 7 and 20). The results of the stability and flow value are presented at Table 4.12 and Fig. 4.12.

Table 4.12: **Result of bituminous stabilization on marshall stability and flow tests**

Bitumen %	Gauge Reading	Stability (KN)	Gauge Reading	Flow value in 0.25mm
0	-	-	-	-*
2	20.5	0.9	370	16.3
4	25.5	1.12	410	18.0
6	26.3	1.16	460	20.2
8	21.3	0.94	535	23.5
10	11.4	0.54	640	28.2

*The sample failed during the extraction process.

4.9 VOLUME STABILITY

The expansion of the soil is obtained from the soaked CBR by placing dial on top of the immersed moulds and monitoring their readings.

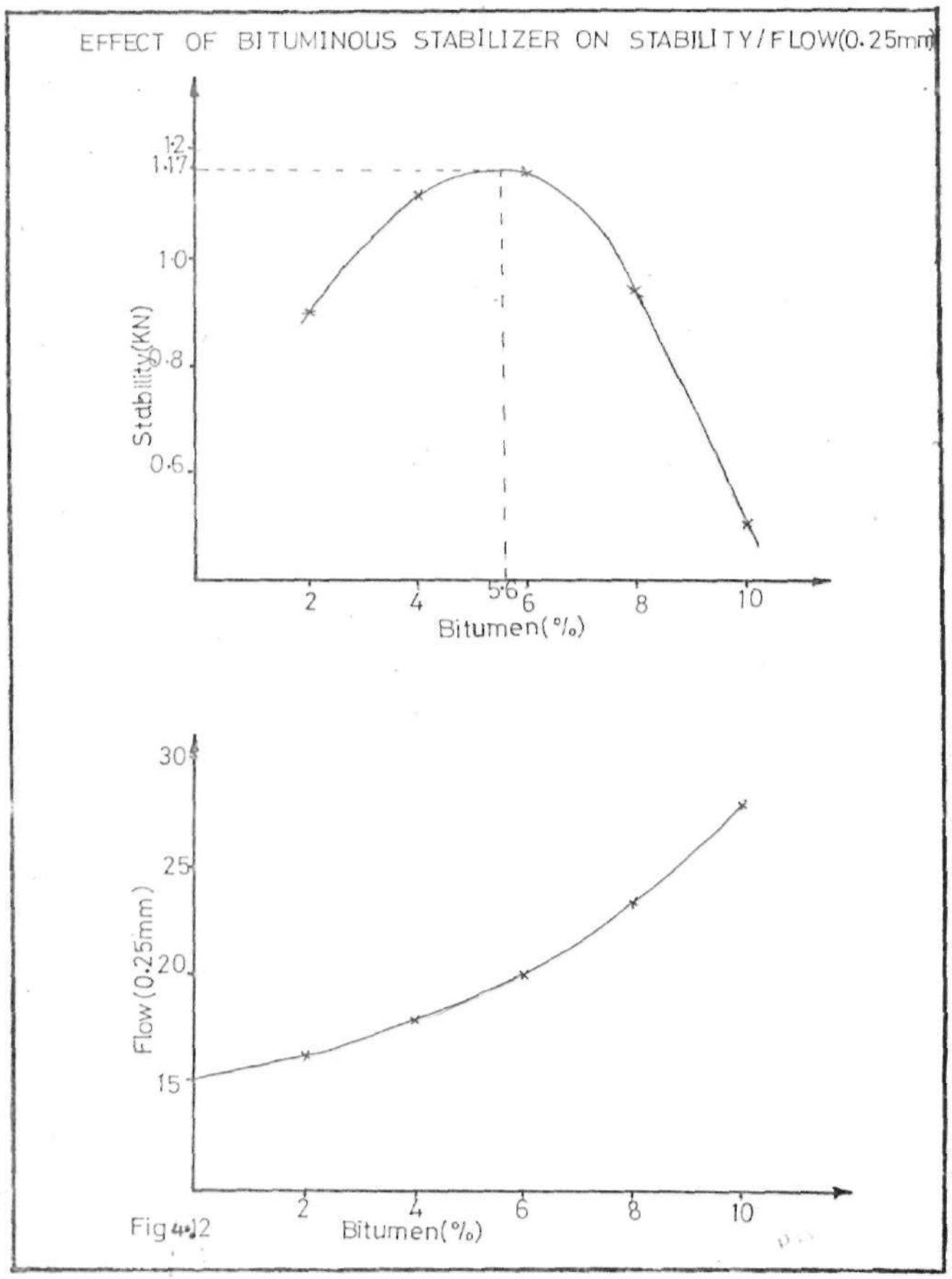

EFFECT OF BITUMINOUS STABILIZER ON STABILITY/FLOW(0.25mm)
Stability(KN)
1·2
1·17
1·0
0·8
0·6
2
4
5·6
6
8
10
Bitumen(%)
Flow (0.25mm)
30
25
20
15
2
4
6
8
10
Bitumen(%)

Fig 4.12

Table 3.13: Preliminary Test Results on the Basic Soil Sample and the Recommended Values from the Specification

Test carried out	Basic Sample Results	Specification Subgrade	Sub-base	base
Initial moisture content (%)	9.9	-	-	-
Specific gravity	2.46	<3	<3	<3
Liquid limit	-	<40	<30	<30
Plastic limit	NP	-	-	-
Plasticity index	-	<10	<12	<12
Optimum moisture content (%)	8.8	-	-	-
Max dry density (KN/M^3)	20.14	-	-	-
CBR (unsoaked)(%)	47	>10	>30	>80
CBR (soaked)(%)	9	>10	25-55	>75

Results of the initial tests on the sample are summarized in Table 3.13. These results confirmed that the soil was unsuitable for fill, sub-base and base materials on account of strength measured in terms of soaked C.B.R.

4.10 WEIGHING OUT THE BITUMEN AND MIXING

The percentages of bitumen used is by weight. One of the difficulties in weighing out the bitumen is that it adheres to the container. With the soil to be used still in the weighing balance, the percentage of bitumen by poured into the soil as the bitumen is in a liquid

form, so that it can sticked to the soil. Mixing was done by hand for about 10 minutes. It was observed that the bitumen was more freely mixed into the soil and better dispersed if the required water was mixed with the soil. However, it could have been more desirable to use a system of laboratory mixing that will give a mixing efficiency close to that obtained in mixing processes used in the field.

CHAPTER 5

5.0 ANALYSIS OF RESULTS

5.1 PRELIMINARY TESTS ON BITUMEN BINDER

The results obtained from the preliminary tests carried out and the specifications are showed in Table 4.1. The results agreed with the traditional American cutback MCO which is written in the binder container supplied by a reputable petroleum company.

5.2 GRADING ANALYSIS

The particle size distribution of the natural soil is presented as curve on a semi-logarithmic plot. The mass percentage of particles smaller than a given size D is plotted against the lognrithm (base 10) of D as in Fig. 4.1.

It can be seen that the particles sizes are well graded indicating that the particles be within a wide range. Values obtained from the calculated coefficient of uniformity and coefficient of curature (see Table 4.2), also give good insights of soil classification. With reference to the coefficient of uniformity and coefficient of curature criteria, the material is a well graded soil consisting mainly of sand with silt fraction of less than 10%. Using unified Soil Classification Systems, the soil is considered to be silty sand with about 26% of natural soil passing the NO.200 B.S sieve.

5.3 DRY DENSITY/MOISTURE CONTENT RELATIONSHIP

The results of modified AASHTO compaction test with various percentages of stabilizers are presented in Tables 4.3 - 4.5 and also the graphical presentation of optimum moisture content (O.M.C), dry density against stabilizer content are showed in Figs. 4.2 and 4.3 respectively.

5.3.1 Bitumen-Stabilizer

The OMC showed an appreciable decrease with 0 - 2%, then an increase at 4% bitumen and after it decreased again with 6% to 10% bitumen with 10% being the minimum. Maximum OMC occurred at 0% bitumen.

For the case of maximum dry density (MDD), the graph showed an increase with 0 - 2% bitumen, the decreased with 4 - 10% bitumen. The MDD had the minimum at 10% and the maximum at 2% bitumen.

5.3.2 Lime-Stabilizer

The OMC showed a decrease with 0 - 4% lime, then an appreciable increase with 6 - 10% lime. The minimum is shown at 4% and the maximum at 10% lime.

From literature, it showed a decrease in maximum dry density but the result of MDD increased with 0 - 2% lime, then decreased at 4%, thereafter increased to a maximum at 6% lime. There was a decrease again with 8% to 10% lime.

5.3.3 Cement-Stabilizer

The OMC decreased with 0 - 2% cement, then increased at 4%. It remained steady at 6% cement, then fell slightly at 8% and finally increased at 10% cement which had the maximum value.

The MDD graph showed a decrease with 0 - 2%. There was a steady MDD from 4 - 8% cement, then decrease at 10%. The maximum MDD is between 4 - 8% cement.

5.4 CALIFORNIA BEARING RATIO (CBR) TEST

The results of the CBR tests for samples are cured for 1 day, air cured for 7 days and soaked for 7 days are presented at Tables 4.6 - 4.8 and for the graphical presentation are shown at Figs. 4.4 - 4.6.

5.4.1 Bitumen-Stabilizer

The CBR values decreased when air cured for 1 day with 0 - 2%, but increased to maximum at 4% bitumen. Thereafter it decreased with 6 - 10% bitumen.

There was tremendous increased in strength when the bitumen stabilized soil were air cured for 7 days. CBR value increased with 0 - 4% bitumen. The 4% bitumen had maximum CBR value and then decreased with 6 - 10%.

However, there was catastrophic loss of strength, when the stabilized soils were soaked for 7 days in water. Again, the CBR value increased with 0 - 4% and the maximum occurred at 4% bitumen. The CBR decreased with 6 - 10% bitumen.

5.4.2 Lime - Stabilizer

The CBR values increased with 0% to 4% when the stabilized Soil were air cured for 1 day, decrease at 6% lime and pick up again at 8% lime with the maximum CBR at 10% lime.

An increase of strenght with 0% to 6% lime when cured for 7days and thereafter decrease with 8% to 10% lime. The maximum CBR was at 6% lime.

There was a decrease in strenght when the stabilized soil were soaked for 7days. The CBR values increased with 0% to 4% lime then decreased with 6% to 10% lime with the maximum occuring at 4% lime.

5.4.3 Cement Stabilizer

The CBR value increased with 0% to 4% cement but decreased with 6% to 8% and pick up again at 10% cement. The maximum occured at both 4% and 10% when the stabilized Soil when air cured for 1day.

There was strenght increase when the stabilized soil were air cured for 7days. The CBR values increased with 0% to 8% cement but fell at 10%. Maximum value occurred at 8% cement.

For the 7days soaked, there were very high increase at CBR values with 2% to 8% cement and then fell slightly at 10% cement. Maximum value occured at 8% cement.

5.5 TRIAXIAL TEST

Tables 4.9 and 4.10 show effect of stabilized soil strength when air cured for 7 days and also air cured for 7 days then soaked for 7 days. The frictional angle (Qu), cohesion (Cu) against stabilizer for both conditions are presented Figs. 4.7 to 4.10.

5.5.1. BITUMEN STABILIZER

It was expected that, in the presence of bitumen the soil particles will increase in the cohesion and decrease in the angle of shearing resistance, both of which are strength, parameters of the soil. In this case, the cohesion increased with 0% to 4% bitumen as well as the frictional angle. Beyond 4% bitumen both the cohesion and frictional angle decreased slowly. The maximum cohesion and frictional angle were in 4% bitumen.

The method of curing and temperature also affect the strength. After the triaxial samples were air cured for 7 days and then soaked for 7 days, the samples labelled 0 - 2% bitumen failed after 3 days of the 7 days soaked.

The strength gain were very small but followed the same pattern as that of 7 days air cured. That is, beyond 4% bitumen both the cohesions and frictional angles decreased with 8% to 10% bitumen. The maximum value for cohesion and frictional angle occurred at 4% bitumen.

5.5.2 LIME-STABILIZER

For the 7 days air cured, strength showed an appreciable increase with 0 - 4% lime for both cohesions and frictional angles. Thereafter both the strength parameters decreased and the parameters had the maximum value at 4% lime.

When the samples were air cured for 7 days and then soaked for 7 days, there were slightly fall in strength. Strength parameters increased with 2% to 4% lime and decreased after wards. The maximum values for both strength parameters were at 4% lime.

5.5.3 CEMENT STABILIZER

The strength parameters increased gradually when the samples air cured for 7 days; with 0% to 10% cement. Maximum value occurred at 10% for both the strength parameters.

Again, there was hydration action taking place when the samples for the triaxial were air cured for 7 days and then soaked for 7 days. Tremendous strength were gain from this action, both strength parameters increased with 2% to 10% and the maximum value occurred at 10% cement.

5.6 ABSORPTION TEST

The result is shown on Table 4.1 and graphical presentation is also showed on Fig. 4.11. From the

graph, it is obvious that 0% and 2% bitumen absorbed more water than the other percentages.

The water-proofing mechanism results from diffusion of water through bituminous is slow, but finite. They are not completely water barriers, the bitumens plugging of the voids in the soil thus removing channels for the flow of water and from the coating of the soil particles and molecules (in the voids) surfaces. The bitumen will only delay them from the incoming water by its resistance and drying out in low humidity envoirnment. Mixing procedures have influence on the absorption property because it alters the pattern of formation of the protective bitumen film. 10% bitumen had the greatest water proofing effect in this case under the given test and mixing procedures but very soft and can easily fail under heavy load.

5.7 EFFECT OF BITUMEN STABILIZER ON STABILITY, FLOW AND VOLUME STABILITY

The results are shown on Table 4.12 and the graphs are presented on Fig. 4.12. The stability curve showed stability of the mix went on increasing with increase in bitumen content, but it achieved its maximum value at about 5.6% bitumen content and thereafter rapidly decreased. The bitumen stabilized soil exhibited maximum stability between 4% and 6% bitumen. The flow for the marshall stability max. value was 19.5 x 0.25mm and the corresponding flow range was between 18.0 x

0.25mm and 20.2 x 0.25mm respectively.

The volume stability results for all the stabilized soil showed no expansion (swell) that is the dial gauge did not move.

CHAPTER 6

6.0 CONCLUSION AND RECOMMENDATION

6.1 Conclusion

The general specifications for Federal Republic of Nigeria (Roads and Bridges) stipluate the minimum strength of various pavement components determined at maximum dry density and optimum moisture content by either West African Standard compaction or modified AASHTO compaction test after at least 24 hours soaking, to simulate the worse-condition, (7days) have been shown in Table 4.13.

The natural soil had satisfied the percentage passing the NO.200 B.S. sieve, hence it could not be rejected on this basis. One should bear in mind that from literature, sandy soils can be stabilized using mainly bitumen and cement.

Based on 7 days air cured condition, bituminous stabilization had shown appreciable increase of the CBR value at 4% bitumen. Due to this criterion, the material may be used for fill, sub-base and base materials while lime and cement had good CBR value at 2% of the stabilizers, because successful roads have been built of material with a minimum CBR of 50%. In tropical countries, the soaked CBR is used for design and from this aspect bituminous stabilization at 4% bitumen is suitable for fill material only while at 4% lime, the

materials are good for fill and sub-base materials. For the case of cement stabilization with respect to soaked CBR, there was tremendous strength increase due to hydration with 2% cement on wards. Therefore the materials are good for fill, sub-base and base materials. Although lime stabilization showed strength increase, the soil easily disintegrated into a loose granular mass on touching. This is the main reason why lime stabilization is not recommended for sand. The triaxial strength test also takes the same pattern as the CBR test and also these percentages of the stabilizers have good volume stability.

In general, the amount of water absorbed with increase in bitumen content and the change in strength relative to the soaked, strength decrease. From economical point of view, 4% bitumen is adequate because increase in bitumen percentage waterproofed the water absorption rate better. Bitumen stabilized soil exhibited maximum stability at range between 4 and 6% by weight of dry soil.

6.2 Recommendation

Under the soaked condition, the range of percentages tested, only cement stabilized soil is to be used for base construction. Lime is not an effective means of stabilizing silty-sand as previously noted.

However, the following recommendations can be made, silty sand group of soil can be effectively stabilized

with 4% bitumen for fill material, from 2% cement should be used for fill, sub-base and base materials. High percentages of cement should be avoided because it can cause cracking, and deformation of the stabilized material into a loose granular mass.

Bituminous stabilization should be encourage in Nigeria just as in far East, especially for light and medium traffic roads. Nigeria is a potential and supplier of bitumen from her petroleum reserves. If these resources are well tapped, it will make bitumen immediately available and cheaper. This will help to lessen the demand for expensive cement.

Again, similar research should be done, on different types of soils because the existing empirical strength criteria for stabilized soils that were developed in temperate countries should be examined carefully when being applied in Africa. Effect of small amount of cement and bitumen, lime and bitumen shall be investigated carefully so that the stabilization criteria shall be established based on them.

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Appendix A

Data Sheet I

Determination of moisture content of the Soil

Container No.	158	135	137	Average
Wt of container + wet soil M_1	37.2	37.7	50.5	
Wt of container + dry soil M_2	34.5	34.9	46.6	
Wt of container ..... M_3	8.1	4.8	8.2	9.9%
Dry weight of soil ....M_2- M_3	26.4	30.1	38.4	
Wt of moisture ..... M_1-M_2	2.7	2.8	3.9	
Moisture content m = $\frac{M_1 - M_2}{M_2 - M_3}$				

Determination of Specific Gravity of Bitumen

Wt of bottle + water (full) W_4 ..... 1595.7g

Wt of bottle w + water W_3 ..... 1599g

Wt of bottle + Bitumen W_2 ..... 724.2g

Wt of bottle W_1 ..... 557.2g

Wt of water $(\frac{W_4 - W_1}{})$ 1038.5g

Wt of water added to Bitumen $(W_3 - W_2)$ .. 874.8g

Wt of Bitumen $W_2 - W_1$ 167g

Wt of water displaced by Bitumen $W_4 - W_2$ =W=163.7g

Specify gravity of Bitumen $W_2 - W_1/W$ 1.02

Data Sheet 2

DETERMINATION OF THE SPECIFIC GRAVITY OF SOIL PARTICLES

(Standard Laboratory method)

OPERATOR: ATUEGBU JOB: M.Sc PROJECT

TIME OF TEST: 23°C

Bottle No.	1	2	3
Wt of bottle + water (full) W4	352.6	336.9	344.7
Wt of bottle + soil + water W3	385.2	362.8	369.5
Wt of bottle + soil W2	156.9	132.1	137.6
Wt of bottle W1	104	88.5	95.7
Wt addit. of water (W4 - WL)	248.6	248.4	249
Wt of water added to soil(W3-W2)	227.3	230.7	231.9
Wt of water displaced by soil	52.9	43.6	41.9
(W4-WL) - (W3 -W2)=W	21.3	17.7	17.1
Specific gravity of Soil particles (W2 - WL)/W	2.48	2.46	2.45

Average of Gravity Soil Particles 2.46

Values of K for Use in Equation for Computing Diameter of Particle in Hydrometer Analysis

Temperature, deg C	Specific Gravity of Soil Particles								
	2.45	2.50	2.55	2.60	2.65	2.70	2.75	2.80	2.85
16	0.01510	0.01505	0.01481	0.01457	0.01435	0.01414	0.01394	0.01374	0.01356
17	0.01511	0.01486	0.01462	0.01439	0.01417	0.01396	0.01376	0.01356	0.01338
18	0.01492	0.01467	0.01443	0.01421	0.01399	0.01378	0.01359	0.01339	0.01321
19	0.01474	0.01449	0.01425	0.01403	0.01382	0.01361	0.01342	0.01323	0.01305
20	0.01456	0.01431	0.01408	0.01386	0.01365	0.01344	0.01325	0.01307	0.01289
21	0.01438	0.01414	0.01391	0.01369	0.01348	0.01328	0.01309	0.01291	0.01273
22	0.01421	0.01397	0.01374	0.01353	0.01332	0.01312	0.01294	0.01276	0.01258
23	0.01404	0.01381	0.01358	0.01337	0.01317	0.01297	0.01279	0.01261	0.01243
24	0.01388	0.01365	0.01342	0.01321	0.01301	0.01282	0.01264	0.01246	0.01229
25	0.01372	0.01347	0.01327	0.01306	0.01286	0.01267	0.01249	0.01232	0.01215
26	0.01357	0.01334	0.01312	0.01291	0.01272	0.01253	0.01235	0.01218	0.01201
27	0.01342	0.01319	0.01297	0.01277	0.01258	0.01239	0.01221	0.01204	0.01188
28	0.01327	0.01304	0.01283	0.01264	0.01244	0.01225	0.01208	0.01191	0.01175
29	0.01312	0.01290	0.01269	0.01249	0.01230	0.01212	0.01195	0.01178	0.01162
30	0.01298	0.01276	0.01256	0.01236	0.01217	0.01199	0.01182	0.01165	0.01149

unit of $K = mm\left(\frac{min}{cm}\right)^{\frac{1}{2}}$

Data Sheet 3

Sieve Analysis on Basic Soil

Gross mass of Soil(M_0)= 200gm

Mass passing 2mm Sieve(M_1)= 190.45gm

Mass retained on 2mm Sieve= 9.55gm

Mass used in Sedimentation Analysis (M_2)=100gm

Student Name ATUEGBU Date 16/01/91

Sieve number	Opening Size (mm)	Mass of retained (gm)	Fraction retained	Cummulative fraction retained	Fraction finer
7	2.411	9.55	0.1158	0.1158	0.88
14	1.204	4.70	0.0570	0.1728	0.82
25	0.699	20.85	0.2525	0.4255	0.57
36	0.422	13.10	0.1588	0.5843	0.42
52	0.295	10.60	0.1285	0.7128	0.29
72	0.211	10.00	0.1212	0.8340	0.17
100	0.152	7.50	0.0909	0.9249	0.08
200	0.076	6.20	0.0752	1.00	0.00

Data Sheet 4

Sedimentation (Hydrometer) Analysis

Gross Mass of Soil (M_o) = 200gm

Mass passing 2mm Sieve (M_1) 190.45gm

Mass use in Sedimentation analysis (M_2)

- 100gm W = 82.50gm

Elapsed Time	Hydro-meter Reading (g/l)(Ra)	Temp. ^oC	Effec-tive depth 1 (cm)	Fully corrected reading (Rc)	Frac-tion finer
20secs	14	23	15.6	12.3	0.15
40 "	12	23	16.0	10.3	0.12
1.0mm	10.5	23	16.6	8.8	0.11
1min 20secs	7.80	23	17.68	6.1	0.07
1min 40secs	6.5	23	18.2	4.8	0.06
2.0mins	5.50	23	18.6	3.8	0.05
2.5 "	5.00	23	18.8	3.3	0.04
5.0 "	2.8	23	19.68	1.1	0.01
10 "	0.8	23	20.48	-0.9	
15 "	0.00	23	20.80	-1.7	

Data Sheet 6

DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL USING STANDARD*/HEAVY* COMPACTION

Job. M.Sc ..... Sample No. Stabilizer Operator. ATUEGBU .....

Site ..... Depth ..... 1m ..... Date .....

Amount retained on 3/4" B.S. Sieve ..... g ..... Total weight of sample ..... g .....

