PAVEMENT FAILURE INVESTIGATION

CASE STUDY: KATABU - PAMBEGUA - JOS ROAD

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A thesis submitted to the Postgraduate School, Ahmadu Bello University Zaria, in partial fulfillment ot the requirements tor the award of the Master of Science (M.Sc) degree in Civil Engineering Construction Materials.

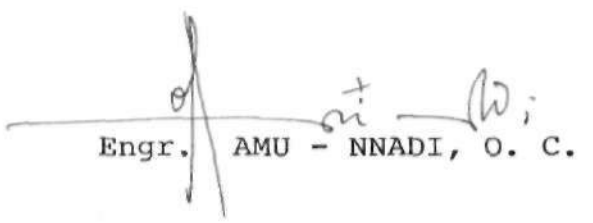
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JUNE, 1991

DECLARATION

This is to certify that this work/dissertation has been composed and compiled by myself and that it is a record of my own research work carried out in the Civil Engineering Department of Ahmadu Bello University and my past work experiences in the Federal Minisry of Works and Housing and also in the Pavement Evaluation Unit of the Federal Ministry of Works and Housing in Katabu, Kaduna State.

It has never been a presentation for a higher degree or diploma anywhere.



Engr. AMU - NNADI, O. C.

DEDICATION

This work is dedicated to my wife and children whose support saw me