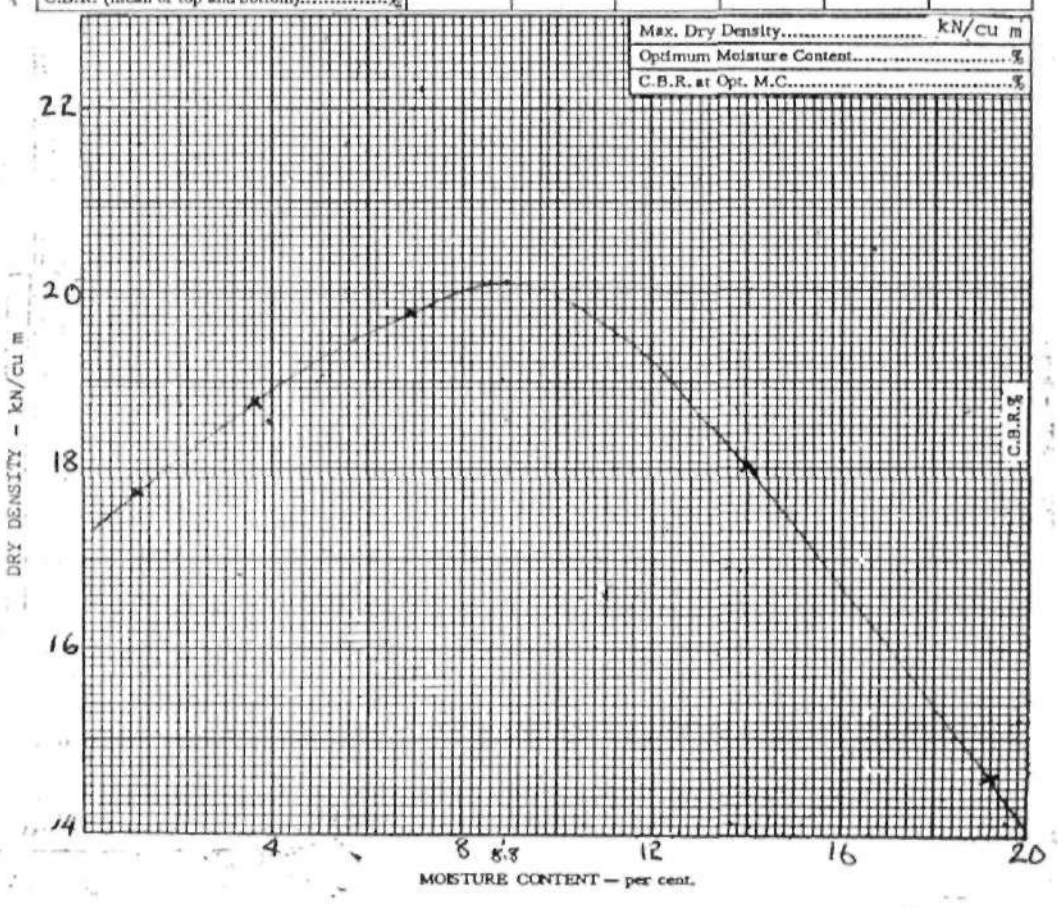
B.S.*/C.B.R.* Mould ..... *Delete the inappropriate word

Wt. of mould and wet soil ..... (W_2) ..... g	6250	6390	6565	6505	6195		
Wt. of mould ..... (W_1) ..... g	4430	4430	4430	4430	4430	4430	4430
Wt. of wet soil ..... ($W_2 - W_1$) ..... g	1820	1960	2135	2075	1765		
Bulk density $\gamma = \frac{W_2 - W_1}{X}$ ..... kN/cu m	18.00	19.39	21.12	20.52	17.46		

For B.S. Mould x = 101.1.

MOISTURE CONTENT DETERMINATIONS

Container No.	193	71	39	32	193	135	30	36	16	15		
Wt. of wet soil and container ..... g	37.2	38.2	41.7	37.8	40.0	42.4	47.0	45.0	63.2	65.0		
Wt. of dry soil and container ..... g	36.9	37.7	40.8	36.9	38.1	39.9	42.1	40.7	54.9	55.8		
Wt. of container ..... g	8.6	9.4	9.4	9.4	8.6	5.5	9.0	9.4	10.7	9.7		
Wt. of dry soil (W_s) ..... g	28.3	28.3	31.1	27.5	29.5	34.4	33.1	31.5	44.4	46.1		
Wt. of moisture (W_w) ..... g	0.3	0.5	1.2	0.9	1.9	2.5	4.9	4.1	8.3	9.2		
Moisture content $100 W_w/W_s$ ..... %	1.06	1.06	3.86	3.27	6.44	7.27	14.8	13.23	18.47	19.96		
Average moisture content (m) ..... %	1.06		3.57		6.86		14.02		19.23			
Dry density $\gamma d = 100\gamma/100+m$ ..... kN/cu m	17.72		18.72		19.76		18.00		14.64			
C.B.R. (mean of top and bottom) ..... %												



Data Sheet 4

Sedimentation (Hydrometer) Analysis

Gross Mass of Soil (M_o) = 200gm

Mass passing 2mm Sieve (M_1) 190.45gm

Mass use in Sedimentation analysis (M_2)

= 100gm W = 82.50gm

Elapsed Time	Hydrometer Reading (g/l)(Ra)	Temp. ^oC	Effective depth l (cm)	Fully corrected reading (Rc)	Fraction finer
20secs	14	23	15.6	12.3	0.15
40 "	12	23	16.0	10.3	0.12
1.0mm	10.5	23	16.6	8.8	0.11
1min 20secs	7.80	23	17.68	6.1	0.07
1min 40secs	6.5	23	18.2	4.8	0.06
2.0mins	5.50	23	18.6	3.8	0.05
2.5 "	5.00	23	18.8	3.3	0.04
5.0 "	2.8	23	19.68	1.1	0.01
10 "	0.8	23	20.48	-0.9	
15 "	0.00	23	20.80	-1.7	

Data Sheet 5

Combined Particles Size Analysis

Gross mass of Soil(M_o) = 200gm

Mass passing 32mm Sieve(M_1) = 190.45gm

Mass used in Sedimentation Analysis (M_2) = 100gm

Particle size (mm)	Percentage Smaller			Total
	Sieve Analysis	Hydrometer		
	out of $M_o - M_1$	out of M_1	out of M_1	
2.00	100	100		100
2.00		88		88
1.00		82		82
0.60		670		57
0.40		42		42
0.3		29		29
0.2		17		17
0.15		8		8
0.096			15	15
0.076		0		0
0.057			12	12
0.051			11	11
0.046			7.0	7.0
0.043			5	5
0.038			4	4
0.038				

APPENDIX B

Note $X = \frac{991 - 48}{9.81} = 101.1$

Where V = Volume of the mould $=991.48cm^3$

Gravitational Acceleration

$(g) = 9.81m/s^2$

Data Sheet 6

DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL USING STANDARD*/HEAVY* COMPACTION

Job M.Sc Sample No Stabilizer Operator ATKERBY

Site ..... Depth 1m Date .....

Amount retained on 3/4" B.S. Sieve ..... g ..... Total weight of sample ..... g

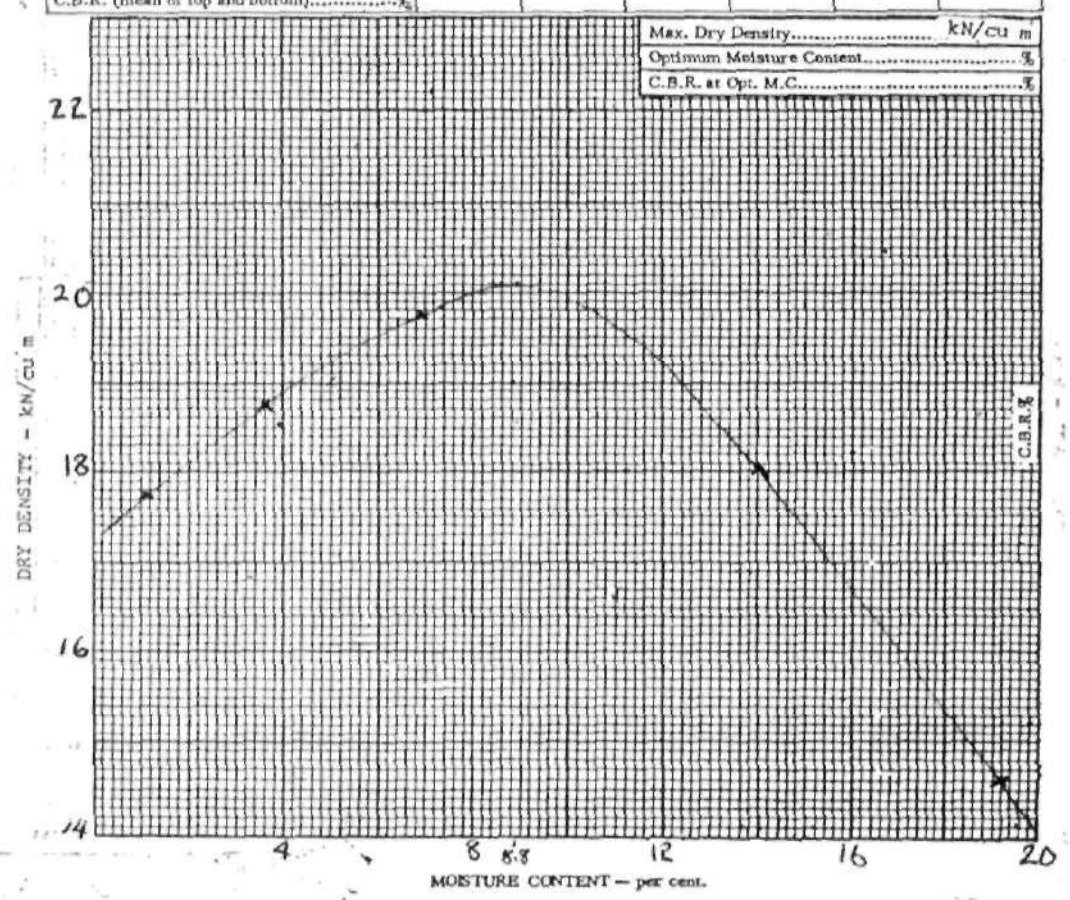
B.S.*/C.B.R.* Mould ..... *Delete the inappropriate word

Wt. of mould and wet soil ..... (W_2) ..... g	6250	6390	6565	6505	6195		
Wt. of mould ..... (W_1) ..... g	4430	4430	4430	4430	4430	4430	4430
Wt. of wet soil ..... ($W_2 - W_1$) ..... g	1820	1960	2135	2075	1765		
Bulk density $\gamma = \frac{W_2 - W_1}{X}$ ..... kN/cu m	18.00	19.39	21.12	20.52	17.46		

For B.S. Mould x = 101.14

MOISTURE CONTENT DETERMINATIONS

Container No.	193	71	39	32	193	135	30	36	16	15		
Wt. of wet soil and container ..... g	37.2	38.2	41.7	37.8	40.0	42.4	47.0	45.0	63.2	65.0		
Wt. of dry soil and container ..... g	36.9	37.7	40.8	36.9	38.1	39.9	42.1	40.9	54.9	55.8		
Wt. of container ..... g	8.6	9.4	9.4	9.4	8.6	5.5	9.0	9.4	10.7	9.7		
Wt. of dry soil (W_d) ..... g	28.3	28.3	31.1	27.5	29.5	34.4	33.1	31.5	44.9	46.1		
Wt. of moisture (W_w) ..... g	0.3	0.5	1.2	0.9	1.9	2.5	4.9	4.1	8.3	9.2		
Moisture content 100 W_w/W_d ..... %	1.06	1.06	3.86	3.27	6.44	7.27	14.8	13.23	18.49	19.96		
Average moisture content (m) ..... %	1.06		3.57		6.86		14.02		19.23			
Dry density $\gamma_d = 100\gamma/100+m$ ..... kN/cu m	17.72		18.72		19.76		18.00		14.64			
C.B.R. (mean of top and bottom) ..... %												



Data Sheet 6

DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL USING STANDARD*/HEAVY* COMPACTION

Job M.Sc Sample 2% Bitumen Operator A.J.McCOY

Site ..... Depth ..... m. Date .....

Amount retained on 3/4" B.S. Sieve ..... g. Total weight of sample ..... g.

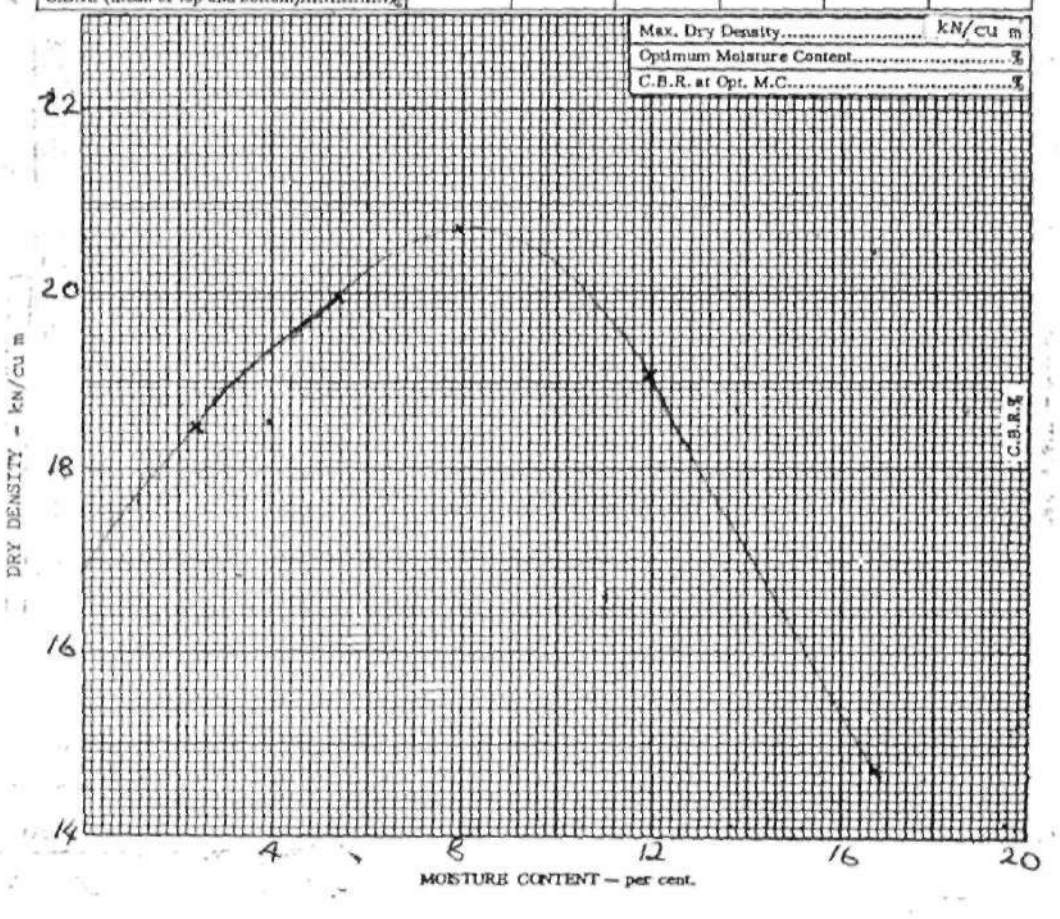
B.S.*/C.B.R.* Mould ..... *Delete the inappropriate word

Wt. of mould and wet soil ..... (W2) ..... g.	6345	6540	6690	6590	6160		
Wt. of mould ..... (W1) ..... g.	4430	4430	4430	4430	4430		
Wt. of wet soil ..... (W2 - W1) ..... g.	1915	2110	2260	2160	1730		
Bulk density $\gamma = \frac{W_2 - W_1}{X}$ ..... kN/cu m.	18.94	20.87	22.35	21.36	17.11		

For B.S. Mould x = 101.1.

MOISTURE CONTENT DETERMINATIONS

Container No.	27	17	30	135	54	42	43	32	193	175		
Wt. of wet soil and container ..... g.	33.2	32.2	36.6	29.6	43.7	43.7	46.3	51.2	63.4	57.5		
Wt. of dry soil and container ..... g.	32.6	31.7	35.3	28.3	41.1	41.0	42.5	46.6	55.7	50.4		
Wt. of container ..... g.	9.6	9.2	9.0	5.4	7.3	5.4	9.6	9.4	8.6	8.5		
Wt. of dry soil (Ws) ..... g.	23.0	22.5	26.3	22.9	31.8	35.6	32.9	37.2	47.1	41.9		
Wt. of moisture (Ww) ..... g.	0.6	0.5	1.3	1.3	2.6	2.7	3.8	4.6	7.7	7.1		
Moisture content 100 Ww/Ws	2.61	2.22	4.94	5.68	8.18	7.58	11.52	12.37	16.35	16.75		
Average moisture content (m) ..... %	2.42		5.31		7.88		11.96		16.65			
Dry density $\gamma_d = 100\gamma/100+m$ ..... kN/cu m	18.49		19.82		20.72		19.08		14.67			
C.B.R. (mean of top and bottom) ..... %												



Date Sheet 6

DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD*/HEAVY* COMPACTION

Job M.Sc Sample 4% - Bitumen Operator ATHEBY

Site ..... Depth ..... m. Date .....

Amount retained on 3/4" B.S. Sieve ..... g. Total weight of sample ..... g.

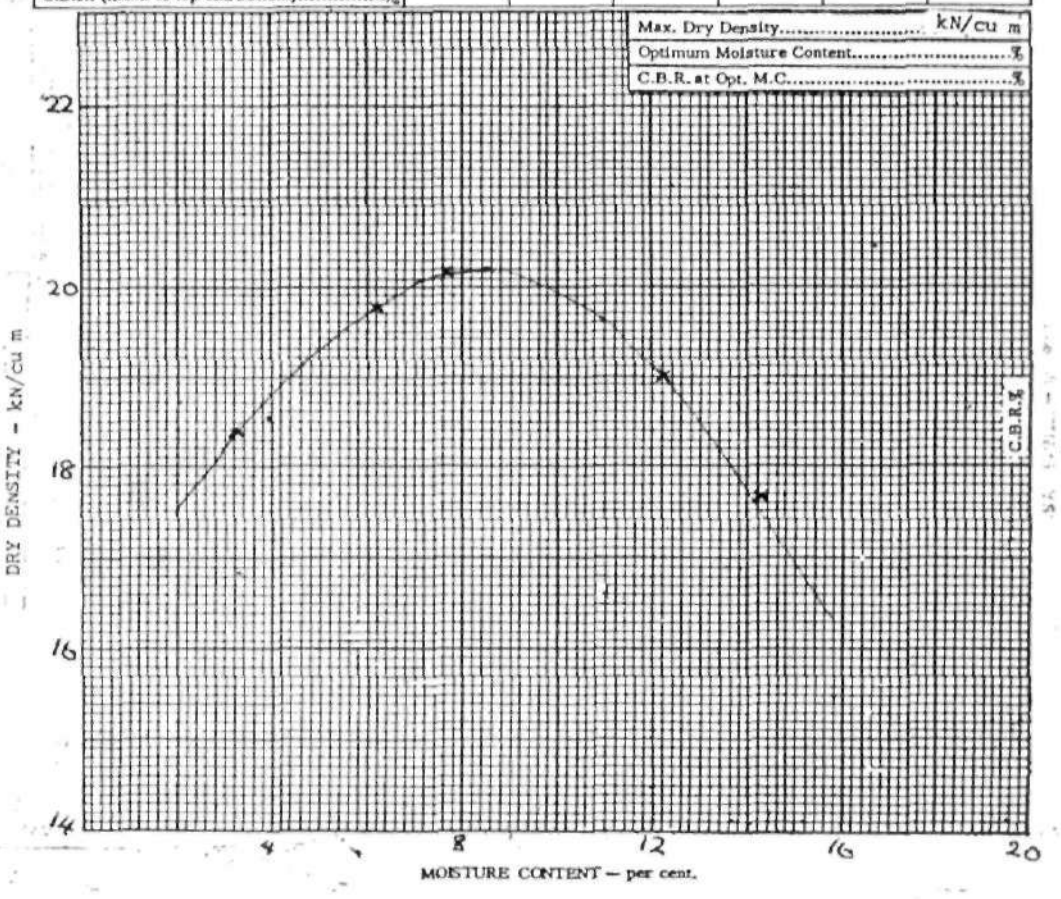
B.S.*/C.B.R.* Mould ..... *Delete the inappropriate word

Wt. of mould and wet soil ..... (W2) ..... g.	6350	6550	6625	6585	6470		
Wt. of mould ..... (W1) ..... g.	4430	4430	4430	4430	4430		
Wt. of wet soil ..... (W2 - W1) ..... g.	1920	2120	2195	2155	2040		
Bulk density $\gamma = \frac{W_2 - W_1}{X}$ ..... kN/cu m	18.99	20.97	21.71	21.32	20.18		

For B.S. Mould x = 101.19.

MOISTURE CONTENT DETERMINATIONS

Container No.	32	39	158	193	34	42	71	180	55	57		
Wt. of wet soil and container ..... g.	37.3	35.5	28.6	33.2	40.4	37.1	52.6	48.3	56.8	54.7		
Wt. of dry soil and container ..... g.	36.6	34.5	27.5	31.7	38.2	34.8	47.8	44.0	51.0	48.3		
Wt. of container ..... g.	9.4	9.4	8.6	8.6	9.2	5.4	9.4	8.8	9.8	9.2		
Wt. of dry soil (Ws) ..... g.	27.2	25.1	18.9	23.1	29.0	29.4	38.5	35.2	41.5	44.1		
Wt. of moisture (Ww) ..... g.	0.7	1.0	1.1	1.5	2.2	2.4	4.7	4.3	5.8	6.4		
Moisture content 100 Ww/Ws ..... %	2.57	3.98	5.82	6.49	7.59	7.82	12.21	12.22	13.98	14.51		
Average moisture content (m) ..... %	3.28		6.16		7.71		12.22		14.25			
Dry density $\gamma d = 100\gamma/100+m$ ..... kN/cu m	18.39		19.75		20.16		19.00		17.66			
C.B.R. (mean of top and bottom) ..... %												



Data Sheet 6

DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL USING STANDARD*/HEAVY* COMPACTION

Job M.Sc Sample 6% - Bitumen Operator ATHEGBU

Site ..... Depth 1m Date .....

Amount retained on 3/4" B.S. Sieve ..... g ..... Total weight of sample ..... g .....

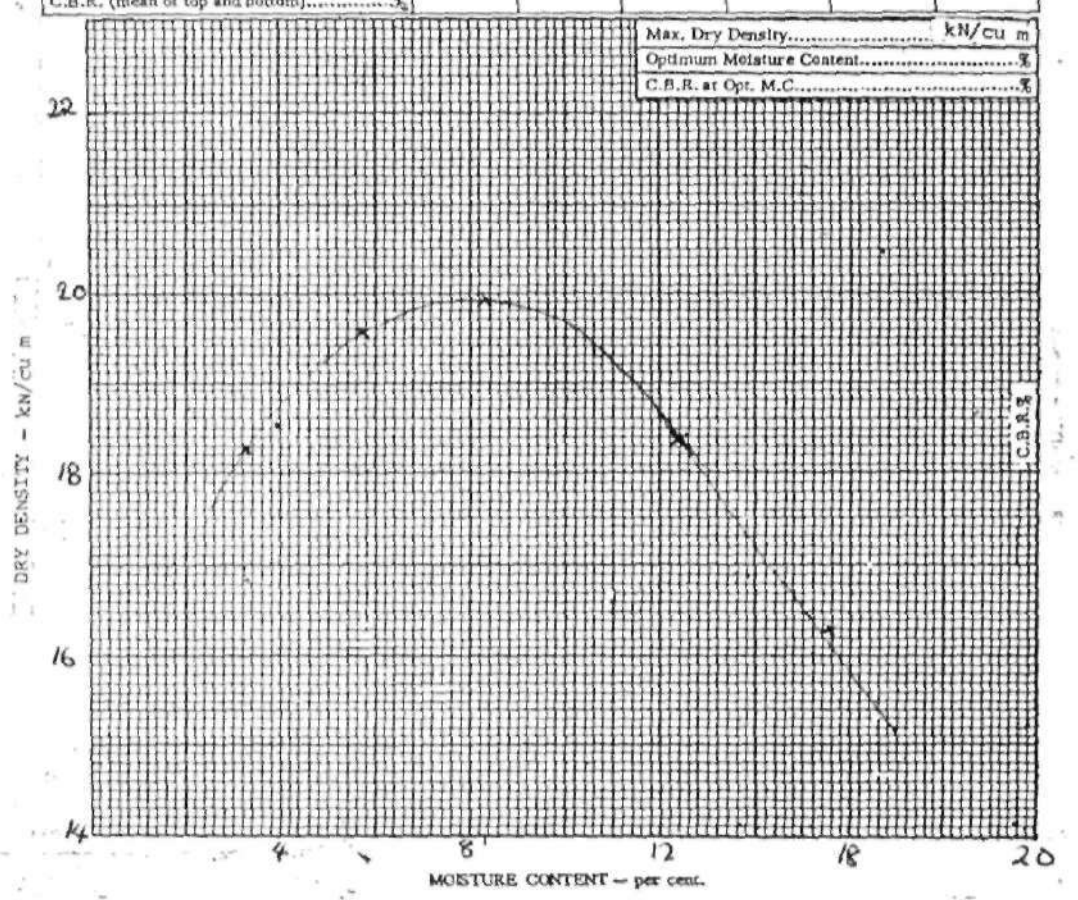
B.S.*/C.B.R.* Mould ..... *Delete the inappropriate word

Wt. of mould and wet soil ..... (W_2) ..... g	6335	6520	6610	6580	6305		
Wt. of mould ..... (W_1) ..... g	4430	4430	4430	4430	4430		
Wt. of wet soil ..... ($W_2 - W_1$) ..... g	1705	2090	2180	2090	1935		
Bulk density $\gamma = \frac{W_2 - W_1}{X}$ ..... kN/cu m	18.84	20.67	21.56	20.67	19.14		

For B.S. Mould x = 101.19

MOISTURE CONTENT DETERMINATIONS

Container No.	30	36	15	135	54	17	40	38	24	16		
Wt. of wet soil and container ..... g	39.3	41.3	37.1	50.1	52.6	47.9	51.2	48.9	48.5	53.0		
Wt. of dry soil and container ..... g	38.4	40.3	35.6	47.7	49.3	44.9	46.5	44.5	42.7	46.6		
Wt. of container ..... g	9.0	9.4	9.7	5.5	9.3	9.2	9.9	10.2	9.6	10.0		
Wt. of dry soil (W_d) ..... g	29.4	30.9	25.9	42.2	40.0	35.7	36.6	34.3	33.1	36.6		
Wt. of moisture (W_m) ..... g	0.9	1.0	1.5	2.4	3.0	3.0	4.7	4.0	5.8	6.4		
Moisture content 100 W_m/W_d ..... %	3.04	3.24	5.79	5.69	8.25	8.40	12.84	11.66	17.52	17.49		
Average moisture content (m) ..... %	3.15	5.74	8.33	12.35	17.51							
Dry density $\gamma d = 100\gamma/100+m$ ..... kN/cu m	18.26	19.55	19.90	18.40	16.29							
C.B.R. (mean of top and bottom) ..... %												



Data Sheet 6

DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL USING STANDARD*/HEAVY* COMPACTION

Job M. Sc Sample 8% - Bitumen Operator ATIEGBU

Site ..... Depth ..... m Date .....

Amount retained on 3/4" B.S. Sieve ..... g Total weight of sample ..... g

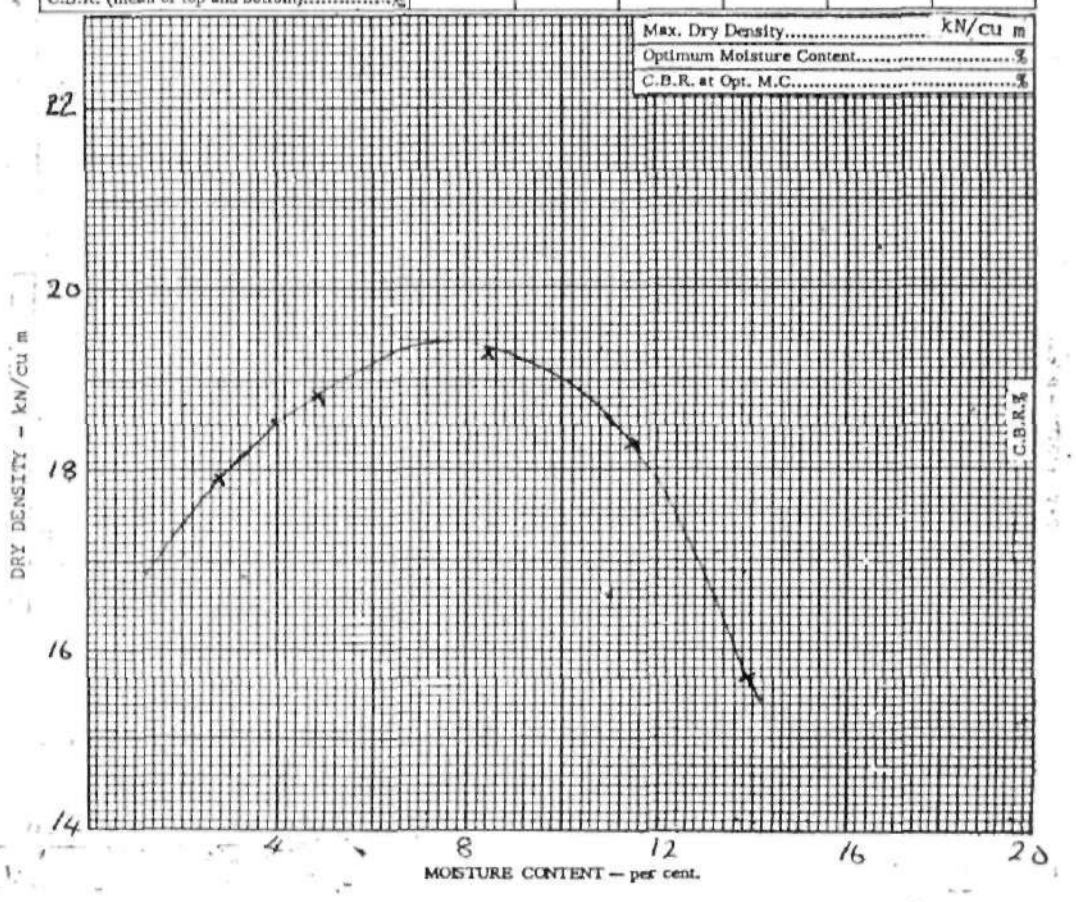
B.S.*/C.B.R.* Mould ..... *Delete the inappropriate word

Wt. of mould and wet soil ..... (W_2) ..... g	6290	6425	6540	6470	6240		
Wt. of mould ..... (W_1) ..... g	4430	4430	4430	4430	4430		
Wt. of wet soil ..... ($W_2 - W_1$) ..... g	1860	1995	2110	2060	1810		
Bulk density $\gamma = \frac{W_2 - W_1}{X}$ ..... kN/cu m	18·40	19·73	20·87	20·38	17·90		

For B.S. Mould x = 101.13.

MOISTURE CONTENT DETERMINATIONS

Container No.	44	149	175	168	16	24	15	135	32	39		
Wt. of wet soil and container ..... g	44·2	33·3	51·8	54·2	55·4	50·9	48·0	34·9	43·6	44·1		
Wt. of dry soil and container ..... g	43·4	32·6	49·8	52·1	51·9	47·7	44·0	31·9	39·5	39·8		
Wt. of container ..... g	9·4	9·1	8·5	8·6	10·0	9·6	9·7	5·5	9·4	9·4		
Wt. of dry soil (W_d) ..... g	34·0	23·5	41·3	43·5	41·9	38·1	34·3	26·4	30·1	30·4		
Wt. of moisture (W_m) ..... g	0·8	0·7	2·0	2·1	3·5	3·2	4·0	3·0	4·1	4·3		
Moisture content 100 W_m/W_d ..... %	2·35	2·98	4·84	4·83	8·35	8·40	11·66	11·36	13·62	14·14		
Average moisture content (m) ..... %	2·67		4·84		8·38		11·51		13·88			
Dry density $\gamma d = 100\gamma/100+m$ ..... kN/cu m	17·92		18·82		19·26		18·28		15·72			
C.B.R. (mean of top and bottom) ..... %												



Data Sheet 6

DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD*/HEAVY* COMPACTION

Job. M.Sc ..... Sample 10% - Bitumen ..... Operator ATHEGBA .....

Site ..... Depth ..... m ..... Date .....

Amount retained on 3/4" B.S. Sieve ..... g ..... Total weight of sample ..... g .....

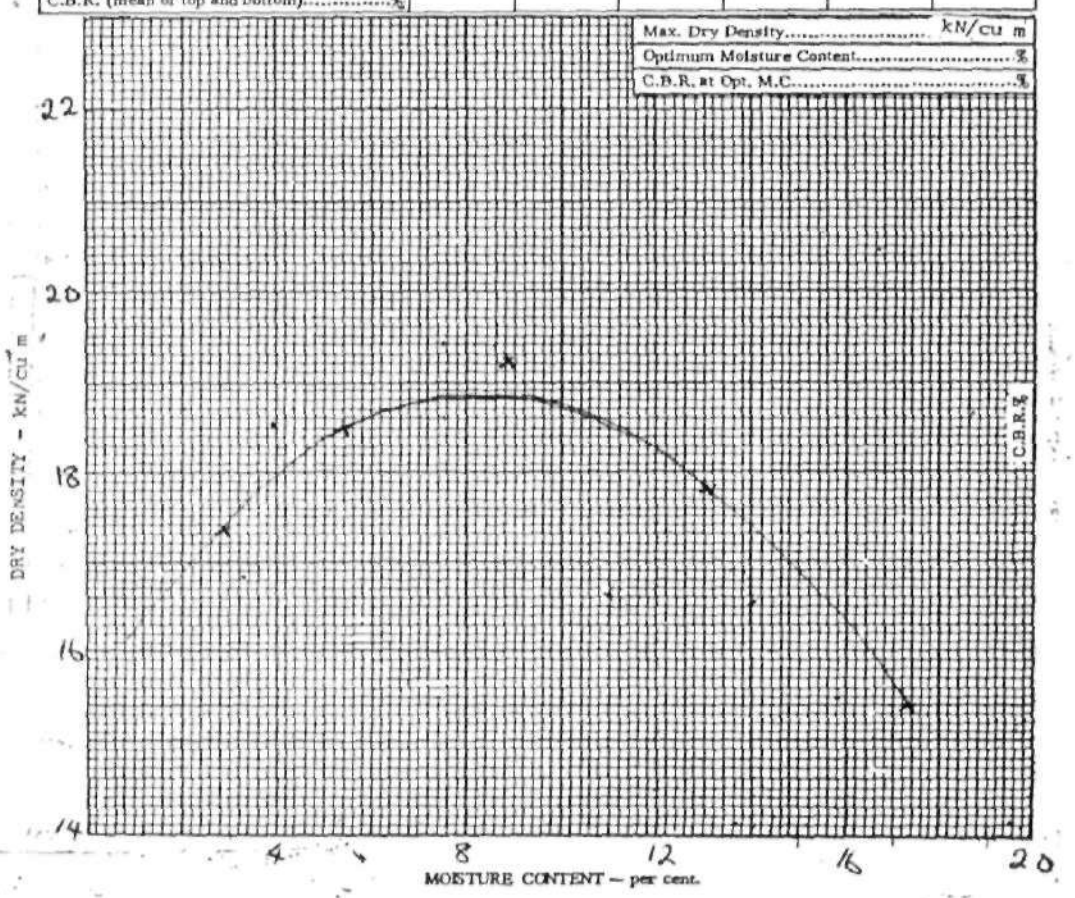
B.S.*/C.B.R.* Mould ..... *Delete the inappropriate word

Wt. of mould and wet soil ..... (W_2) ..... g	6235	6400	6543	6465	6255		
Wt. of mould ..... (W_1) ..... g	4430	4430	4430	4430	4430		
Wt. of wet soil ..... ($W_2 - W_1$) ..... g	1805	1970	2113	2035	1825		
Bulk density $\gamma = \frac{W_2 - W_1}{X}$ ..... kN/cu m	17.85	19.49	20.90	20.13	18.05		

*For B.S. Mould x = 101.12

MOISTURE CONTENT DETERMINATIONS

Container No.	54	17	38	40	30	36	34	154	42	180		
Wt. of wet soil and container ..... g	45.7	62.8	44.4	42.6	45.5	55.2	54.3	51.9	52.9	64.7		
Wt. of dry soil and container ..... g	44.5	61.5	42.5	41.1	42.6	51.4	49.2	46.8	45.6	56.7		
Wt. of container ..... g	9.3	9.2	10.2	9.9	9.0	9.4	9.2	8.6	5.4	8.8		
Wt. of dry soil (W_d) ..... g	35.2	52.3	32.3	31.2	33.6	42.0	40.0	38.2	40.2	47.9		
Wt. of moisture (W_m) ..... g	1.2	1.3	1.9	1.5	2.9	3.8	5.1	5.1	7.3	8.0		
Moisture content 100 W_m/W_d ..... %	3.41	2.49	5.88	4.81	8.63	9.05	12.75	13.35	18.16	16.70		
Average moisture content (m) ..... %	2.95		5.35		8.84		13.05		17.43			
Dry density $\gamma_d = 100\gamma/100+m$ ..... kN/cu m	17.34		18.50		19.20		17.81		15.37			
C.B.R. (mean of top and bottom) ..... %												



Data Sheet 6

DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL USING STANDARD*/HEAVY* COMPACTION

Job M. Sc ..... Sample 2% - Lime ..... Operator AIWEGBU.....

Site ..... Depth ..... m ..... Date .....

Amount retained on 3/4" B.S. Sieve ..... g ..... Total weight of sample ..... g .....

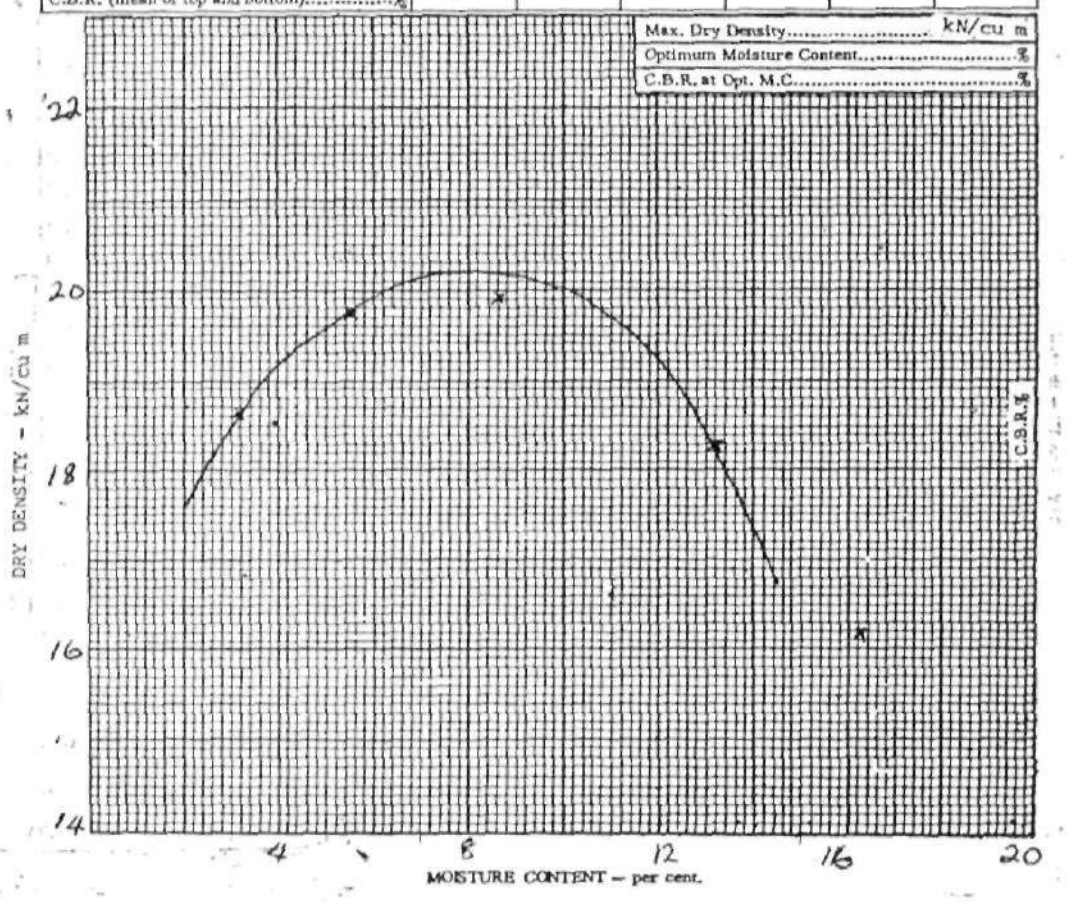
B.S.*/C.B.R.* Mould ..... *Delete the inappropriate word

Wt. of mould and wet soil ..... (W_2) ..... g	6375	6535	6615	6526	6378		
Wt. of mould ..... (W_1) ..... g	4430	4430	4430	4430	4430		
Wt. of wet soil ..... ($W_2 - W_1$) ..... g	1945	2105	2185	2095	1948		
Bulk density $\gamma = \frac{W_2 - W_1}{X}$ ..... kN/cu m	19.24	20.82	21.61	20.72	19.27		

For B.S. Mould x = 101.1

MOISTURE CONTENT DETERMINATIONS

Container No.	168	135	193	158	15	32	43	34	39	17		
Wt. of wet soil and container ..... g	37.3	32.7	38.9	38.2	36.2	30.4	37.3	36.5	40.9	40.1		
Wt. of dry soil and container ..... g	36.3	32.0	37.2	36.8	34.4	28.5	34.1	33.3	35.9	35.2		
Wt. of container ..... g	8.6	5.5	8.6	8.6	9.7	9.4	9.6	9.2	9.4	9.2		
Wt. of dry soil (W_d) ..... g	27.7	26.5	28.6	28.2	24.7	19.1	24.5	24.1	26.5	26.0		
Wt. of moisture (W_m) ..... g	1.0	0.7	1.7	1.4	1.8	1.9	3.2	3.2	5.0	4.9		
Moisture content 100 W_m/W_d ..... %	3.61	2.64	5.94	4.96	7.29	9.95	13.06	13.27	18.87	18.85		
Average moisture content (m) ..... %	3.13		5.45		8.62		13.17		18.86			
Dry density $\gamma_d = 100\gamma/100+m$ ..... kN/cu m	18.66		19.74		19.90		18.31		16.21			
C.B.R. (mean of top and bottom) ..... %												



Data Sheet 6

DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL USING STANDARD*/HEAVY* COMPACTION

Job M.Sc Sample 4% Lime Operator ATHEGBU

Site ..... Depth ..... m Date .....

Amount retained on 3/4" B.S. Sieve ..... g Total weight of sample ..... g

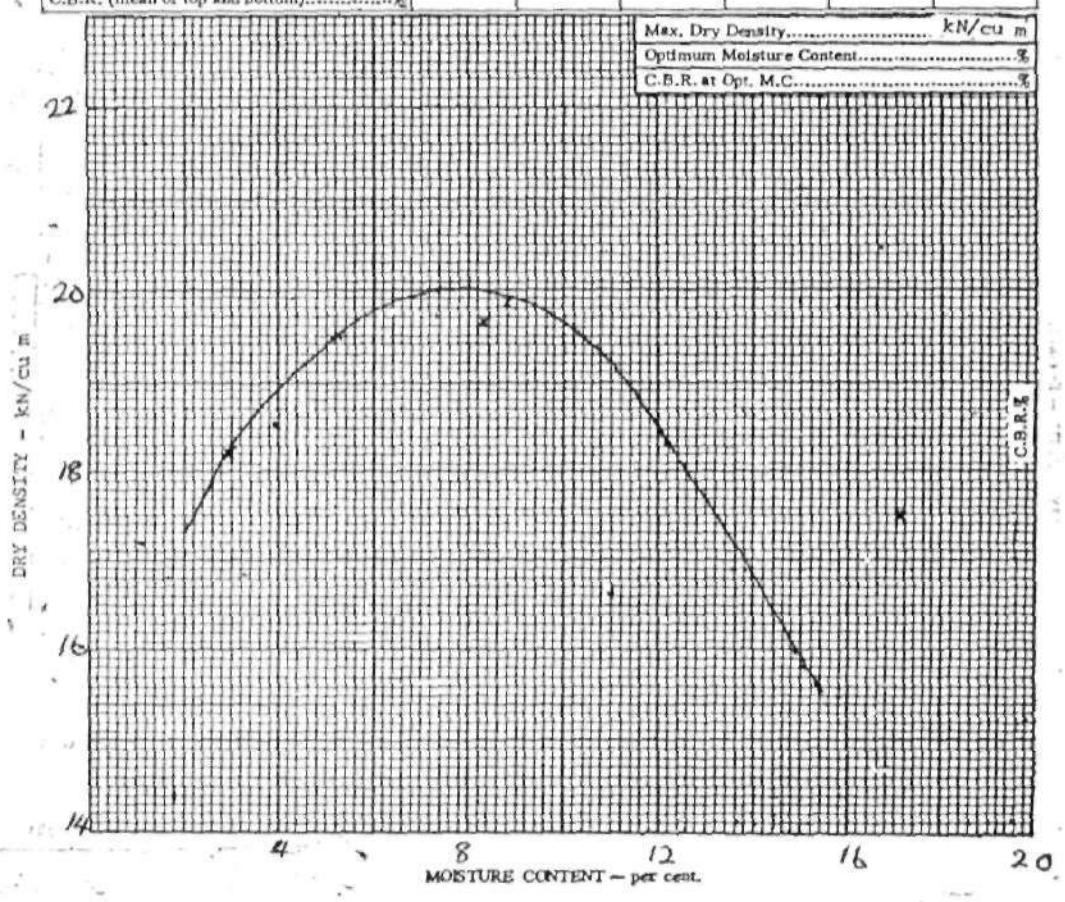
B.S.*/C.B.R.* Mould ..... *Delete the inappropriate word

Wt. of mould and wet soil ..... (W2) ..... g	6325	6498	6580	6380	6225		
Wt. of mould ..... (W1) ..... g	4430	4430	4430	4430	4430		
Wt. of wet soil ..... (W2 - W1) ..... g	1895	2068	2150	1950	1795		
Bulk density $\gamma = \frac{W_2 - W_1}{X}$ ..... kN/cu m	18·74	20·45	21·27	19·29	17·75		

For B.S. Mould x = 101.1

MOISTURE CONTENT DETERMINATIONS

Container No.	180	57	54	71	30	55	40	38	24	16		
Wt. of wet soil and container ..... g	39·4	38·1	29·6	30·4	21·1	31·1	42·6	47·7	43·7	38·3		
Wt. of dry soil and container ..... g	38·5	37·3	28·6	29·4	27·6	29·4	37·7	42·3	37·5	33·2		
Wt. of container ..... g	8·5	9·2	7·3	8·8	9·0	9·3	9·5	10·2	9·6	10·0		
Wt. of dry soil (Wd) ..... g	30·0	28·1	19·3	20·6	18·6	20·1	28·2	32·1	27·9	23·2		
Wt. of moisture (Wm) ..... g	0·9	0·8	1·0	1·0	1·5	1·7	4·9	5·4	6·2	5·1		
Moisture content 100 Wm/Wd ..... %	3·0	2·85	5·18	4·85	8·06	8·46	17·38	16·8	22·2	21·98		
Average moisture content (m) ..... %	2·93		5·02		8·26		17·10		22·10			
Dry density $\gamma d = 100\gamma/100+m$ ..... kN/cu m	18·21		19·47		19·65		16·47		14·54			
C.B.R. (mean of top and bottom) ..... %												



Data Sheet 6

DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL USING STANDARD*/HEAVY* COMPACTION

Job M.Sc Sample 6% - 4lime Operator ATIEGBU

Site ..... Depth 1m Date .....

Amount retained on 3/4" B.S. Sieve .....g..... Total weight of sample .....g.....

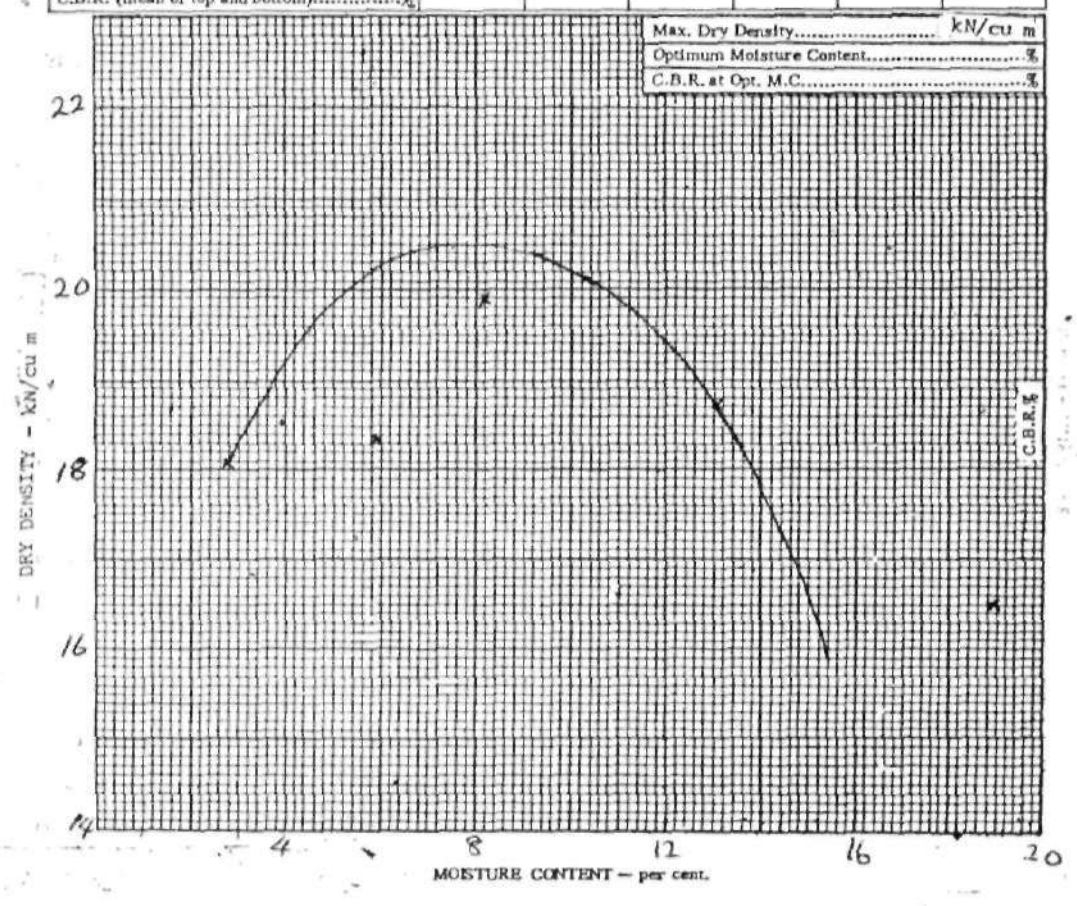
B.S.*/C.B.R.* Mould ..... *Delete the inappropriate word

Wt. of mould and wet soil ..... (W_2) ..... g	6310	6395	6605	6565	6415		
Wt. of mould ..... (W_1) ..... g	4430	4430	4430	4430	4430		
Wt. of wet soil ..... ($W_2 - W_1$) ..... g	1880	1965	2175	2135	1985		
Bulk density $\gamma = \frac{W_2 - W_1}{x}$ ..... kN/cu m	18.60	19.44	21.51	21.12	14.63		

For B.S. Mould x = 101.1.

MOISTURE CONTENT DETERMINATIONS

Container No.	24	135	32	17	34	16	71	15	36	57		
Wt. of wet soil and container ..... g	28.1	27.1	28.9	29.5	28.5	36.9	33.0	37.9	57.7	58.5		
Wt. of dry soil and container ..... g	27.6	26.5	27.8	28.4	27.1	34.9	30.3	36.5	50.1	48.9		
Wt. of container ..... g	9.6	5.5	9.4	9.2	9.4	10.0	9.4	9.7	9.4	9.2		
Wt. of dry soil (W_d) ..... g	18.0	21.0	18.4	19.2	17.7	23.9	20.9	26.8	40.7	39.7		
Wt. of moisture (W_m) ..... g	0.5	0.6	1.1	1.1	1.4	2.0	2.7	3.4	7.6	7.6		
Moisture content 100 W_m/W_s ..... %	2.78	2.86	5.98	5.73	7.91	8.35	12.92	12.67	18.67	19.4		
Average moisture content (m) ..... %	2.78		5.86		8.14		12.81		18.91			
Dry density $\gamma_d = 100\gamma/100+m$ ..... kN/cu m	18.10		18.36		19.89		18.72		16.51			
C.B.R. (mean of top and bottom) ..... %												



Data Sheet 6

DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL USING STANDARD*/HEAVY* COMPACTION

Job M.Sc Sample 8%-Lime Operator ATHEEBA

Site ..... Depth 1m Date .....

Amount retained on 3/4" B.S. Sieve .....g..... Total weight of sample .....g.....

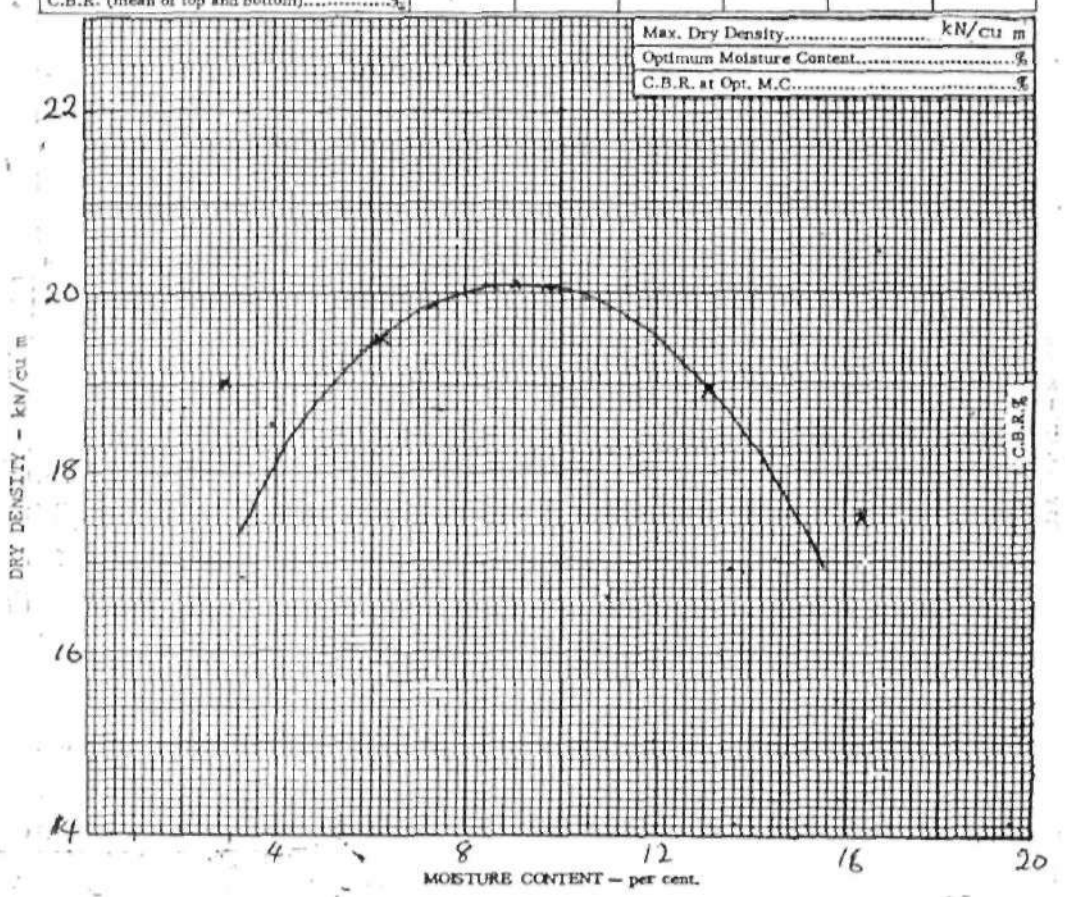
B.S.*/C.B.R.* Mould ..... *Delete the inappropriate word

Wt. of mould and wet soil ..... (W_2) ..... g	6992	7112	7244	7170	7070		
Wt. of mould ..... (W_1) ..... g	5014	5014	5014	5014	5014		
Wt. of wet soil ..... ($W_2 - W_1$) ..... g	1978	2098	2330	2156	2056		
Bulk density $\gamma = \frac{W_2 - W_1}{X}$ ..... kN/cu m	19.56	20.75	22.06	21.33	20.34		

For B.S. Mould x = 101.19

MOISTURE CONTENT DETERMINATIONS

Container No.	44	74	42	132	15	150	151	177	71	163		
Wt. of wet soil and container ..... g	37.4	28.4	45.8	44.3	49.4	55.3	38.0	49.7	50.5	59.1		
Wt. of dry soil and container ..... g	36.5	27.9	43.4	42.0	45.8	51.3	34.7	44.7	44.5	52.5		
Wt. of container ..... g	8.4	8.7	4.8	4.5	9.0	8.1	8.2	8.0	8.9	8.0		
Wt. of dry soil (W_d) ..... g	27.9	19.2	38.6	37.5	36.8	43.2	26.5	36.7	35.6	44.5		
Wt. of moisture (W_m) ..... g	0.9	0.5	2.4	2.3	3.6	4.0	3.3	5.0	5.8	7.2		
Moisture content 100 W_m/W_d ..... %	3.2	2.6	6.2	6.1	9.8	9.3	12.5	13.6	16.3	16.2		
Average moisture content (m) ..... %	2.9		6.2		9.6		13.1		16.3			
Dry density $\gamma_d = 100\gamma/100+m$ ..... kN/cu m	19.0		19.5		20.1		18.9		17.5			
C.B.R. (mean of top and bottom) ..... %												



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Data Sheet 6

DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD*/HEAVY* COMPACTION

Job M.S.c Sample 10% - Lime Operator ATHEGRY

Site ..... Depth ..... Im ..... Date .....

Amount retained on 3/4" B.S. Sieve ..... g ..... Total weight of sample ..... g .....

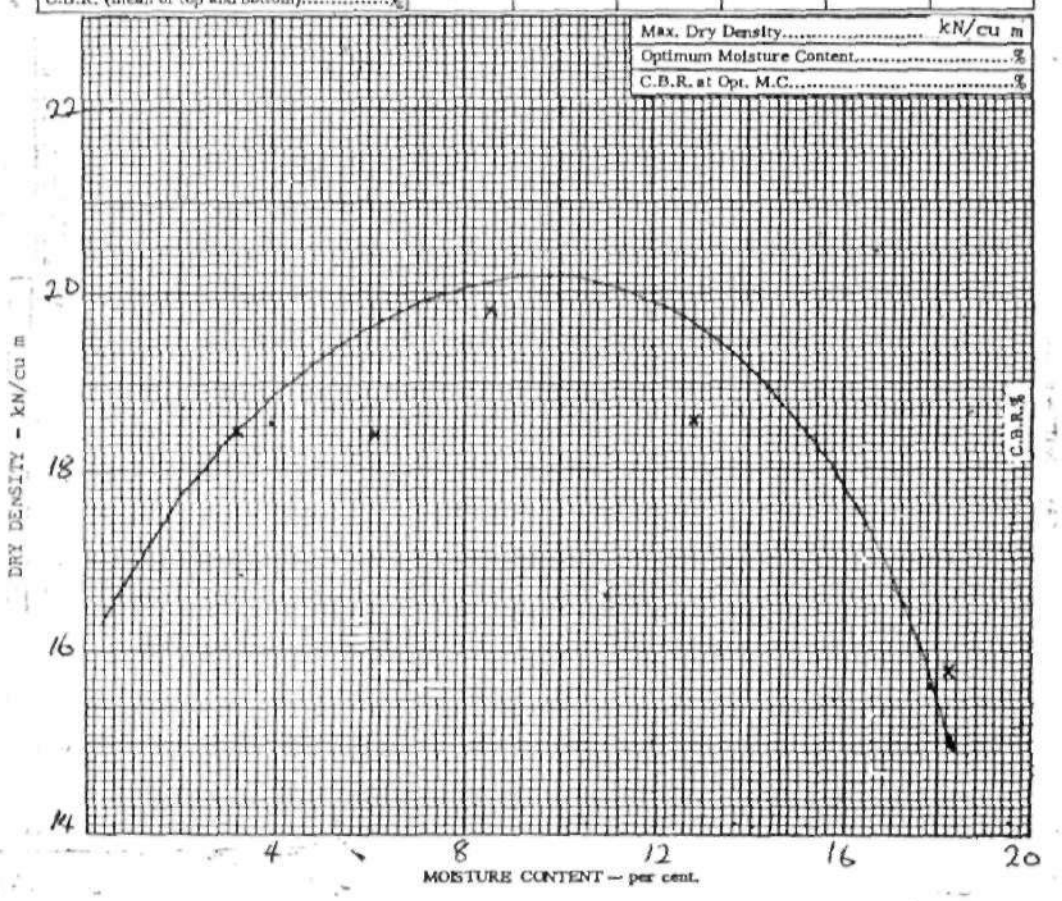
B.S.*/C.B.R.* Mould ..... *Delete the inappropriate word

Wt. of mould and wet soil ..... (W_2) ..... g	6255	6405	6600	6550	6215		
Wt. of mould ..... (W_1) ..... g	4430	4430	4430	4430	4430		
Wt. of wet soil ..... ($W_2 - W_1$) ..... g	1925	1975	2170	2120	2120		
Bulk density $\gamma = \frac{W_2 - W_1}{X}$ ..... kN/cu m	14.04	14.54	21.46	20.97	18.64		

For B.S.* Mould x = 101.7.

MOISTURE CONTENT DETERMINATIONS

Container No.	158	168	43	54	71	42	180	38	57	175		
Wt. of wet soil and container ..... g	31.9	26.7	26.5	25.6	28.4	29.9	31.3	37.8	59.2	57.6		
Wt. of dry soil and container ..... g	31.1	26.2	25.4	24.8	26.7	28.0	34.5	36.0	51.5	50.0		
Wt. of container ..... g	8.6	8.6	9.6	9.3	9.4	5.4	8.8	10.2	9.2	8.5		
Wt. of dry soil (W_d) ..... g	22.5	17.6	15.8	15.5	17.5	22.6	25.7	25.8	42.3	41.5		
Wt. of moisture (W_w) ..... g	0.8	0.5	1.1	0.8	1.5	1.9	4.8	1.8	7.1	7.6		
Moisture content 100 W_w/W_d ..... %	3.56	2.84	6.96	5.16	8.57	8.41	18.68	6.98	18.26	18.31		
Average moisture content (m) ..... %	3.20		6.06		8.49		12.83		18.25			
Dry density $\gamma_d = 100\gamma/100+m$ ..... kN/cu m	18.45		18.42		19.78		18.57		15.76			
C.B.R. (mean of top and bottom) ..... %												



Date Sheet 6

DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL USING STANDARD*/HEAVY* COMPACTION

Job M.Ss Sample 2% - Cement Operator ATUGGAY

Site ..... Depth ..... m Date .....

Amount retained on 3/4" B.S. Sieve ..... g Total weight of sample ..... g

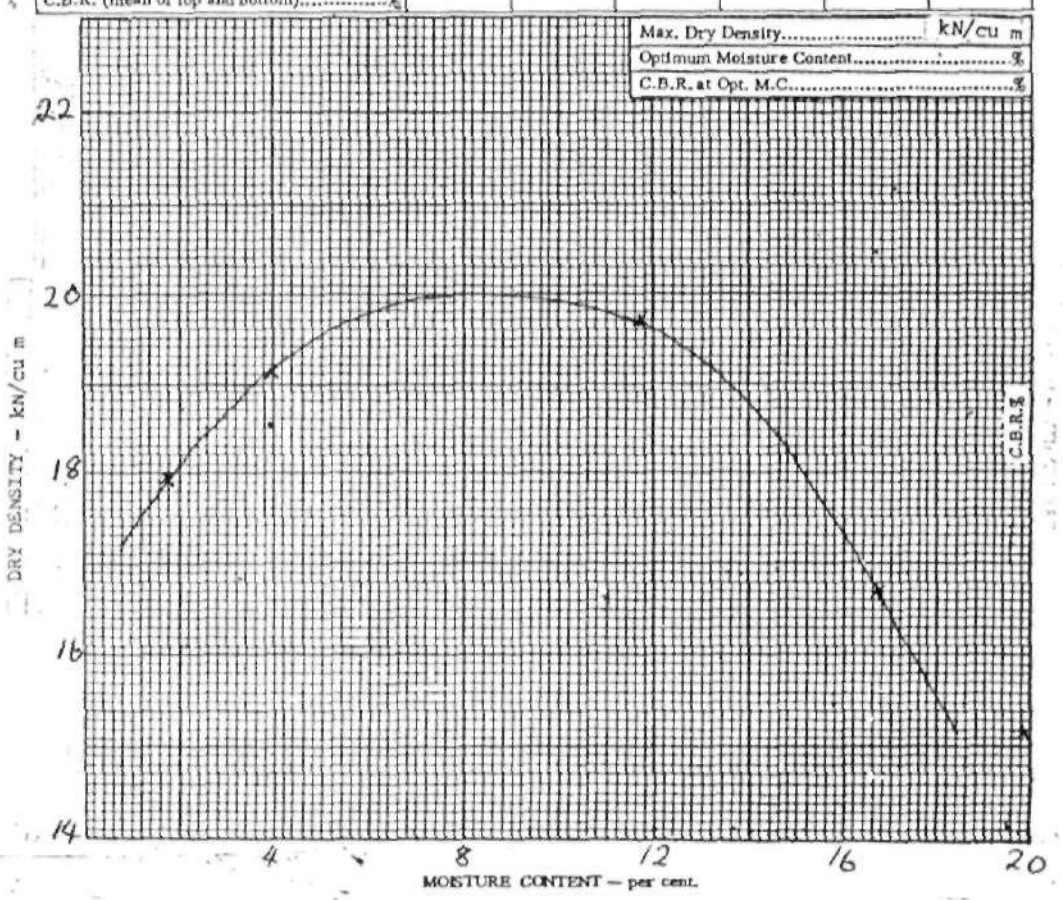
B.S.*/C.B.R.* Mould ..... *Delete the inappropriate word

Wt. of mould and wet soil ..... (W_2) ..... g	6275	6440	6590	6405	6265		
Wt. of mould ..... (W_1) ..... g	4430	4430	4430	4430	4430		
Wt. of wet soil ..... ($W_2 - W_1$) ..... g	1845	2010	2160	1975	1835		
Bulk density $\gamma = \frac{W_2 - W_1}{x}$ ..... kN/cu m	18.25	19.88	21.36	19.54	18.15		

For B.S. Mould x = 101.1

MOISTURE CONTENT DETERMINATIONS

Container No.	36	54	175	168	34	42	24	44	135	40		
Wt. of wet soil and container ..... g	38.0	39.2	31.2	29.3	46.0	41.0	47.1	52.0	46.8	59.8		
Wt. of dry soil and container ..... g	37.7	38.5	30.2	28.5	42.2	37.2	41.6	45.8	51.4	51.5		
Wt. of container ..... g	8.8	8.6	7.9	8.0	8.5	4.9	9.0	8.5	4.8	9.0		
Wt. of dry soil (W_d) ..... g	28.9	29.9	22.4	20.5	33.7	32.3	32.6	37.3	46.6	42.5		
Wt. of moisture (W_m) ..... g	0.3	0.7	0.9	0.8	3.8	3.8	5.5	6.2	7.4	8.3		
Moisture content 100 W_m/W_d ..... %	1.04	2.34	4.02	3.90	11.76	11.76	16.87	16.62	20.17	19.53		
Average moisture content (m) ..... %	1.69		3.96		11.76		16.75		19.85			
Dry density $\gamma_d = 100\gamma/100+m$ ..... kN/cu m	17.95		19.12		19.72		16.74		15.14			
C.B.R. (mean of top and bottom) ..... %												



Date Sheet 6

DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL USING STANDARD*/HEAVY* COMPACTION

Job M. Sc Sample 4% - Cement Operator ATKEGBU

Site ..... Depth ..... m Date .....

Amount retained on 3/4" B.S. Sieve ..... g Total weight of sample ..... g

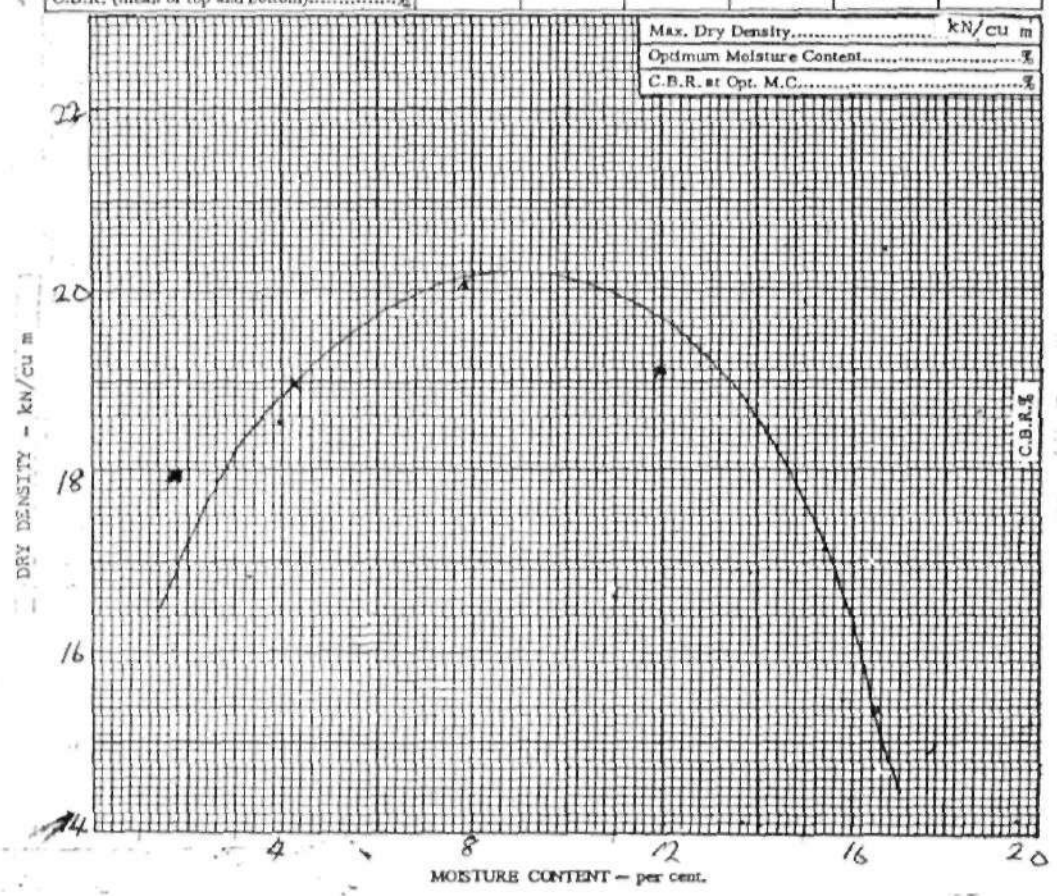
B.S.*/C.B.R.* Mould ..... *Delete the inappropriate word

Wt. of mould and wet soil ..... (W_2) ..... g	6280	6430	6620	6590	6240		
Wt. of mould ..... (W_1) ..... g	4430	4430	4430	4430	4430		
Wt. of wet soil ..... ($W_2 - W_1$) ..... g	1850	2000	2190	2160	1810		
Bulk density $\gamma = \frac{W_2 - W_1}{X}$ ..... kN/cu m	18·30	19·78	21·66	21·36	17·90		

For B.S. Mould x = 101.14

MOISTURE CONTENT DETERMINATIONS

Container No.	40	135	39	158	24	175	36	54	44	168		
Wt. of wet soil and container ..... g	34·9	31·8	51·0	55·5	48·1	50·0	47·3	47·1	54·1	55·4		
Wt. of dry soil and container ..... g	34·5	31·2	49·3	53·6	45·3	41·0	43·2	43·1	47·7	48·7		
Wt. of container ..... g	9·0	5·5	9·4	8·6	9·6	8·5	9·4	9·3	9·4	8·6		
Wt. of dry soil (W_d) ..... g	25·5	31·7	39·9	45·0	35·7	38·5	33·8	33·8	38·3	41·1		
Wt. of moisture (W_m) ..... g	0·4	0·6	1·7	1·4	2·8	3·0	4·1	4·0	6·4	6·7		
Moisture content 100 W_m/W_d ..... %	1·57	1·89	4·26	4·22	7·84	7·79	12·13	11·83	16·71	16·30		
Average moisture content (m) ..... %	1·73		4·24		7·82		11·98		16·51			
Dry density $\gamma_d = 100\gamma/100+m$ ..... kN/cu m	17·99		18·98		20·09		19·07		15·36			
C.B.R. (mean of top and bottom) ..... %												



Data Sheet 6

DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL USING STANDARD*/HEAVY* COMPACTION

Job M. Sc ..... Sample 6% Cement ..... Operator A.J.HEGBY .....

Site ..... Depth ..... m ..... Date .....

Amount retained on 3/4" B.S. Sieve ..... g ..... Total weight of sample ..... g .....

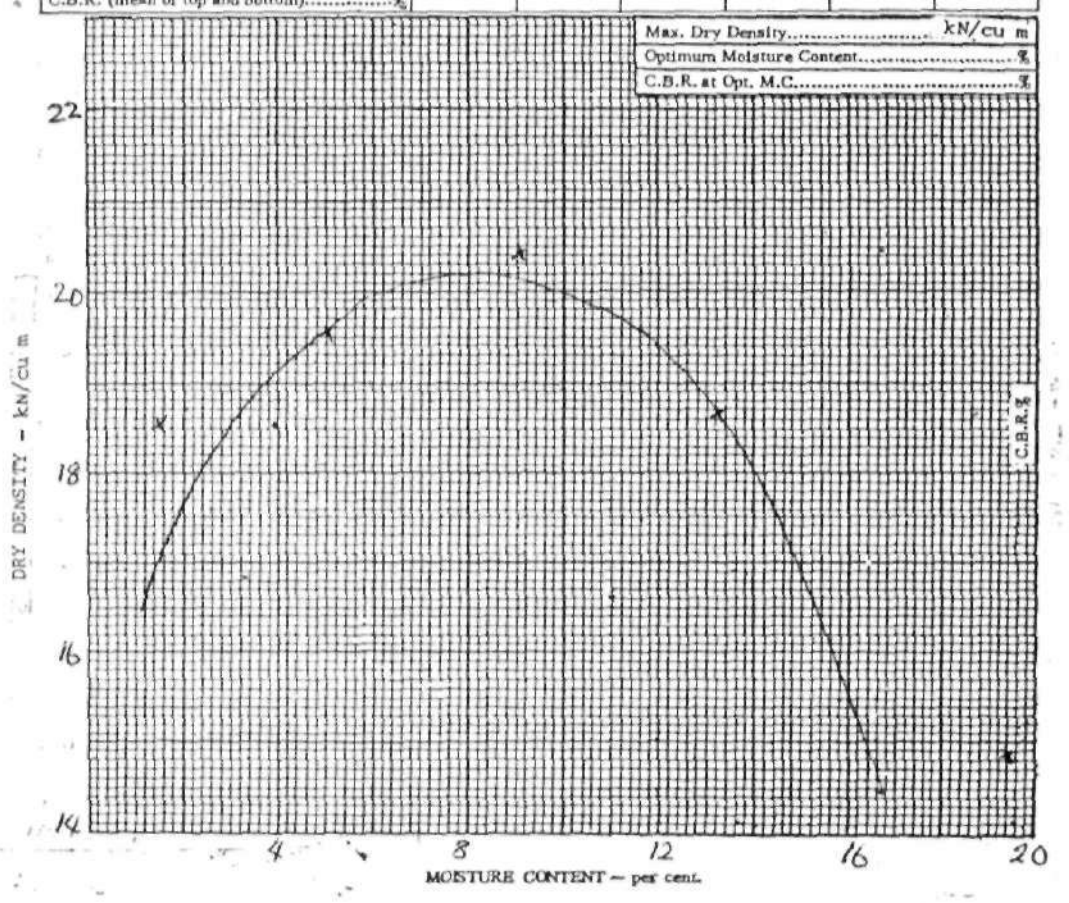
B.S.*/C.B.R.* Mould ..... *Delete the inappropriate word

Wt. of mould and wet soil ..... (W_2) ..... g	6335	6506	6680	6565	6225		
Wt. of mould ..... (W_1) ..... g	4430	4430	4430	4430	4430		
Wt. of wet soil ..... ($W_2 - W_1$) ..... g	1905	2075	2250	2135	1795		
Bulk density $\gamma = \frac{W_2 - W_1}{X}$ ..... kN/cu m	18.84	20.52	22.26	21.12	17.75		

For B.S. Mould x = 101.1

MOISTURE CONTENT DETERMINATIONS

Container No.	180	16	38	193	32	15	17	39	71	30		
Wt. of wet soil and container ..... g	36.4	46.8	37.9	44.6	45.8	54.7	56.4	55.6	68.1	49.8		
Wt. of dry soil and container ..... g	36.3	45.8	36.7	42.7	42.8	50.9	50.7	50.3	57.7	43.6		
Wt. of container ..... g	8.3	9.4	9.8	8.3	8.8	9.1	8.7	8.9	8.8	8.4		
Wt. of dry soil (W_d) ..... g	28.0	36.4	26.9	34.4	34.0	41.8	42.0	41.4	48.9	35.2		
Wt. of moisture (W_m) ..... g	0.1	1.0	1.2	1.9	3.0	3.8	5.4	5.6	10.4	6.2		
Moisture content 100 W_m/W_d ..... %	0.36	2.75	4.46	5.52	8.82	9.09	12.86	13.63	21.27	17.61		
Average moisture content (m) ..... %	1.56		4.99		8.96		13.25		19.44			
Dry density $\gamma_d = 100\gamma/100+m$ ..... kN/cu m	18.55		19.54		20.43		18.65		14.86			
C.B.R. (mean of top and bottom) ..... %												



Data Sheet 6

DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL USING STANDARD*/HEAVY* COMPACTION

Job M.Sc Sample 8% - Cement Operator AIUEGBU

Site ..... Depth ..... m Date .....

Amount retained on 3/4" B.S. Sieve ..... g Total weight of sample ..... g

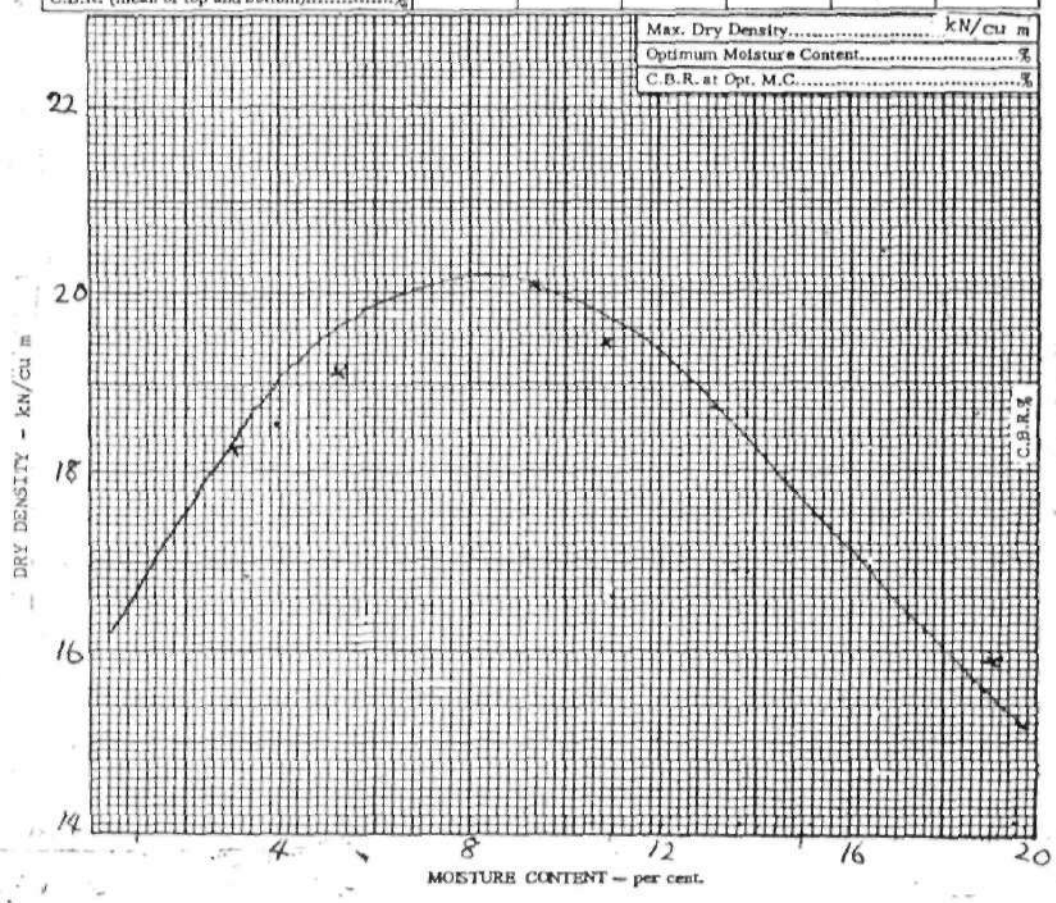
B.S.*/C.B.R.* Mould ..... *Delete the inappropriate word

Wt. of mould and wet soil ..... (W2) ..... g	6330	6465	6650	6610	6345		
Wt. of mould ..... (W1) ..... g	4430	4430	4430	4430	4430		
Wt. of wet soil ..... (W2 - W1) ..... g	1900	2035	2220	2180	1913		
Bulk density $\gamma = \frac{W_2 - W_1}{X}$ ..... kN/cu m	18.79	20.13	21.96	21.56	18.94		

For B.S. Mould x = 101.19

MOISTURE CONTENT DETERMINATIONS

Container No.	71	30	17	39	42	24	168	149	32	15	
Wt. of wet soil and container ..... g	26.2	36.2	43.8	34.9	34.4	41.8	44.5	44.5	59.2	67.4	
Wt. of dry soil and container ..... g	25.7	35.4	42.1	38.3	36.3	39.1	41.0	40.1	51.5	57.7	
Wt. of container ..... g	8.8	8.4	8.7	8.9	4.9	8.5	8.0	8.1	8.8	9.1	
Wt. of dry soil (Ws) ..... g	16.9	27.0	33.4	29.4	31.4	30.6	33.0	32.8	42.7	48.6	
Wt. of moisture (Ww) ..... g	0.5	0.8	1.7	1.6	3.1	2.7	3.5	3.6	7.7	9.7	
Moisture content 100 Ww/Ws ..... %	2.96	2.96	5.09	5.44	9.87	8.82	10.61	10.98	18.03	19.96	
Average moisture content (m) ..... %	2.96		5.27		9.35		10.80		19.00		
Dry density $\gamma_d = 100\gamma/100+m$ ..... kN/cu m	18.25		19.12		20.08		19.46		15.92		
C.B.R. (mean of top and bottom) ..... %											



Date Sheet 6

DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD*/HEAVY* COMPACTION

Job M.Sc Sample 10% - cement Operator ATHEGBU

Site ..... Depth ..... m Date .....

Amount retained on 3/4" B.S. Sieve ..... g ..... Total weight of sample ..... g .....

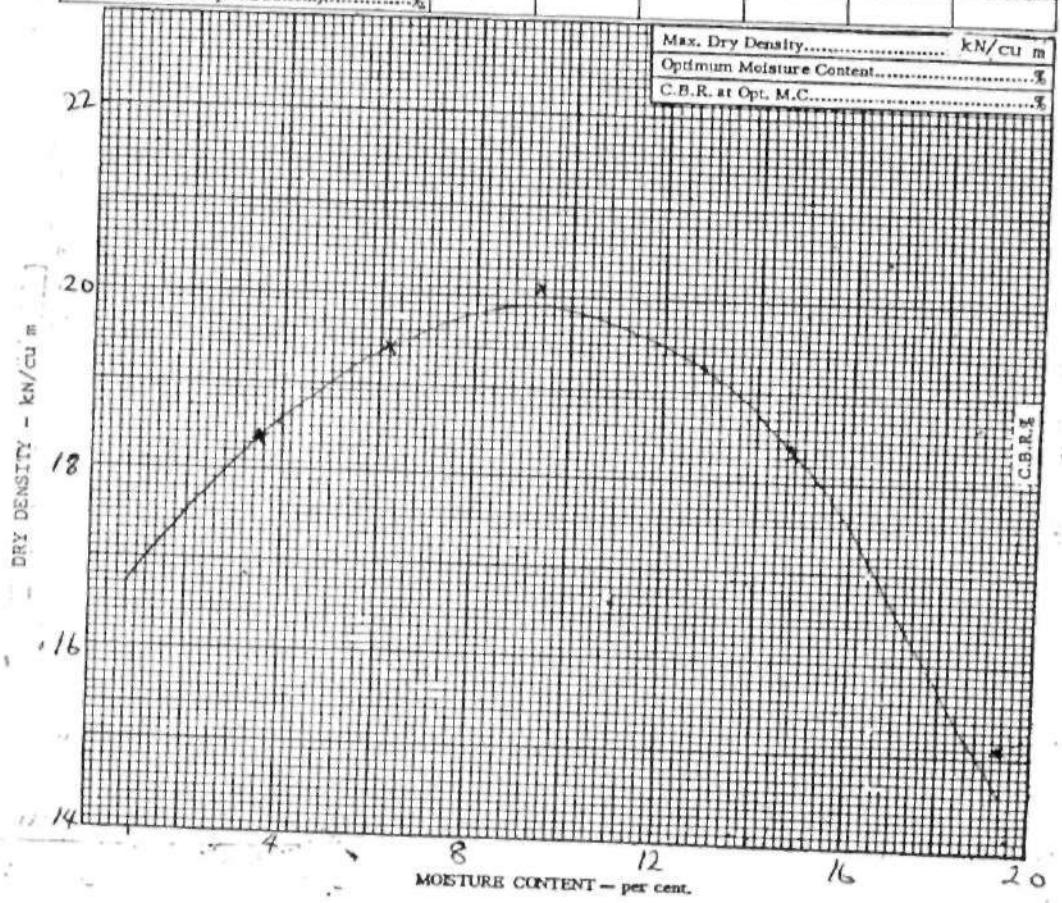
B.S.*/C.B.R.* Mould ..... *Delete the inappropriate word

Wt. of mould and wet soil ..... (W_2) ..... g	6350	6510	6655	6550	6255			
Wt. of mould ..... (W_1) ..... g	4430	4430	4430	4430	4430			
Wt. of wet soil ..... ($W_2 - W_1$) ..... g	1920	2080	2225	2120	1825			
Bulk density $\gamma = \frac{W_2 - W_1}{X}$ ..... kN/cu m	18.99	20.57	22.01	20.97	18.05			

For B.S. Mould x = 101.14.

MOISTURE CONTENT DETERMINATIONS

Container No.	38	193	16	180	40	135	54	158	175	36		
Wt. of wet soil and container ..... g	37.3	40.0	43.3	43.6	44.0	37.7	52.3	50.2	51.2	52.5		
Wt. of dry soil and container ..... g	36.4	38.9	41.3	41.6	41.0	34.9	46.7	44.6	44.1	45.5		
Wt. of container ..... g	9.8	8.3	9.4	8.3	9.0	4.8	8.6	8.1	7.4	8.8		
Wt. of dry soil (W_d) ..... g	26.6	30.6	31.9	33.3	32.0	30.1	38.1	36.7	36.2	36.7		
Wt. of moisture (W_m) ..... g	0.9	1.1	2.0	2.0	3.0	2.8	5.6	5.4	7.1	7.0		
Moisture content 100 W_m/W_d ..... %	3.38	3.59	6.27	6.01	9.38	9.30	14.70	14.71	19.61	19.07		
Average moisture content (m) ..... %	3.49		6.14		9.34		14.70		19.34			
Dry density $\gamma_d = 100\gamma/100+m$ ..... kN/cu m	18.35		19.38		20.13		18.28		15.12			
C.B.R. (mean of top and bottom) ..... %												



Appendix C

CBR Test Results for both Soaked and unsoaked cases for sta ilized soil calibration

CBR Machine's Factor = 0.01286kN/Div.

Data Sheet 7

CBR For Air Cured for 1 day

- 0% Bitumen

Penetration (mm)	Standard load (kN/)	TOP			BOTTOM			
		Load indicator Dial	Load (kN)	CBR (%)	Load indicator Dial	Load (kN)	CBR (%)	Average
0		0	0		0	0		
0.6		40	0.5		55	0.7		
1.3		60	0.8		73	0.9		
1.9		95	1.2		110	1.4		
2.5	13.24	145	1.9	14.1	145	1.9	14.1	
3.8		200	2.6		185	2.4		14.5
5.0	19.96	230	3.0	14.8	205	2.6	13.2	
6.4		300	3.9		225	2.9		
7.6		343	4.4		239	3.1		
8.9		383	4.9		262	3.4		
10.2		427	5.5		269	3.5		
11.4		451	5.8		278	3.6		
12.7		525	6.8		294	3.8		

Data Sheet 7

Air cured for 1 day

- 2% Bitumen

Penetration (mm)	Standard load (kN/)	TOP			BOTTOM			
		Load indicator Dial	Load (kN)	CBR (%)	Load indicator Dial	Load (kN)	CBR (%)	Average
0		0	0		0	0		
0.6		28	0.4		31	0.4		
1.3		45	0.6		39	0.5		
1.9		69	0.9		62	0.8		
2.5	13.24	155	2.0	15.1	99	1.3	9.6	
3.8		195	2.5		132	1.7		12.5
5.0	19.96	238	3.1	15.3	152	2.0	9.8	
6.4		528	3.3		172	2.2		
7.6		295	3.8		195	2.5		
8.9		327	4.2		202	2.6		
10.2		349	4.5		218	2.8		
11.4		372	4.8		230	3.0		
12.7		399	5.1		250	3.2		

Data Sheet 7

Air cured for 1 day

- 4% Bitumen

Penetration (mm)	Standard load (kN/)	TOP			BOTTOM			
		Load indicator Dial	Load (kN)	CBR (%)	Load indicator Dial	Load (kN)	CBR (%)	Average
0		0	0		0	0		
0.6		70	0.9		60	0.8		
1.3		130	1.7		135	1.7		
1.9		200	2.6		220	2.8		
2.5	13.24	300	3.9	29.1	298	3.8	28.9	
3.8		460	5.9		382	4.9		31.3
5.0	19.96	502	6.5	32.3	470	6.0	30.3	
5.4		511	6.6		525	6.8		
7.6		528	6.8		572	7.4		
8.9		542	7.0		607	7.8		
10.2		550	7.1		652	8.4		
11.4		585	7.5		700	9.0		
12.7		600	7.7		740	9.5		

Data Sheet 7

Air cured for 1 day

- 6% Bitumen

Penetration (mm)	Standard load (kN/)	TOP			BOTTOM			Average
		Load indicator Dial	Load (kN)	CBR (%)	Load indicator Dial	Load (kN)	CBR (%)	
0		0	0		0	0		
0.6		20	0.3		30	0.4		
1.3		38	0.5		80	1.0		
1.9		60	0.8		150	1.9		
2.5	13.24	90	1.2	8.7	215	2.8	20.9	
3.8		148	1.9		320	4.1		20.1
5.0	19.96	235	3.0	15.1	390	5.0	25.1	
6.4		298	3.8		440	5.7		
7.6		365	4.7		455	5.9		
8.9		382	4.9		486	6.2		
10.2		370	4.8		510	6.6		
11.4		350	4.5		540	6.9		
12.7		319	4.1		580	7.5		

Data Sheet 7

Air cured for 1 day

8% Bitumen

Penetration (mm)	Standard load (kN/)	TOP			BOTTOM			Average
		Load indicator Dial	Load (kN)	CBR (%)	Load indicator Dial	Load (kN)	CBR (%)	
0		0	0		0	0		
0.6		18	0.2		30	0.4		
1.3		32	0.4		70	0.9		
1.9		52	0.7		120	1.5		
2.5	13.24	170	2.2	16.5	185	2.4	18.9	
3.8		198	2.5		210	2.7		19.0
5.0	19.96	310	4.0	20.0	255	3.3	16.4	
6.4		410	5.3		310	4.0		
7.6		480	6.2		390	5.0		
8.9		490	6.3		420	5.4		
10.2		510	6.6		495	6.4		
11.4		670	8.6		561	7.2		
12.7		710	9.1		612	7.9		

Data Sheet 7

Air cured for 1 day

10% Bitumen

Penetration (mm)	Standard load (kN/)	TOP			BOTTOM			
		Load indicator Dial	Load (kN)	CBR (%)	Load indicator Dial	Load (kN)	CBR (%)	Average
0		0	0		0	0		
0.6		7	0.1		5	0.1		
1.3		12	0.2		9	0.1		
1.9		18	0.2		15	0.2		
2.5	13.24	25	0.3	2.4	21	0.3	2.0	
3.8		42	0.5		38	0.5		3.5
5.0	19.96	64	0.8	4.1	45	0.6	2.9	
5.4		87	1.1		55	0.7		
7.6		109	1.4		62	0.8		
8.9		120	1.5		66	0.8		
10.2		128	1.6		73	0.9		
11.4		125	1.6		79	1.0		
12.7		118	1.5		90	1.2		

Data Sheet 7

CBR; Air cured for 7 days

- 0% Bitumen

Penetration (mm)	Standard load (kN/)	TOP			BOTTOM			Average
		Load indicator Dial	Load (kN)	CBR (%)	Load indicator Dial	Load (kN)	CBR (%)	
0		0	0		0	0		
0.6		97	1.2		125	1.6		
1.3		192	2.5		194	2.5		
1.9		225	2.9		218	2.8		
2.5	13.24	427	5.5	41.5	330	4.2	32.1	
3.8		665	8.5		458	5.9		47.1
5.0	19.96	836	10.8	53.9	625	8.0	40.3	
6.4		1033	13.3		775	10.0		
7.6		1250	16.1		945	12.2		
8.9		1348	17.3		1135	14.6		
10.2		1405	18.1		1290	16.6		
11.4		1550	19.9		1425	18.3		
12.7		1670	21.5		1572	20.2		

Data Sheet 7

Air cured for 7 days

- 2% Bitumen

Penetration (mm)	Standard load (kN/)	TOP			BOTTOM			Average
		Load indicator Dial	Load (kN)	CBR (%)	Load indicator Dial	Load (kN)	CBR (%)	
0		0	0		0	0		
0.6		95	1.2		83	1.1		
1.3		218	2.8		125	1.6		
1.9		335	4.3		198	2.5		
2.5	13.24	488	6.3	47.4	368	4.7	35.7	
3.8		625	8.0		554	7.1		48.3
5.0	19.96	775	10.0	49.9	725	9.3	46.7	
6.4		899	11.6		895	11.5		
7.6		1032	13.3		1034	13.5		
8.9		1155	14.9		1145	14.7		
10.2		1342	17.3		1237	15.9		
11.4		1397	18.0		1285	16.5		
12.7		1455	18.7		1345	17.3		

Data Sheet 7

Air cured for 7 days

- 4% Bitumen

Penetration (mm)	Standard load (kN/)	TOP			BOTTOM			Average
		Load indicator Dial	Load (kN)	CBR (%)	Load indicator Dial	Load (kN)	CBR (%)	
0		0	0		0	0		
0.6		127	1.6		107	1.4		
1.3		185	2.4		165	2.1		
1.9		375	4.8		297	3.8		
2.5	13.24	643	8,3	62.5	585	7.5	56.8	
3.8		845	10.9		770	9.9		82.6
5.0	19.96	1285	16.5	82.8	1280	16.5	82.5	
6.4		1343	17.3		1275			
7.6		1405	18.1		1305			
8.9		1497	19.3		1385			
10.2		1550	19.9		1465			
11.4		1675	21.5					
12.7		1897	24.4					

Data Sheet 7

Air cured for 7 days

- 6% Bitumen

Penetration (mm)	Standard load (kN/)	TOP			BOTTOM			Average
		Load indicator Dial	Load (kN)	CBR (%)	Load indicator Dial	Load (kN)	CBR (%)	
0		0	0		0	0		
0.6		20	0.3		55	0.7		
1.3		45	0.6		120	1.5		
1.9		80	1.0		290	3.7		
2.5	13.24	435	5.6	42.3	370	4.8	35.9	
3.8		560	7.2		470	6.0		44.0
5.0	19.96	690	8.9	44.5	675	8.7	43.5	
5.4		1000	12.9		860	11.1		
7.6		1280	16,5		1035	13.3		
8.9		1373	17.7		1205	15.5		
10.2					1355	17.4		
11.4					1490	19.2		
12.7					1630	21.0		

Data Sheet 7

Air cured for 7 days

- 8% Bitumen

Penetration (mm)	Standard load (kN/)	TOP			BOTTOM			
		Load indicator Dial	Load (kN)	CBR (%)	Load indicator Dial	Load (kN)	CBR (%)	Average
0		0	0		0	0		
0.6		20	0.3		55	0.7		
1.3		35	0.5		90	1.2		
1.9		89	1.1		145	1.9		
2.5	13.24	190	2.4	18.5	195	2.5	18.9	
3.8		235	3.0		300	3.9		27.3
5.0	19.96	398	5.1	25.6	450	5.8	29.0	
5.4		590	7.6		500	6.4		
7.6		724	9.3		675	8.7		
8.9		950	12.2		730	9.4		
10.2		1090	14.0		790	10.2		
11.4		1150	14.8		840	10.8		
12.7		1260	16.2		950	12.2		

Data Sheet 7

Air cured for 7 days

- 10% Bitumen

Penetration (mm)	Standard load (kN/)	TOP			BOTTOM			
		Load indicator Dial	Load (kN)	CBR (%)	Load indicator Dial	Load (kN)	CBR (%)	Average
0		0	0		0	0		
0.6		18	0.2		30	0.4		
1.3		32	0.4		70	0.9		
1.9		53	0.7		120	1.5		
2.5	13.24	90	1.2	8.7	155	2.0	15.1	
3.8		198	2.5		190	2.4		18.2
5.0	19.96	310	4.0	20.0	254	3.3	16.4	
6.4		410	5.3		320	4.1		
7.6		480	6.2		440	5.7		
8.9		450	5.8		540	6.9		
10.2		410	5.3		675	8.7		
11.4		310	4.0		764	9.8		
12.7		290	3.7		898	11.5		

Data Sheet 7

CBR Soaked for 7 days

- 0% Bitumen

Penetration (mm)	Standard load (kN/)	TOP			BOTTOM			
		Load indicator Dial	Load (kN)	CBR (%)	Load indicator Dial	Load (kN)	CBR (%)	Average
0		0	0		0	0		
0.6		36	0.5		3.0	0.4		
1.3		49	0.6		47	0.6		
1.9		66	0.8		69	0.9		
2.5	13.24	80	1.0	7.8	100	1.3	9.7	
3.8		86	1.1		110	1.4		8.75
5.0	19.96	105	1.4	6.8	125	1.6	8.1	
6.4		117	1.5		140	1.8		
7.6		130	1.7		134	2.0		
8.9		145	1.9		167	2.1		
10.2		156	2.0		178	2.3		
11.4		165	2.1		185	2.4		
12.7		179	2.3		195	2.5		

Data Sheet 7

Soaked for 7 days

- 4% Bitumen

Penetration (mm)	Standard load (kN/)	TOP			BOTTOM			Average
		Load indicator Dial	Load (kN)	CBR (%)	Load indicator Dial	Load (kN)	CBR (%)	
0		0	0		0	0		
0.6		5	0.1		40	0.5		
1.3		15	0.2		75	1.0		
1.9		20	0.3		105	1.4		
2.5	13.24	95	0.7	5.3	142	1.8	13.8	
3.8		97	1.2		212	2.7		14.4
5.0	19.96	185	2.4	11.9	262	3.4	10.9	
5.4		205	2.6		285	3.7		
7.6		240	3.1		310	4.0		
8.9		315	4.1		365	4.7		
10.2		365	4.7		415	5.3		
11.4		395	5.1		460	5.9		
12.7		440	5.7		520	6.7		

Data Sheet 7

Soaked for 7 days

- 2% Bitumen

Penetration (mm)	Standard load (kN/)	TOP			BOTTOM			Average
		Load indicator Dial	Load (kN)	CBR (%)	Load indicator Dial	Load (kN)	CBR (%)	
0		0	0		0	0		
0.6		28	0.4		27	0.3		
1.3		42	0.5		38	0.5		
1.9		65	0.8		67	0.9		
2.5	13.24	97	1.2	9.4	101	1.3	9.8	
3.8		108	1.4		121	1.6		9.6
5.0	19.96	128	1.6	8.2	135	1.7	8.7	
5.4		135	1.7		140	1.8		
7.6		159	2.0		152	2.0		
8.9		162	2.1		167	2.1		
10.2		192	2.5		179	2.3		
11.4		209	2.7		192	2.5		
12.7		217	2.8		208	2.6		

Data Sheet 7

Soaked for 7 days

- 6% Bitumen

Penetration (mm)	Standard load (kN/)	TOP			BOTTOM			
		Load indicator Dial	Load (kN)	CBR (%)	Load indicator Dial	Load (kN)	CBR (%)	Average
0		0	0		0	0		
0.6		8	0.1		17	0.2		
1.3		15	0.2		40	0.5		
1.9		32	0.4		60	0.8		
2.5	13.24	54	0.7	5.2	83	1.1	8.1	
3.8		82	1.1		135	1.7		9.6
5.0	19.96	102	1.3	6.6	195	2.5	12.6	
5.4		245	3.2		260	3.3		
7.6		305	3.9		350	4.5		
8.9		375	4.8		410	5.3		
10.2		425	5.5		495	6.4		
11.4		467	6.0		575	7.4		
12.7		509	6.5		655	8,4		

Data Sheet 7

Soaked for 7 days

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- 8% Bitumen

Penetration (mm)	Standard load (kN/)	TOP			BOTTOM			Average
		Load indicator Dial	Load (kN)	CBR (%)	Load indicator Dial	Load (kN)	CBR (%)	
0		0	0		0	0		
0.6		10	0.1		7	0.1		
1.3		32	0.4		25	0.3		
1.9		51	0.7		45	0.6		
2.5	13.24	75	.0	7.3	66	0.8	6.4	
3.8		83	1.1		72	0.9		8.8
5.0	19.96	115	1.5	11.2	97	1.2	6.2	
5.4		150	1.9		108	1.4		
7.6		185	2.4		130	1.7		
8.9		220	2.8		140	1.8		
10.2		253	3.3		157	2.0		
11.4		295	3.8		195	2.5		
12.7		317	4.1		210	2.7		

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Data Sheet 7

Soaked for 7 days

- 10% Bitumen

Penetration (mm)	Standard load (kN/)	TOP			BOTTOM			Average
		Load indicator Dial	Load (kN)	CBR (%)	Load indicator Dial	Load (kN)	CBR (%)	
0		0	0		0	0		
0.6		12	0.2		5	0.1		
1.3		32	0.4		10	0.1		
1.9		43	0.6		27	0.3		
2.5	13.24	55	0.7	5.3	42	0.5	4.1	
3.8		68	0.9		54	0.7		5.1
5.0	19.96	94	1.2	6.1	62	0.8	4.0	
6.4		117	1.5		68	0.9		
7.6		128	1.6		76	1.0		
8.9		142	1.8		85	1.1		
10.2		156	2.0		98	1.3		
11.4		179	2.3		120	1.5		
12.7		201	2.6		132	1.7		

Data Sheet 7

1 day air cured

- 2% Lime

Penetration (mm)	Standard load (kN/)	TOP			BOTTOM			Average
		Load indicator Dial	Load (kN)	CBR (%)	Load indicator Dial	Load (kN)	CBR (%)	
0		0	0		0	0		
0.6		75	1.0		190	2.4		
1.3		160	2.1		380	4.9		
1.9		270	3.5		430	5.5		
2.5	13.24	410	5.3	40	600	7.7	58	
3.8		705	9.1		830	10.7		65
5.0	19.96	1080	13.9	70	920	11.8	59	
6.4		1480	19.0		1140	14.7		
7.6		1795	23.1		1220	15.7		
8.9		1817	23.4		1440	18.5		
10.2		1920	24.7		1630	21.0		
11.4		2110	27.1		1820	23.4		
12.7		2230	28.7		2090	26.9		

Data Sheet 7

Air cured for 1 day

- 4% Lime

Penetration (mm)	Standard load (kN/)	TOP			BOTTOM			
		Load indicator Dial	Load (kN)	CBR (%)	Load indicator Dial	Load (kN)	CBR (%)	Average
0		0	0		0	0		
0.6		205	2.6		240	3.1		
1.3		302	3.9		430	5.5		
1.9		420	5.4		570	7.3		
2.5	13.24	720	9.3	70	740	9.5	72	
3.8		910	11.7		1040	13.40		83
5.0	19.96	1230	15.0	79	1335	17.2	86	
6.4	~~1450~~	1450	18.6		1613	20.7		
7.6		1730	22.2		1777	22.9		
8.9		1940	24.9		1832	23.6		
10.2		2210	28.4		1923	24.7		
11.4		2390	30.7		2130	27.4		
12.7		2450	31.5		2310	29.7		

Data Sheet 7

1 day air cured

6% Lime

Penetration (mm)	Standard load (kN/)	TOP			BOTTOM			
		Load indicator Dial	Load (kN)	CBR (%)	Load indicator Dial	Load (kN)	CBR (%)	Average
0		0	0		0	0		
0.6		60	0.8		190	2.4		
1.3		98	1.3		350	4.5		
1.9		140	1.8		420	5.4		
2.5		180	2.3	18	500	6.4	49	
3.8		310	4.0		700	9.0		44
5.0		470	6.0	30	895	11.5	58	
6.4		600	7.7		1000	12.9		
7.6		810	10.4		1120	14.4		
8.9		990	12.7		1280	16.5		
10.2		1180	15.2		1340	17.2		
11.4		1410	18.1		1530	19.7		
12.7		1630	21.0		1670	21.5		

Data Sheet 7

Air cured for 1 day

8% Lime

Penetration (mm)	Standard load (kN/)	TOP			BOTTOM			Average
		Load indicator Dial	Load (kN)	CBR (%)	Load indicator Dial	Load (kN)	CBR (%)	
0								
0.6		0	0		0	0		
1.3		100	1.3		70	0.9		
1.9		180	2.3		260	3.3		
2.5		270	3.5		350	4.5		
3.8	13.24	450	5.8	44	475	6.1	46	
5.0		630	8.1		600	7.7		56
5.4	19.96	890	11.4	57	840	10.8	54	
7.6		1001	12.9		970	12.5		
8.9		1190	15.3		1145	14.7		
10.2		1585	20.4		1570	20.2		
11.4		1730	22.2		1710	22.0		
12.7		1831	23.5		1903	24.5		

Data Sheet 7

Air cured for 1 day

10% Lime

Penetration (mm)	Standard load (kN/)	TOP			BOTTOM			Average
		Load indicator Dial	Load (kN)	CBR (%)	Load indicator Dial	Load (kN)	CBR (%)	
0		0	0		0	0		
0.6		270	3.5		290	3.7		
1.3		500	6.4		420	5.4		
1.9		800	10.3		560	7.2		
2.5	13.24	1000	12.9	97	810	10.4	79	
3.8		1375	17.7		980	12.6		93
5.0	19.96	1663	21.4	107	1190	15.3	77	
5.4		1910	24.6		1370	17.6		
7.6		2090	26.9		1495	19.2		
8.9		2130	27.4		1644	21.1		
10.2		2310	29.7		1752	22.5		
11.4		2430	31.2		1850	23.8		
12.7		2541	32.7		1975	25.4		

Data Sheet 7

7 days air cured (unsoaked)

2% Lime

Penetration (mm)	Standard load (kN/)	TOP			BOTTOM			Average
		Load indicator Dial	Load (kN)	CBR (%)	Load indicator Dial	Load (kN)	CBR (%)	
0		0	0		0	0		
0.6		90	1.2		220	2.8		
1.3		180	2.3		420	5.4		
1.9		390	5.0		590	7.6		
2.5	13.24	500	6.4	48.6	740	7.5	71.9	
3.8		770	9.9		1160	14.9		75.7
5.0	19.96	950	12.2	61.2	1400	18.0	90.2	
6.4		1110	14.3		1600	20.6		
7.6		1300	16.7		1800	23.1		
8.9		1700	21.9		1950	25.1		
10.2		1960	25.2		2050	26.5		
11.4		2100	27.0		2160	27.8		
12.7		2200	28.0		2270	29.2		

Data Sheet 7

7 days air cured (unsoaked)

4% Lime

Penetration (mm)	Standard load (kN/)	TOP			BOTTOM			Average
		Load indicator Dial	Load (kN)	CBR (%)	Load indicator Dial	Load (kN)	CBR (%)	
0		0	0		0	0		
0.6		470	6.0		580	7.5		
1.3		800	10.3		880	11.3		
1.9		910	11.7		1100	14.1		
2.5	13.24	1140	14.7	110.7	1370	17.6	133.1	
3.8		1250	16.1		1530	19.7		121.9
5.0	19.96	1400	18.0	90.2	1820	23.4	117.3	
6.4		1670	21.5		1980	25.5		
7.6					2020	26.0		
8.9					2080	26.7		
10.2								
11.4								
12.7								

Data Sheet 7

7 days air cured (unsoaked)

6% Lime

Penetration (mm)	Standard load (kN/)	TOP			BOTTOM			Average
		Load indicator Dial	Load (kN)	CBR (%)	Load indicator Dial	Load (kN)	CBR (%)	
0		0	0		0	0		
0.6		220	2.8		550	7.1		
1.3		650	8.4		1150	14.8		
1.9		1100	14.1		1530	19.7		
2.5	13.24	1400	18.0	136	17.20	22.1	167.9	
3.8		1900	24.7		1970	25.3		152
5.0	19.96	2110	25.8	129	2010	25.8	129	
6.4					2130	27.4		
7.6					2138	27.5		
8.9					2140	27.5		
10.2					2142	275		
11.4								
12.7								

Data Sheet 7

Air cured for 7 days

8% Lime

Penetration (mm)	Standard load (kN/)	TOP			BOTTOM			Average
		Load indicator Dial	Load (kN)	CBR (%)	Load indicator Dial	Load (kN)	CBR (%)	
0		0	0		0	0		
0.6		210	2.7		427	5.5		
1.3		460	5.9		787	10.12		
1.9		910	11.7		1067	13.72		
2.5	13.24	1260	16.2	122	1184	15.2	115	
3.8		1330	17.1		1272	16.4		119
5.0	19.96	1395	17.1	90	1398	19.0	90	
6.4		1403	18.1		1452	18.7		
7.6		1415	18.2					
8.9								
10.2								
11.4								
12.7								

Data Sheet 7

Air cured for 7 days

10% Lime

Penetration (mm)	Standard load (kN/)	TOP			BOTTOM			
		Load indicator Dial	Load (kN)	CBR (%)	Load indicator Dial	Load (kN)	CBR (%)	Average
0		0	0		0	0		
0.6		370	4.8		95	1.2		
1.3		760	9.8		150	1.9		
1.9		900	11.6		300	3.9		
2.5	13.24	1300	16.7	126	500	6.4	48.0	
3.8		1600	20.6		770	10.2		100
5.0	19.96	1730	22.2	111	1150	14.8	74.0	
6.4		1920	24.7		1350	17.4		
7.6		2100	27.0		1500	19.3		
8.9					1810	23.3		
10.2					2090	26.9		
11.4					2210	28.4		
12.7					2310	29.7		

Data Sheet 7

7 days Soaked

2% Lime

Penetration (mm)	Standard load (kN/)	TOP			BOTTOM			Average
		Load indicator Dial	Load (kN)	CBR (%)	Load indicator Dial	Load (kN)	CBR (%)	
0	0	0	0		0	0		
0.6		60	0.8		140	1.8		
1.3		118	1.5		242	3.1		
1.9		190	2.4		325	4.2		
2.5	13.24	280	3.6	27.2	390	5.0	37.8	
3.8		490	6.3		510	6.6		43.3
5.0	19.96	725	9.3	46.6	625	8.0	40.1	
6.4		945	12.2		700	9.0		
7.6		1030	13.2		782	10.1		
8.9		1175	15.1		875	11.3		
10.2		1400	18.0		950	12.2		
11.4		1541	19.8		1017	13.1		
12.7		1630	21.0		1069	13.7		

Data Sheet 7

7 days Soaked

4% Lime

Penetration (mm)	Standard load (kN/)	TOP			BOTTOM			Average
		Load indicator Dial	Load (kN)	CBR (%)	Load indicator Dial	Load (kN)	CBR (%)	
0		0	0		0	0		
0.6		68	0.9		180	2.3		
1.3		160	2.1		300	3.9		
1.9		290	3.7		325	4.2		
2.5	13.24	444	5.7	43.1	480	6.2	46.8	
3.8		732	9.4		600	7.7		52.7
5.0	19.96	912	11.7	58.6	700	9.0	45.1	
5.4		1081	13.9		780	10.0		
7.6		1081	13.9		870	11.2		
8.9		1081	13.9		950	12.2		
10.2		1068	13.7		1020	13.1		
11.4					1084	13.9		
12.7					1071	14.0		

Data Sheet 7

7 days soaked

6% Lime

Penetration (mm)	Standard load (kN/)	TOP			BOTTOM			Average
		Load indicator Dial	Load (kN)	CBR (%)	Load indicator Dial	Load (kN)	CBR (%)	
0		0	0		0	0		
0.6		30	0.4		50	0.6		
1.3		55	0.7		145	1.7		
1.9		83	1.1		240	3.1		
2.5	13.24	120	1.5	11.3	350	4.5	34.0	
3.8		225	2.9		582	7.5		37.8
5.0	19.96	370	4.8	24.0	800	10.3	51.6	
6.4		450	5.8		970	12.5		
7.6		718	9.2		1140	14.7		
8.9		920	11.8		1300	16.7		
10.2		1060	13.6		1580	20.3		
11.4		1170	15.0		1630	21.0		
12.7		1290	16.6		1740	22.4		

Data Sheet 7

7 days Soaked

8% Lime

Penetration (mm)	Standard load (kN/)	TOP			BOTTOM			Average
		Load indicator Dial	Load (kN)	CBR (%)	Load indicator Dial	Load (kN)	CBR (%)	
0		0	0		0	0		
0.6		24	0.3		40	0.5		
1.3		54	0.7		100	1.3		
1.9		100	1.3		190	2.4		
2.5	13.24	160	2.1	15.9	290	3.7	27.9	
3.8		220	2.8		480	6.2		36.1
5.0	19.96	470	6.0	30.1	655	8.4	42.1	
6.4		640	8.2		820	10.5		
7.6		780	10.0		1008	13.0		
8.9		900	11.6		1155	14.9		
10.2		1020	13.1		1308	16.8		
11.4		1100	14.1		1450	18.6		
12.7		1130	14.5		1545	19.9		

Data Sheet 7

Air cured for 7 days

10% Lime

Penetration (mm)	Standard load (kN/)	TOP			BOTTOM			Average
		Load indicator Dial	Load (kN)	CBR (%)	Load indicator Dial	Load (kN)	CBR (%)	
0		0	0		0	0		
0.6		16	0.2		52	0.7		
1.3		34	0.4		110	1.4		
1.9		55	0.7		190	2.4		
2.5	13.24	86	1.1	8.3	260	3.3	24.9	
3.8		180	2.3		408	5.2		26.8
5.0	19.96	300	3.9	19.5	528	6.8	34.1	
6.4		470	6.0		625	8.0		
7.6		650	8.4		718	9.2		
8.9		830	10.7		818	10.5		
10.2		993	12.8		902	11.6		
11.4		1180	15.2		970	12.5		
12.7		1350	17.4		1050	13.5		

Data Sheet 7

Air cured for 1 day

2% Cement

Penetration (mm)	Standard load (kN/)	TOP			BOTTOM			Average
		Load indicator Dial	Load (kN)	CBR (%)	Load indicator Dial	Load (kN)	CBR (%)	
0		0	0		0	0		
0.6		15	0.2		28	0.4		
1.3		38	0.5		52	0.7		
1.9		72	0.9		68	0.9		
2.5		110	1.4	11	87	1.1	9	
3.8		200	2.6		230	3.0		20
5.0	19.96	300	3.9	19	325	4.2	21	
6.4		440	5.7		385	5.0		
7.6		530	6.8		432	5.6		
8.9		580	7.5		483	6.2		
10.2		630	8.1		520	6.7		
11.4		675	8.7		553	7.1		
12.7		708	9.1		575	7.4		

Data Sheet 7

Air cured for 1 day

4% Cement

Penetration (mm)	Standard load (kN/)	TOP			BOTTOM			Average
		Load indicator Dial	Load (kN)	CBR (%)	Load indicator Dial	Load (kN)	CBR (%)	
0		0	0		0	0		
0.6		48	0.6		75	1.0		
1.3		128	1.6		150	1.9		
1.9		200	2.6		192	2.5		
2.5	13.24	250	3.2	24	230	2.8	21	
3.8		338	4.3		280	3.6		23
5.0	19.96	390	5.0	25	330	4.2	21	
5.4		430	5.5		365	4.7		
7.6		480	6.2		402	5.2		
8.9		520	6.7		435	5.6		
10.2		550	7.1		460	5.9		
11.4		580	7.5		490	6.3		
12.7		602	7.1		515	6.6		

Data Sheet 7

Air cured for 1 day

6% Cement

Penetration (mm)	Standard load (kN/)	TOP			BOTTOM			Average
		Load indicator Dial	Load (kN)	CBR (%)	Load indicator Dial	Load (kN)	CBR (%)	
0		0	0		0	0		
0.6		45	0.6		80	1.0		
1.3		105	1.4		115	1.5		
1.9		145	1.9		180	2.3		
2.5	13.24	210	2.7	20	220	2.8	21	
3.8		270	3.5		290	3.7		22
5.0	19.96	325	4.2	21	335	4.3	22	
5.4		395	5.1		480	6.2		
7.6		485	6.2		540	6.9		
8.9		520	6.7		680	8.7		
10.2		715	9.2		755	9.7		
11.4		955	12.3		935	12.0		
12.7		1010	13.0		1020	13.1		

Data Sheet 7

Air cured for 1 day

8% Cement

Penetration (mm)	Standard load (kN/)	TOP			BOTTOM			Average
		Load indicator Dial	Load (kN)	CBR (%)	Load indicator Dial	Load (kN)	CBR (%)	
0		0	0		0	0		
0.6		70	0.9		75	1.0		
1.3		120	1.5		95	1.2		
1.9		170	2.2		115	1.5		
2.5	13.24	215	2.8	21	139	1.8	14	
3.8		280	3.6		170	2.2		18
5.0	19.90	340	4.4	22	200	2.6	13	
5.4		387	5.0		225	2.9		
7.6		430	5.5		254	3.3		
8.9		460	5.9		275	3.5		
10.2		490	6.3		300	3.9		
11.4		510	6.6		330	4.2		
12.7		540	6.9		350	4.5		

Data Sheet 7

Air cured for 1 day

10% Cement

Penetration (mm)	Standard load (kN/)	TOP			BOTTOH			Average
		Load indicator Dial	Load (kN)	CBR (%)	Load indicator Dial	Load (kN)	CBR (%)	
0		0	0		0	0		
0.6		110	1.4		81	1.0		
1.3		180	2.3		110	1.4		
1.9		200	2.6		230	3.0		
2.5	13.24	215	2.8	21	250	3.2	24	
3.8		270	3.5		280	3.6		23
5.0	19.96	320	4.1	21	330	4.2	21	
6.4		380	4.9		380	4.9		
7.6		420	5.4		420	5.4		
8.9		460	5.9		460	5.9		
10.2		525	6.8		525	6.8		
11.4		580	7.5		580	7.5		
12.7		630	8.1		630	8.1		

Data Sheet 7

Air Cured for 7 days

- 2% Cement

Penetration (mm)	Standard load (kN/)	TOP			BOTTOM			Average
		Load indicator Dial	Load (kN)	CBR (%)	Load indicator Dial	Load (kN)	CBR (%)	
0		0	0		0	0		
0.6		95	1.2		390	5.0		
1.3		153	2.0		492	6.3		
1.9		225	2.9		575	7.5		
2.5	13.24	315	4.1	31	640	8.2	62	
3.8		525	6.8		760	9.8		56
5.0	19.96	760	9.8	49	875	11.3	56	
5.4		980	12.6		950	12.2		
7.6		1065	13.7		1032	13.3		
8.9		1210	15.6		1125	14.5		
10.2		1435	18.5		1200	15.4		
11.4		1575	20.3		1260	16.2		
12.7		1664	21.4		1310	16.8		

Data Sheet 7

Air cured for 7 days

- 4% Cement

Penetration (mm)	Standard load (kN/)	TOP			BOTTOM			Average
		Load indicator Dial	Load (kN)	CBR (%)	Load indicator Dial	Load (kN)	CBR (%)	
0		0	0		0	0		
0.6		178	2.3		310	4.0		
1.3		278	3.6		630	5.5		
1.9		408	5.2		455	5.9		
2.5	13.24	562	7.2	55	610	7.8	59	
3.8		850	10.9		730	9.4		63
5.0	19.96	1030	13.2	66	830	10.7	54	
5.4		1199	15.4		910	11.7		
7.6		1260	16.2		1000	12.9		
8.9					1080	13.9		
10.2					1150	14.8		
11.4					1214	15.6		
12.7					1227	15.8		

Data Sheet 7

Air cured for 7 days

- 6% Cement

Penetration (mm)	Standard load (kN/)	TOP			BOTTOM			Average
		Load indicator Dial	Load (kN)	CBR (%)	Load indicator Dial	Load (kN)	CBR (%)	
0		0	0		0	0		
0.6		795	10.2		460	5.9		
1.3		820	10.5		555	7.1		
1.9		848	10.9		650	8.4		
2.5	13.24	885	11.4	86	760	9.8	74	
3.8		990	12.7		992	12.8		82
5.0	19.96	1115	14.3	72	1210	15.6	78	
6.4		1195	15.4		1380	17.7		
7.6		1463	18.8		1550	19.9		
8.9		1665	21.4		1710	22.0		
10.2		1805	23.3		1990	25.6		
11.4		1915	24.6		2040	26.2		
12.7		2035	26.2		2150	27.6		

Data Sheet 7

Air cured for 7 days

- 8% Cement unsoaked

Penetration (mm)	Standard load (kN/)	TOP			BOTTOH			Average
		Load indicator Dial	Load (kN)	CBR (%)	Load indicator Dial	Load (kN)	CBR (%)	
0		0	0		0	0		
0.6		120	1.5		220	2.8		
1.3		410	5.3		925	11.9		
1.9		740	9.5		1315	16.9		
2.5	13.24	1020	13.1	99	1415	18.2	137	
3.8		1430	18.4		1605	20.6		124
5.0	19.96	1710	22.0	110	1780	22.9	115	
6.4		1835	23.6		1820	23.4		
7.6		1840	23.7		1940	24.9		
8.9		1845	23.7		2090	26.9		
10.2					2192	28.2		
11.4					2220	28.5		
12.7								

Data Sheet 7

Air cured for 7 days

- 10% Cement

Penetration (mm)	Standard load (kN/)	TOP			BOTTOM			Average
		Load indicator Dial	Load (kN)	CBR (%)	Load indicator Dial	Load (kN)	CBR (%)	
0		0	0		0	0		
0.6		245	3.2		535	6.9		
1.3		480	6.2		735	9.5		
1.9		795	10.2		905	11.6		
2.5	13.24	913	11.7	89	1055	13.6	103	
3.8		1020	13.1		1175	15.1		96
5.0	19.96	1170	15.0	75	1415	18.2	91	
6.4		1440	18.5		1575	20.3		
7.6		1525	19.6		1625	20.9		
8.9		1640	21.1		1705	21.9		
10.2		1705	21.9		1790	23.0		
11.4		1795	23.1		1850	23.8		
12.7		1825	23.5		1940	24.9		

Data Sheet 7

7 days soaked

2% Cement

Penetration (mm)	Standard load (kN/)	TOP			BOTTOM			Average
		Load indicator Dial	Load (kN)	CBR (%)	Load indicator Dial	Load (kN)	CBR (%)	
0		0	0		0	0		
0.6		150	1.9		355	4.6		
1.3		320	4.1		880	11.3		
1.9		500	6.4		1072	13.8		
2.5	13.24	830	10.7	81	1265	16.3	123	
3.8		940	12.1		1385	17.8		102
5.0	19.96	1090	14.0	70	1455	18.7	94	
6.4		1360	17.5		1520	19.5		
7.6		1450	18.6		1590	20.4		
8.9		1502	19.3		1645	21.2		
10.2		1585	20.4		1720	22.1		
11.4		1645	21.2		1870	24.0		
12.7		1725	22.2		1990	25.6		

Data Sheet 7

7 days soaked

4% Cement

Penetration (mm)	Standard load (kN/)	TOP Load indicator Dial	TOP Load (kN)	TOP CBR (%)	BOTTOM Load indicator Dial	BOTTOM Load (kN)	BOTTOM CBR (%)	Average
0		0	0		0	0		
0.6		550	7.1		1055	13.6		
1.3		1085	14.0		1295	16.7		
1.9		1100	14.1		1820	23.4		
2.5	13.24	1305	16.8	127	2040	26.2	198	
3.8		1465	18.8		2185	28.1		163
5.0	19.96	1755	22.6	113	2225	28.6	143	
6.4		1825	23.5		2340	30.1		
7.6		1910	24.6		2450	31.5		
8.9		1995	25.7		2560	32.9		
10.2		2064	26.5					
11.4		2145	27.6					
12.7		2325	29.9					

Data Sheet 7

7 day soaked

6% Cement

Penetration (mm)	Standard load (kN/)	TOP			BOTTOM			Average
		Load indicator Dial	Load (kN)	CBR (%)	Load indicator Dial	Load (kN)	CBR (%)	
0		0	0		0	0		
0.6		1320	17.0		1365	17.6		
1.3		1695	21.8		1660	21.3		
1.9		1930	23.5		1995	25.7		
2.5	13.24	2025	26.0	197	2110	27.1	205	
3.8		2115	27.2		2320	29.8		201
5.0	19.96	2365	30.4	152	2445	31.4	158	
6.4		2475	31.8		2535	32.6		
7.6		2645	34.0		2685	34.5		
8.9		2745	35.9		2780	35.8		
10.2								
11.4								
12.7								

Data Sheet 7

7 days soaked

8% Cement

Penetration (mm)	Standard load (kN/)	TOP			BOTTOM			
		Load indicator Dial	Load (kN)	CBR (%)	Load indicator Dial	Load (kN)	CBR (%)	Average
0		0	0		0	0		
0.6		1565	20.1		1495	19.2		
1.3		1700	21.9		1610	20.7		
1.9		2015	25.9		1830	23.5		
2.5	13.24	2380	30.6	23	2020	26.0	196	
3.8		2560	32.9		2415	31.1		214
5.0	19.96	2750	35.4	177	2513	34.9	175	
6.4		2885	37.1		2795	35.9		
7.6		2915	37.5		2875	37.0		
8.9					2965	38.1		
10.2								
11.4								
12.7								

Data Sheet 7

7 days Soaked

- 10% Cement

Penetration (mm)	Standard load (kN/)	TOP			BOTTOM			
		Load indicator Dial	Load (kN)	CBR (%)	Load indicator Dial	Load (kN)	CBR (%)	Average
0		0	0		0	0		
0.6		1365	17.6		1465	18.8		
1.3		1540	19.8		1690	21.7		
1.9		1985	25.5		1830	23.5		
2.5	13.24	2115	27.2	205	2045	26.3	199	
3.8		2385	30.7		2370	30.5		202
5.0	19.96	2610	33.6	168	2665	34.3	172	
6.4		2735	35.2		2740	35.2		
7.6		2840	36.5		2815	36.2		
8.9		2970	38.2		2995	38.5		
10.2								
11.4								
12.7								

APPENDIX D

Triaxial test machine's calibration

factor = 5.3×10^{-3} kN/div.

Data Sheet 11

Sample air dry For 7 days - 0% Bitumen

Strain Dial Gauge (mm)	Area X 10^3 (m^3)	Proving Ring Dial	Proving Ring Dial	Proving Ring Dial	Comp Stress ($\sigma_1 - \sigma_2$) kN/m^2	Comp Stress ($\sigma_1 - \sigma_2$) kN/m^2	Comp Stress ($\sigma_1 - \sigma_2$) kN/m^2	Strain $\frac{l}{l_o} \times 100$
0	1.14	0	0	0	0	0	0	0
0.38	1.15	2	5	9	9.2	23.0	41.5	0.5
0.76	1.16	7	9	15	32.0	41.1	68.5	1.0
1.14	1.18	13	16	25	158.4	71.9	112.3	1.5
1.52	1.19	42	25	34	187.1	111.3	151.4	2.0
1.91	1.20	67	33	48	295.9	145.8	212.0	2.5
2.28	1.21	84	56	46	367.9	245.3	201.5	3.0
2.67	1.23	95	70	42	409.3	301.6	181.0	3.5
3.05	1.24	100	75.5	38	427.4	322.7	162.4	4.0
3.43	1.25	102	75		32.5	318	-	4.5
3.81	1.27	104	73		421.5	304.6	-	5.0
4.19	1.28	100.5	71		416.1	294.0	-	5.5
4.57	1.30	100			407.7	-	-	6.0
5.33	1.31							7.0
6.10	1.33							8.0
6.86	1.34							9.0
7.62	1.36							10.0

Data Sheet 11

Sample air cured For 7 days - 2% Bitumen

Strain Dial Gauge (mm)	Area X 10^3 (m^3)	Proving Ring Dial	Proving Ring Dial	Proving Ring Dial	Comp Stress ($\sigma_1-\sigma_3$) kN/m^2	Comp Stress ($\sigma_1-\sigma_2$) kN/m^2	Comp Stress ($\sigma_1-\sigma_2$) kN/m^2	Strain $\frac{l}{l_o}$ x
0	1.14	0	0	0	0	0	0	0
0.38	1.15	10	56	51	46.1	258.1	235.0	0.5
0.76	1.16	76	90	64	347.2	411.2	292.4	1.0
1.14	1.18	115	109	74	516.5	489.6	332.4	1.5
1.52	1.19	141	122	81	628.0	543.4	360.8	2.0
1.91	1.20	160	128.5	84	706.7	5 .5	371.0	2.5
2.28	1.21	171	130	85	749.0	569.4	372.3	3.0
2.67	1.23	180	130.5	85	775.6	562.3	366.3	3.5
3.05	1.24	183	128	83.5	782.2	547.1	356.9	4.0
3.43	1.25	186	124	80	788.6	525.8	339.2	4.5
3.81	1.27	187	120	77	780.4	500.8	321.3	5.0
4.19	1.28	188	116	74	778.4	480.3	306.4	5.5
4.57	1.30							6.0
5.33	1.31							7.0
6.10	1.33							8.0
6.86	1.34							9.0
7.62	1.36							10.0

Data Sheet 11

Air cured for 7 days - 4% Bitumen

Strain Dial Gauge (mm)	Area X 10^3 (m^3)	Proving Ring Dial	Proving Ring Dial	Proving Ring Dial	Comp Stress ($\sigma_1 - \sigma_2$) kN/m^2	Comp Stress ($\sigma_1 - \sigma_2$) kN/m^2	Comp Stress ($\sigma_1 - \sigma_2$) kN/m^2	Strain $\frac{l}{l_0} \times 100$
0	1.14	0	0	0	0	0	0	0
0.38	1.15	5	7	27	23.0	32.3	24.4	0.5
0.76	1.16	10	55	33	45.7	251.3	150.8	1.0
1.14	1.18	31	95	36	139.2	426.7	161.7	1.5
1.52	1.19	83	133	72	369.7	592.4	320.7	2.0
1.91	1.20	119	171	98	525.6	755.3	432.8	2.5
2.28	1.21	162	193	117	709.6	845.4	512.5	3.0
2.67	1.23	210	204	130.8	904.9	879.0	562.3	3.5
3.05	1.24	237	209.5	128	1013	895.4	547.1	4.0
3.43	1.25	240	209	125	1017.6	886.2	530.0	4.5
3.81	1.27	244	205	122	1018.3	855.5	509.1	5.0
4.19	1.28	247	200		1022.7	828.1		5.5
4.57	1.30	246			1002.9			6.0
5.33	1.31							7.0
6.10	1.33							8.0
6.86	1.34							9.0
7.62	1.36							10.0

Data Sheet 11

Air cured for 7 days - 6% Bitumen

Strain Dial Gauge (mm)	Area X 10^{-3} (m^3)	Proving Ring Dial	Proving Ring Dial	Proving Ring Dial	Comp Stress ($\sigma_1 - \sigma_3$) kN/m^2	Comp Stress ($\sigma_1 - \sigma_3$) kN/m^2	Comp Stress ($\sigma_1 - \sigma_3$) kN/m^2	Strain $\frac{\delta}{l_0} \times 100$
0	1.14	0	0	0	0	0	0	0
0.38	1.15	10	8	15	46.1	36.9	69.1	0.5
0.76	1.16	16	14	48	73.1	64.0	219.3	1.0
1.14	1.18	85	51	72	381.8	229.1	323.4	1.5
1.52	1.19	142	90	92	632.4	400.8	409.7	2.0
1.91	1.20	180	119	105	795.0	525.6	463.8	2.5
2.28	1.21	202	140	112	884.8	613.2	490.6	3.0
2.67	1.23	213	152	113.5	917.8	655.0	489.1	3.5
3.05	1.24	218	158	112	931.8	675.3	478.7	4.0
3.43	1.25	219	160	109	928.6	678.4	462.2	4.5
3.81	1.27	219	162	106	913.9	676.1	442.4	5.0
4.19	1.28	218	162	102	902.7	670.3	422.3	5.5
4.57	1.30	217.5	161	98	886.7	656.4	399.5	6.0
5.33	1.31	212	158		857.7	639.2		7.0
6.10	1.33	208	156.5					8.0
6.86	1.34		156.5					9.0
7.62	1.36		147.5					10.0

Data Sheet 11

Air cured for 7 days - 8% Bitumen

Strain Dial Gauge (mm)	Area X 10^{-3} (m^3)	Proving Ring Dial	Proving Ring Dial	Proving Ring Dial	Comp Stress $(\sigma_1 - \sigma_2)$ kN/m^2	Comp Stress $(\sigma_1 - \sigma_2)$ kN/m^2	Comp Stress $(\sigma_1 - \sigma_2)$ kN/m^2	Strain $\frac{l}{l_0} \times 100$
0	1.14	0	0	0	0	0	0	0
0.38	1.15	8	5	14	36.9	23.0	64.5	0.5
0.76	1.16	15	9	25	68.5	41.1	114.2	1.0
1.14	1.18	19	15	38	85.3	67.4	170.7	1.5
1.52	1.19	32	42	57	142.5	187.1	253.9	2.0
1.91	1.20	64	75	69	282.7	331.3	304.8	2.5
2.28	1.21	94	97	76	411.7	424.9	332.9	3.0
2.67	1.23	122	115	81	525.7	495.5	349.0	3.5
3.05	1.24	145	128	86	619.8	547.1	367.6	4.0
3.43	1.25	151	137	94	640.0	580.9	398.6	4.5
3.81	1.27	174	146	95	726.1	584.2	396.5	5.0
4.19	1.28	184	148	97	761.9	612.8	401.6	5.5
4.57	1.30	192.0	147	75	782.8	599.3	305.8	6.0
5.33	1.31	191	146		756.6	590.7		7.0
6.10	1.33	190	144		737.2	573.8		8.0
6.86	1.34							9.0
7.62	1.36	-						10.0

Data Sheet 11

Air cured for 7 day 10% Bitumen

Strain Dial Gauge (mm)	Area X 10^3 (m^3)	Proving Ring Dial	Proving Ring Dial	Proving Ring Dial	Comp Stress ($\sigma_1-\sigma_2$) kN/m^2	Comp Stress ($\sigma_1-\sigma_2$) kN/m^2	Comp Stress ($\sigma_1-\sigma_2$) kN/m^2	Strain $\frac{l}{l_0}$ x100
0	1.14	0	0	0	0	0	0	0
0.38	1.15	12	9	4	55.3	41.5	18.4	0.5
0.76	1.16	25	15	9	114.2	68.5	41.1	1.0
1.14	1.18	47	26	15	211.1	116.8	67.4	1.5
1.52	1.19	83	53	26	369.7	236.1	115.8	2.0
1.91	1.20	108	79	40	477.0	348.9	176.7	2.5
2.28	1.21	127	98	57	556.3	429.3	249.7	3.0
2.67	1.23	146	111	71	629.1	478.3	305.9	3.5
3.05	1.24	149	120	77.5	636.9	512.9	331.3	4.0
3.43	1.25	151.5	120.0	77.0	642.4	508.8	376.5	4.5
3.81	1.27	152	119	76	634.3	496.6	317.2	5.0
4.19	1.28	150	118	73	621.1	488.6	310.5	5.5
4.57	1.30							6.0
5.33	1.31							7.0
6.10	1.33							8.0
6.86	1.34							9.0
7.62	1.36							10.0

Data Sheet 11

Air cured for 7 days & soaked for 7 days

4% Bitumen

Strain Dial Gauge (mm)	Area X 10^3 (m^3)	Proving Ring Dial	Proving Ring Dial	Proving Ring Dial	Comp Stress $(\sigma_1 - \sigma_2)$ kN/m^2	Comp Stress $(\sigma_1 - \sigma_2)$ kN/m^2	Comp Stress $(\sigma_1 - \sigma_2)$ kN/m^2	Strain $(\frac{l}{l_0} \times 100)$
0	1.14	0	0	0	0	0	0	0
0.38	1.15	9	7	3	41.5	32.3	13.8	0.5
0.76	1.16	12	11	8	54.8	50.3	36.6	1.0
1.14	1.18	17	19	13	76.4	85.3	58.4	1.5
1.52	1.19	29	24	18	129.2	106.9	80.2	2.0
1.91	1.20	47	35	22	207.6	154.6	97.2	2.5
2.28	1.21	68	45	26	297.9	197.1	113.9	3.0
2.67	1.23	79	58	32	340.4	249.9	137.9	3.5
3.05	1.24	88	65	45	376.1	277.8	192.3	4.0
3.43	1.25	96	74	58	407.0	373.8	245.9	4.5
3.81	1.27	107	78	59	421.5	385.5	246.2	5.0
4.19	1.28	103	83	61	426.5	343.7	252.6	5.5
4.57	1.30	107.5	85	61	438.3	346.5	248.7	6.0
5.33	1.31	105	84	59	424.8	339.8	238.7	7.0
6.10	1.33							8.0
6.86	1.34							9.0
7.62	1.36							10.0

Data Sheet 11

Air cured for 7 days & 7 days

soaked - 6% Bitumen

Strain Dial Gauge (mm)	Area X 10^3 (m^3)	Proving Ring Dial	Proving Ring Dial	Proving Ring Dial	Comp Stress ($\sigma_1-\sigma_2$) kN/m^2	Comp Stress ($\sigma_1-\sigma_2$) kN/m^2	Comp Stress ($\sigma_1-\sigma_2$) kN/m^2	Strain $\frac{l}{l_o}$ x
0	1.14	0	0	0	0	0	0	0
0.38	1.15	5	12	8	23.0	55.3	36.9	0.5
0.76	1.16	9	20	13	41.1	914	59.4	1.0
1.14	1.18	15	32	17	67.4	143.7	76.4	1.5
1.52	1.19	42	46	22	187.1	204.9	98.0	2.0
1.91	1.20	63	63	26	278.3	278.3	114.8	2.5
2.28	1.21	75	72	32	328.5	315.4	140.2	3.0
2.67	1.23	97	80	39	418.0	344.7	168.0	3.5
3.05	1.24	115	86	45	491.5	367.6	192.3	4.0
3.43	1.25	124	89	50	525.8	371.4	212.0	4.5
3.81	1.27	128	92.5	53	524.2	386.0	221.2	5.0
4.19	1.28	130	92.0	56	538.3	380.9	231.8	5.5
4.57	1.30	130		55	530.0		224.2	6.0
5.33	1.31	132						7.0
6.10	1.33							8.0
6.86	1.34							9.0
7.62	1.36							10.0

Data Sheet 11

Air cured for 7 days & 7 days soaked

- 8% Bitumen

Strain Dial Gauge (mm)	Area X 10^3 (m^3)	Proving Ring Dial	Proving Ring Dial	Proving Ring Dial	Comp Stress ($\sigma_1-\sigma_3$) kN/m^2	Comp Stress ($\sigma_1-\sigma_3$) kN/m^2	Comp Stress ($\sigma_1-\sigma_3$) kN/m^2	Strain ($\frac{l}{l_0}$ x100)
0	1.14	0	0	0	0	0	0	0
0.38	1.15	15	17	7	69.1	78.3	32.3	0.5
0.76	1.16	21	25	10	95.9	114.2	45.7	1.0
1.14	1.18	28	38	19	125.8	170.7	85.3	1.5
1.52	1.19	36	49	25	160.3	218.2	111.3	2.0
1.91	1.20	50	56	30	220.8	247.3	132.5	2.5
2.28	1.21	58	63	38	254.1	276.0	166.4	3.0
2.67	1.23	69	67	40	297.3	288.7	172.4	3.5
3.05	1.24	81	67	42	346.2	286.4	179.5	4.0
3.43	1.25	93	73	44	394.3	309.5	186.6	4.5
3.81	1.27	108	76	47	450.1	317.2	196.1	5.0
4.19	1.28	111	79	45	459.6	327.1	186.3	5.5
4.57	1.30	114.5	81		463.8	330.2		6.0
5.33	1.31	114	80		454.3	318.8		7.0
6.10	1.33	115	81					8.0
6.86	1.34							9.0
7.62	1.36							10.0

Data Sheet 11

Air cured for 7 days & 7 days

soaked - 10% Bitumen

Strain Dial Gauge (mm)	Area X 10^3 (m^3)	Proving Ring Dial	Proving Ring Dial	Proving Ring Dial	Comp Stress ($\sigma_1-\sigma_2$) kN/m^2	Comp Stress ($\sigma_1-\sigma_2$) kN/m^2	Comp Stress ($\sigma_1-\sigma_2$) kN/m^2	Strain ($\frac{l}{l_0} \times 100$)
0	1.14	0	0	0	0	0	0	0
0.38	1.15	8	6	4	36.9	27.7	18.4	0.5
0.76	1.16	27	16	8	123.4	73.1	36.6	1.0
1.14	1.18	30	19	10	134.7	85.3	44.9	1.5
1.52	1.19	42	32	15	187.1	142.5	66.8	2.0
1.91	1.20	58	40	21	256.2	176.7	92.8	2.5
2.28	1.21	65	47	26	284.7	205.9	113.9	3.0
2.67	1.23	72	53	28	310.2	228.4	120.6	3.5
3.05	1.24	79	56	30	337.7	239.4	128.2	4.0
3.43	1.25	80	57	30.5	339.2	241.7	129.3	4.5
3.81	1.27	80.5	59	37.5	335.9	246.2	131.5	5.0
4.19	1.28	81.5	56	80	337.5	231.9	124.2	5.5
4.57	1.30	81			330.2			6.0
5.33	1.31							7.0
6.10	1.33							8.0
6.86	1.34							9.0
7.62	1.36							10.0

Data Sheet 11

Air cured for 7 days - 2% Lime

Strain Dial Gauge (mm)	Area X 10^3 (m^3)	Proving Ring Dial	Proving Ring Dial	Proving Ring Dial	Comp Stress ($\sigma_1-\sigma_2$) kN/m^2	Comp Stress ($\sigma_1-\sigma_2$) kN/m^2	Comp Stress ($\sigma_1-\sigma_2$) kN/m^2	Strain $\frac{l}{l_o} \times 100$
0	1.14	0	0	0	0	0	0	0
0.38	1.15	24	30	15	110.6	138.3	69.1	0.5
0.76	1.16	52	58	27	237.6	265.0	123.4	1.0
1.14	1.18	75	77	40	337.9	345.8	179.7	1.5
1.52	1.19	100	98	54	445.4	436.5	240.5	2.0
1.91	1.20	125	111	68	552.1	490.3	300.3	2.5
2.28	1.21	153	124	81	670.2	543.1	354.8	3.0
2.67	1.23	171	131	90	736.8	564.5	387.8	3.5
3.05	1.24	180	135	98	769.4	577.0	418.9	4.0
3.43	1.25	184	158	105	771.7	585.1	445.2	4.5
3.81	1.27	186	141	107	776.2	588.4	446.5	5.0
4.19	1.28	188	143.5	108.5	778.4	594.2	449.3	5.5
4.57	1.30	189	141	107.5	762.4	574.8	438.3	6.0
5.33	1.31							7.0
6.10	1.33							8.0
6.86	1.34							9.0
7.62	1.36							10.0

Data Sheet 11

Air cured for 7 days - 5% Lime

Strain Dial Gauge (mm)	Area X 10^{-3} (m^3)	Proving Ring Dial	Proving Ring Dial	Proving Ring Dial	Comp Stress $(\sigma_1-\sigma_2)$ kN/m^2	Comp Stress $(\sigma_1-\sigma_2)$ kN/m^2	Comp Stress $(\sigma_1-\sigma_2)$ kN/m^2	Strain $\frac{l}{l_0} \times 100$
0	1.14	0	0	0	0	0	0	0
0.38	1.15	39	9	44	179.7	41.5	202.8	0.5
0.76	1.16	100	11	80	456.9	520.3	365.5	1.0
1.14	1.18	136	15	119	610.8	67.4	534.5	1.5
1.52	1.19	176	54	136	783.9	240.5	605.7	2.0
1.91	1.20	215	103	145	949.6	454.9	640.4	2.5
2.28	1.21	243	142	148	1064.4	622.0	648.3	3.0
2.67	1.23	262	172	151.5	1128.9	741.1	652.7	3.5
3.05	1.24	270	190	150	1154.0	812.1	641.1	4.0
3.43	1.25	273.5	198.5	1	1155.4	841.6		4.5
3.81	1.27	271	198					5.0
4.19	1.28		192					5.5
4.57	1.30							6.0
5.33	1.31							7.0
6.10	1.33							8.0
6.86	1.34							9.0
7.62	1.36							10.0

Data Sheet 11

Air cured for 7 days - 6% Lime

Strain Dial Gauge (mm)	Area X 10^{-3} (m^3)	Proving Ring Dial	Proving Ring Dial	Proving Ring Dial	Comp Stress $(\sigma_1-\sigma_2)$ kN/m^2	Comp Stress $(\sigma_1-\sigma_2)$ kN/m^2	Comp Stress $(\sigma_1-\sigma_2)$ kN/m^2	Strain $\frac{l}{l_o} \times 100$
0	1.14	0	0	0	0	0	0	0
0.38	1.15	10	7	11	46.1	32.3	50.7	0.5
0.76	1.16	46	34	24	210.2	155.3	109.7	1.0
1.14	1.18	120	52	48	539.0	238.0	215.6	1.5
1.52	1.19	193	82	72	859.6	365.2	320.7	2.0
1.91	1.20	215	100	95	949.6	441.7	419.6	2.5
2.28	1.21	250	130	120	10951	569.4	525.6	3.0
2.67	1.23	273	195	135	1176.3	840.2	581.7	3.5
3.05	1.24	278	208	140	11882	889.0	598.4	4.0
3.43	1.25	272	205	136	11533	869.2	576.6	4.5
3.81	1.27							5.0
4.19	1.28							5.5
4.57	1.30							6.0
5.33	1.31							7.0
6.10	1.33							8.0
6.86	1.34							9.0
7.62	1.36							10.0

Data Sheet 11

Air cured for 7 days 8% Lime

Strain Dial Gauge (mm)	Area X 10^3 (m^3)	Proving Ring Dial	Proving Ring Dial	Proving Ring Dial	Comp Stress ($\sigma_1 - \sigma_2$) kN/m^2	Comp Stress ($\sigma_1 - \sigma_2$) kN/m^2	Comp Stress ($\sigma_1 - \sigma_2$) kN/m^2	Strain ($\frac{l}{l_o}$ x)
0	1.14	0	0	0	0	0	0	0
0.38	1.15	34	15	11	156.7	69.1	50.7	0.5
0.76	1.16	51	42	24	233.0	191.9	109.7	1.0
1.14	1.18	85	63	39	381.8	283.0	175.2	1.5
1.52	1.19	174	87	51	507.7	387.5	227.1	2.0
1.91	1.20	144	101	68	636.0	446.1	300.3	2.5
2.28	1.21	185	128	80	810.3	560.7	350.4	3.0
2.67	1.23	216	147	92	930.7	633.4	396.4	3.5
3.05	1.24	240	173	101	10258	739.4	431.7	4.0
3.43	1.25	249	190	117	1055.8	805.6	496.1	4.5
3.81	1.27	254	194	128	1060.0	899.6	534.2	5.0
4.19	1.28	251	196	133	1039.3	811.6	550.7	5.5
4.57	1.30		194.5	136		793.0	554.5	6.0
5.33	1.31			134			501.7	7.0
6.10	1.33							8.0
6.86	1.34							9.0
7.62	1.36							10.0

Data Sheet 11

Air cured for 7 days - 10% Lime

Strain Dial Gauge (mm)	Area X 10^3 (m^3)	Proving Ring Dial	Proving Ring Dial	Proving Ring Dial	Comp Stress $(\sigma_1-\sigma_2)$ kN/m^2	Comp Stress $(\sigma_1-\sigma_2)$ kN/m^2	Comp Stress $(\sigma_1-\sigma_2)$ kN/m^2	Strain $\frac{l}{l_o} \times 100$
0	1.14	0	0	0	0	0	0	0
0.38	1.15	52	11	9	239.7	50.7	41.5	0.5
0.76	1.16	77	33	18	351.8	150.8	82.2	1.0
1.14	1.18	102	64	30	458.1	287.5	134.7	1.5
1.52	1.19	143	82	55	636.9	365.2	245.0	2.0
1.91	1.20	182	111	72	803.8	490.2	322.4	2.5
2.28	1.21	199	134	91	871.7	586.9	398.6	3.0
2.67	1.23	210	150	100	904.9	646.3	430.9	3.5
3.05	1.24	214	154.5	103	914.7	660.4	440.2	4.0
3.43	1.25	216	156	104.5	915.8	661.4	443.1	4.5
3.81	1.27	215	158	103	887.2	626.0	429.8	5.0
4.19	1.28							5.5
4.57	1.30							6.0
5.33	1.31							7.0
6.10	1.33							8.0
6.86	1.34							9.0
7.62	1.36							10.0

Data Sheet 11

Air cured for 7 days and 7days soaked - 2% Lime

Strain Dial Gauge (mm)	Area X 10^3 (m^3)	Proving Ring Dial	Proving Ring Dial	Proving Ring Dial	Comp Stress ($\sigma_1-\sigma_2$) kN/m^2	Comp Stress ($\sigma_1-\sigma_2$) kN/m^2	Comp Stress ($\sigma_1-\sigma_2$) kN/m^2	Strain $\frac{l}{l_o} \times 100$
0	1.14	0	0	0	0	0	0	0
0.38	1.15	15	21	8	69.1	96.8	36.9	0.5
0.76	1.16	27	30	12	123.4	137.1	54.8	1.0
1.14	1.18	40	42	19	179.7	188.6	85.3	1.5
1.52	1.19	57	54	25	253.9	240.5	111.3	2.0
1.91	1.20	70	60	38	309.2	265.0	167.8	2.5
2.28	1.21	80	65	48	350.4	284.7	210.2	3.0
2.67	1.23	88	70	50	379.2	301.6	215.4	3.5
3.05	1.24	91	74	53	389.0	316.3	226.5	4.0
3.43	1.25	94	77	52	398.6	326.5	220.5	4.5
3.81	1.27	97.5	76	51	406.9	317.1	212.8	5.0
4.19	1.28	95	-	-	393.4	-	-	5.5
4.57	1.30							6.0
5.33	1.31							7.0
6.10	1.33							8.0
6.86	1.34							9.0
7.62	1.36							10.0

Data Sheet 11

Air cured for 7 days and 7 days

soaked - 4% Lime

Strain Dial Gauge (mm)	Area X 10^3 (m^3)	Proving Ring Dial	Proving Ring Dial	Proving Ring Dial	Comp Stress ($\sigma_1-\sigma_3$) kN/m^2	Comp Stress ($\sigma_1-\sigma_3$) kN/m^2	Comp Stress ($\sigma_1-\sigma_3$) kN/m^2	Strain $\frac{l}{l_0} \times 100$
0	1.14	0	0	0	0	0	0	0
0.38	1.15	5	9	15	23.0	41.5	69.1	0.5
0.76	1.16	7	15	20	32.0	68.5	91.4	1.0
1.14	1.18	9	20	32	40.4	89.8	143.7	1.5
1.52	1.19	11	23	41	49.0	102.4	182.6	2.0
1.91	1.20	18	48	53	79.5	212.0	234.1	2.5
2.28	1.21	20	58	60	87.6	254.1	262.8	3.0
2.67	1.23	32	70	65	137.9	301.6	280.0	3.5
3.05	1.24	53	82	68	226.5	350.5	290.6	4.0
3.43	1.25	72	90	69	305.3	381.6	292.6	4.5
3.81	1.27	95	99	68	396.5	413.1	383.8	5.0
4.19	1.28	110	102		455.5	430.6		5.5
4.57	1.30	121	106		413.3	432.2		6.0
5.33	1.31	130	107.5		526.0	434.9		7.0
6.10	1.33	136	107.0		542.0	426.4		8.0
6.86	1.34	139	1		545.8			9.0
7.62	1.36	137			533.9			10.0

Data Sheet 11

Air cured for 7days and 7days

soaked - 6% Lime

Strain Dial Gauge (mm)	Area X 10^3 (m^3)	Proving Ring Dial	Proving Ring Dial	Proving Ring Dial	Comp Stress ($\sigma_1 - \sigma_3$) kN/m^2	Comp Stress ($\sigma_1 - \sigma_3$) kN/m^2	Comp Stress ($\sigma_1 - \sigma_3$) kN/m^2	Strain ($\frac{l}{l_o}$ x100)
0	1.14	0	0	0	0	0	0	0
0.38	1.15	23	9	5	106.0	41.5	23.0	0.5
0.76	1.16	45	21	10	205.6	95.9	45.7	1.0
1.14	1.18	67	38	12	300.9	170.7	53.9	1.5
1.52	1.19	89	74	21	396.4	329.6	93.5	2.0
1.91	1.20	122	94	38	538.8	415.2	167.8	2.5
2.28	1.21	140	107	50	613.2	455.5	219.0	3.0
2.67	1.23	162	115	62	698.0	495.5	267.2	3.5
3.05	1.24	170	122	71	726.6	521.5	303.5	4.0
3.43	1.25	175	125.5	76	742.0	532.1	322.2	4.5
3.81	1.27	178	128	77.5	742.8	534.2	323.4	5.0
4.19	1.28	180	126	76	745.3	521.7	314.7	5.5
4.57	1.30	177			721.6	-	-	6.0
5.33	1.31							7.0
6.10	1.33							8.0
6.86	1.34							9.0
7.62	1.36							10.0

Data Sheet 11

Air cured for 7days and

Soaked for 7days - 8% Lime

Strain Dial Gauge (mm)	Area X 10^{-3} (m^3)	Proving Ring Dial	Proving Ring Dial	Proving Ring Dial	Comp Stress ($\sigma_1-\sigma_3$) kN/m^2	Comp Stress ($\sigma_1-\sigma_3$) kN/m^2	Comp Stress ($\sigma_1-\sigma_3$) kN/m^2	Strain $\frac{1}{10} \times 100$
0	1.14	0	0	0	0	0	0	0
0.38	1.15	42	8	5	193.6	36.9	23.0	0.5
0.76	1.16	67	17	9	306.1	77.7	41.1	1.0
1.14	1.18	87	26	12	390.8	116.8	53.9	1.5
1.52	1.19	112	48	24	498.8	213.8	106.9	2.0
1.91	1.20	126	59	32	556.5	260.6	141.3	2.5
2.28	1.21	137	66	45	600.1	289.1	197.1	3.0
2.67	1.23	142	89	54	611.9	383.5	232.7	3.5
3.05	1.24	147.5	101	61	630.4	431.7	260.7	4.0
3.43	1.25	150.5	110	65.5	638.1	466.4	277.7	4.5
3.81	1.27	148	114	67	475.7	279.6		5.0
4.19	1.28		116	65		480.3	269.1	5.5
4.57	1.30		113			460.7		6.0
5.33	1.31							7.0
6.10	1.33							8.0
6.86	1.34							9.0
7.62	1.36							10.0

Data Sheet 11

Air cured for 7 days and

Soaked for 7days - 10% Lime

Strain Dial Gauge (mm)	Area X 10^{3} (m^3)	Proving Ring Dial	Proving Ring Dial	Proving Ring Dial	Comp Stress ($\sigma_1-\sigma_2$) kN/m^2	Comp Stress ($\sigma_1-\sigma_2$) kN/m^2	Comp Stress ($\sigma_1-\sigma_2$) kN/m^2	Strain $\frac{l}{l_0} \times 100$
0	1.14	0	0	0	0	0	0	0
0.38	1.15	9	9	4	41.5	41.5	18.4	0.5
0.76	1.16	15	21	9	68.5	95.9	41.1	1.0
1.14	1.18	22	40	12	98.8	179.7	53.9	1.5
1.52	1.19	31	54	24	138.1	240.5	106.9	2.0.
1.91	1.20	40	68	31	176.7	300.3	136.9	2.5
2.28	1.21	68	82	42	297.9	359.2	184.0	3.0
2.67	1.23	82	90	50	353.3	387.8	215.4	3.5
3.05	1.24	100	98	53	427.4	418.9	226.5	4.0
3.43	1.25	113	102	56	479.1	432.5	237.4	4.5
3.81	1.27	124	104	57	517.5	434.0	237.9	5.0
4.19	1.28	133	102.5	55	550.7	424.4	227.7	5.5
4.57	1.30	138			502.6			6.0
5.33	1.31	140			566.4			7.0
6.10	1.33	137			545.9			8.0
6.86	1.34							9.0
7.62	1.36							10.0

Data Sheet 11

Air cured for 7days - 2% Cement

Strain Dial Gauge (mm)	Area X 10^3 (m^3)	Proving Ring Dial	Proving Ring Dial	Proving Ring Dial	Comp Stress ($\sigma_1-\sigma_3$) kN/m^2	Comp Stress ($\sigma_1-\sigma_3$) kN/m^2	Comp Stress ($\sigma_1-\sigma_3$) kN/m^2	Strain ($\frac{l}{l_0}$ x 100)
0	1.14	0	0	0	0	0	0	0
0.38	1.15	14	13	3	64.5	59.9	13.8	0.5
0.76	1.16	22	21	7	100.5	95.9	32.0	1.0
1.14	1.18	38	29	11	170.7	130.3	49.4	1.5
1.52	1.19	51	41	16	227.1	182.6	71.3	2.0
1.91	1.20	64	50	20	282.7	220.8	88.3	2.5
2.28	1.21	70	54	24	306.6	336.5	105.1	3.0
2.67	1.23	75	57	30	323.2	245.6	129.3	3.5
3.05	1.24	77	60.5	32	329.1	258.6	136.8	4.0
3.43	1.25	80.5	59	35	341.3	250.2	148.4	4.5
3.81	1.27	80	-	37.5	333.9	-	156.5	5.0
4.19	1.28	-	-	36.5				5.5
4.57	1.30							6.0
5.33	1.31							7.0
6.10	1.33							8.0
6.86	1.34							9.0
7.62	1.36							10.0

Data Sheet 11

Air cured for 7days - 4% Cement

Strain Dial Gauge (mm)	Area X 10^{-3} (m^3)	Proving Ring Dial	Proving Ring Dial	Proving Ring Dial	Comp Stress ($\sigma_1-\sigma_2$) kN/m^2	Comp Stress ($\sigma_1-\sigma_2$) kN/m^2	Comp Stress ($\sigma_1-\sigma_2$) kN/m^2	Strain $\frac{l}{l_o} \times 100$
0	1.14	0	0	0	0	0	0	0
0.38	1.15	33	19	23	152.1	87.6	106.0	0.5
0.76	1.16	53	23	29	242.2	105.1	132.5	1.0
1.14	1.18	65	33	36	291.9	148.2	161.7	1.5
1.52	1.19	74	48	44	329.6	213.8	196.0	2.0
1.91	1.20	78	62	48	344.5	273.8	212.0	2.5
2.28	1.21	80	70	50	350.4	306.6	219.0	3.0
2.67	1.23	85	75	52.5	366.3	323.2	226.2	3.5
3.05	1.24	90	78.5	51	384.7	335.5	218.0	4.0
3.43	1.25	93.5	78.0		396.44	330.7	-	4.5
3.81	1.27	92.0			383.9	-	-	5.0
4.19	1.28							5.5
4.57	1.30							6.0
5.33	1.31							7.0
6.10	1.33							8.0
6.86	1.34							9.0
7.62	1.36							10.0

Data Sheet 11

Air cured for 7 days - 6% Cement

Strain Dial Gauge (mm)	Area X 10^3 (m^3)	Proving Ring Dial	Proving Ring Dial	Proving Ring Dial	Comp Stress ($\sigma_1 - \sigma_3$) kN/m^2	Comp Stress ($\sigma_1 - \sigma_3$) kN/m^2	Comp Stress ($\sigma_1 - \sigma_3$) kN/m^2	Strain $\frac{l}{l_0} \times 100$
0	1.14	0	0	0	0	0	0	0
0.38	1.15	13	32	45	59.9	147.5	207.4	0.5
0.76	1.16	37	58	64	169.1	265.0	292.4	1.0
1.14	1.18	63	82	72	283,0	368.3	323.4	1.5
1.52	1.19	83	95	80	369.7	423.1	356.3	2.0
1.91	1120	107	111	82	472.6	490.3	362.2	2.5
2.28	1.21	140	114	85	613.2	499.3	372.3	3.0
2.67	1.23	144	117.5	84	620.5	506.3	361.9	3.5
3.05	1.24	147.5	115		630.4	491.5	-	4.0
3.43	1.25	146			619.0			4.5
3.81	1.27							5.0
4.19	1.28							5.5
4.57	1.30							6.0
5.33	1.31							7.0
6.10	1.33							8.0
6.86	1.34							9.0
7.62	1.36							10.0

Data Sheet 11

Air cured for 7days - 8% Cement

Strain Dial Gauge (mm)	Area X 10^{-3} (m^3)	Proving Ring Dial	Proving Ring Dial	Proving Ring Dial	Comp Stress ($\sigma_1-\sigma_2$) kN/m^2	Comp Stress ($\sigma_1-\sigma_2$) kN/m^2	Comp Stress ($\sigma_1-\sigma_2$) kN/m^2	Strain $\frac{\delta}{l_0} \times 100$
0	1.14	0	0	0	0	0	0	0
0.38	1.15	25	24	25	115.2	116.6	115.2	0.5
0.76	1.16	42	65	48	9 .9	297.0	219.3	1.0
1.14	1.18	51	138	56	229.1	619.8	251.5	1.5
1.52	1.19	127	173	127	565.6	770.5	565.6	2.0
1.91	1.20	196	185	145	872.9	824.0	645.8	2.5
2.28	1.21	221	195	153	968.0	854.1	670.2	3.0
2.67	1.23	229.5	197	151	988.9	848.9	650.6	3.5
3.05	1.24	228	196	-	974.5	837.7	-	4.0
3.43	1.25							4.5
3.81	1.27							5.0
4.19	1.28							5.5
4.57	1.30							6.0
5.33	1.31							7.0
6.10	1.33							8.0
6.86	1.34							9.0
7.62	1.36							10.0

Data Sheet 11

Air cured for 7 days - 10% Cement

Strain Dial Gauge (mm)	Area X 10^{-3} (m^3)	Proving Ring Dial	Proving Ring Dial	Proving Ring Dial	Comp Stress $(\sigma_1-\sigma_2)$ kN/m^2	Comp Stress $(\sigma_1-\sigma_2)$ kN/m^2	Comp Stress $(\sigma_1-\sigma_2)$ kN/m^2	Strain $\frac{l}{l_0} \times 100$
0	1.14	0	0	0	0	0	0	0
0.38	1.15	58	4	55	267.3	18.4	253.5	0.5
0.76	1.16	112	17	129	511.7	77.7	589.4	1.0
1.14	1.18	180	34	154	808.5	152.7	691.6	1.5
1.52	1.19	210	64	171	935.3	285.3	761.6	2.0
1.91	1.20	245	89	182	1082.1	393.1	803.8	2.5
2.28	1.21	288	109	187	1261.5	477.4	819.1	3.0
2.67	1.23	307	167	197	1322.8	719.6	823.0	3.5
3.05	1.24	314	208	200	1342.1	889.0	854.8	4.0
3.43	1.25	315.5	213.5	206	1337.7	907.3	873.4	4.5
3.81	1.27	315	212	205	1314.6	884.7	855.5	5.0
4.19	1.28							5.5
4.57	1.30							6.0
5.33	1.31							7.0
6.10	1.33							8.0
6.86	1.34							9.0
7.62	1.36							10.0

Data Sheet 11

Air cured for 7 days and

7 days soaked - 2% cement

Strain Dial Gauge (mm)	Area X 10^{-3} (m^3)	Proving Ring Dial	Proving Ring Dial	Proving Ring Dial	Comp Stress ($\sigma_1-\sigma_3$) kN/m^2	Comp Stress ($\sigma_1-\sigma_3$) kN/m^2	Comp Stress ($\sigma_1-\sigma_3$) kN/m^2	Strain $\frac{l}{l_o} \times 100$
0	1.14	0	0	0	0	0	0	0
0.38	1.15	55	49	18	253.5	225.8	83.0	0.5
0.76	1.16	85	67	21	388.4	306.1	96.0	1.0
1.14	1.18	110	84	33	494.1	377.3	148.	1.5
1.52	1.19	126	98	54	561.2	436.5	240.5	2.0
1.91	1.20	130	109	72	574.2	481.4	318.0	2.5
2.28	1.21	134	110.5	80	586.9	484.0	350.4	3.0
2.67	1.23	137	113	82	590.3	486.9	353.3	3.5
3.05	1.24	139.5	112.5	84	596.3	480.8	359.0	4.0
3.43	1.25	138	-	83	585.1		351.9	4.5
3.81	1.27							5.0
4.19	1.28							5.5
4.57	1.30							6.0
5.33	1.31							7.0
6.10	1.33							8.0
6.86	1.34							9.0
7.62	1.36							10.0

Data Sheet 11

Air cured for 7days and

7days soaked - 4% Cement

Strain Dial Gauge (mm)	Area X 10^3 (m^3)	Proving Ring Dial	Proving Ring Dial	Proving Ring Dial	Comp Stress ($\sigma_1-\sigma_2$) kN/m^2	Comp Stress ($\sigma_1-\sigma_3$) kN/m^2	Comp Stress ($\sigma_1-\sigma_3$) kN/m^2	Strain $\frac{l}{l_0}$ x
0	1.14	0	0	0	0	0	0	0
0.38	1.15	12	15	15	55.3	23.0	23.0	0.5
0.76	1.16	32	21	23	146.2	95.9	105.1	1.0
1.14	1.18	69	45.	40	309.9	202.1	179.7	1.5
1.52	1.19	101	62	65	449.8	276.1	289.5	2.0
1.91	1.20	128	80	82	565.3	353.3	362.2	2.5
2.28	1.21	140	109	97	613.2	477.4	424.9	3.0
2.67	1.23	146	120	99	629.1	517.1	426.6	3.5
3.05	1.24	149.5	125	101	639.0	534.2	431.7	4.0
3.43	1.25	147	128	100	623.3	542.7	424.0	4.5
3.81	1.27	-	127		-	530.0	-	5.0
4.19	1.28							5.5
4.57	1.30							6.0
5.33	1.31							7.0
6.10	1.33							8.0
6.86	1.34							9.0
7.62	1.36							10.0

Data Sheet 11

Air cured for 7days and

7days soaked - 6% Cement

Strain Dial Gauge (mm)	Area X 10^3 (m^3)	Proving Ring Dial	Proving Ring Dial	Proving Ring Dial	Comp Stress ($\sigma_1-\sigma_2$) kN/m^2	Comp Stress ($\sigma_1-\sigma_3$) kN/m^2	Comp Stress ($\sigma_1-\sigma_3$) kN/m^2	Strain $\frac{l}{l_o} \times 100$
0	1.14	0	0	0	0	0	0	0
0.38	1.15	42	42	16	193.7	193.7	73.7	0.5
0.76	1.16	67	67	21	306.1	306.1	95.9	1.0
1.14	1.18	92	85	35	413.2	381.8	157.2	1.5
1.52	1.19	109	105	61	485.5	467.6	271.7	2.0
1.91	1.20	167	123	94	737.6	543.3	415.2	2.5
2.28	1.21	207	148	117	906.7	648.3	512.5	3.0
2.67	1.23	230	185	134	991.0	797.1	577.4	3.5
3.05	1.24	237	192.5	144	10130	822.8	615.5	4.0
3.43	1.25	236	190	142	10006	805.6	602.1	4.5
3.81	1.27							5.0
4.19	1.28							5.5
4.57	1.30							6.0
5.33	1.31							7.0
6.10	1.33							8.0
6.86	1.34							9.0
7.62	1.36							10.0

Data Sheet 11

Air cured for 7days and

7days soaked - 8% Cement

Strain Dial Gauge (mm)	Area X 10^3 (m^3)	Proving Ring Dial	Proving Ring Dial	Proving Ring Dial	Comp Stress ($\sigma_1 - \sigma_2$) kN/m^2	Comp Stress ($\sigma_1 - \sigma_2$) kN/m^2	Comp Stress ($\sigma_1 - \sigma_2$) kN/m^2	Strain $\frac{l}{l_o} \times 100$
0	1.14	0	0	0	0	0	0	0
0.38	1.15	22	20	24	101.4	92.2	110.6	0.5
0.76	1.16	62	45	49	283.3	205.6	223.9	1.0
1.14	1.18	109	72	80	489.6	323.4	359.3	1.5
1.52	1.19	147	107	123	654.7	476.6	547.8	2.0
1.91	1.20	192	142	159	848.0	627.2	702.3	2.5
2.28	1.21	201	179	191	880.4	784.1	836.6	3.0
2.67	1.23	233	225	212	1004.0	969.5	913.5	3.5
3.05	1.24	272	270	219	1162.6	1154.0	936.0	4.0
3.43	1.25	330	275	217	1399.2	1166.0	920.1	4.5
3.81	1.27	341	272		1423.1	-	-	5.0
4.19	1.28	340			1407.8			5.5
4.57	1.30							6.0
5.33	1.31							7.0
6.10	1.33							8.0
6.86	1.34							9.0
7.62	1.36							10.0

Data Sheet 11

Air cured for 7 days and

7 days soaked - 10% Cement

Strain Dial Gauge (mm)	Area X 10^3 (m^3)	Proving Ring Dial	Proving Ring Dial	Proving Ring Dial	Comp Stress ($\sigma_1-\sigma_2$) kN/m^2	Comp Stress ($\sigma_1-\sigma_2$) kN/m^2	Comp Stress ($\sigma_1-\sigma_2$) kN/m^2	Strain $\frac{l}{l_o}$ x100
0	1.14	0	0	0	0	0	0	0
0.38	1.15	9	15	32	41.5	69.1	147.5	0.5
0.76	1.16	15	21	50	68.5	95.9	228.5	1.0
1.14	1.18	53	42	64	238.0	188.6	287.5	1.5
1.52	1.19	122	75	95	543.4	334.0	423.1	2.0
1.91	1.20	195	103	135	861.3	454.9	596.3	2.5
2.28	1.21	260	158	177	1138.9	692.1	762.2	3.0
2.67	1.23	357	204	222	1538.3	879.0	956.6	3.5
3.05	1.24	388	268	270	1658.4	1145.5	1154.0	4.0
3.43	1.25	401.5	303	272	1702.4	1284.1	1153.3	4.5
3.81	1.27	403	343	270	1681.8	1431.4	1126.7	5.0
4.19	1.28	401	-	-	1660.4	-	-	5.5
4.57	1.30							6.0
5.33	1.31							7.0
6.10	1.33							8.0
6.86	1.34							9.0
7.62	1.36							10.0

Data Sheet 12

Result of Absorption Test

Bitumen		Weight in grams					
		Initial	1 days	3 days	7 days	14 days	28 days
0	0-a	2183.5	2203.5	2213.0	2216.5	2226.5	22275
	0-b	2100	2121	2125.0	2136.0	2143	2146
2	2-a	2119	2132.5	2140	2144	2152.5	2155
	2-b	2169.5	2182	2192.5	2198	2200	2201.5
4	4-a	2250.5	2260.5	2263	2263.5	2264	2264.5
	4b	2234	2242	2244.5	2245.0	2246	2248.5
6	6-a	2082	2088	2090.5	2091.5	2092	2094.5
	6-b	2169.5	2179	2180.5	2181.0	2182.5	2183.5
8	8-a	2244	2248	2251	2252.5	2254	2255
	8-b	2234	2240	2243	2244	2246	2247
	10-a	2164	2166	2166.5	2167.5	2168	2170
	10-6	2136.5	2138.5	2139.5	2141	2141.5	2143

Data Sheet 13

Average Temp = $60^{o}C$ MARSHAL STABILITY AND FLOW

Bitumen %	Stability			Flow		
	Gauge Rending	Load (kN)	Average (kN)	Gauge Reading 0.01mm	Average Reading (0.01mm)	Average (0.01mm)
2	16	0.7	0.70	375	16.5	16.3
	13.5	0.59		355	15.62	
	17.9	0.79		380	16.72	
4	18	0.79	0.90	400	17.6	18.0
	21	0.92		410	18.04	
	22.5	0.99		420	18.48	
6	24	1.06	1.12	430	18.92	20.2
	26	1.14		470	20.68	
	26.5	1.17		480	21.12	
8	23.9	1.05	1.16	515	22.66	23.5
	28	1.23		550	42.2	
	27	1.19		540	23.76	
10	25.9	1.14	0.94	680	29.92	28.2
10	20	0.88		630	27.72	
	18	0.79		610	26.84	

Calibration factor = 0.044kN/division

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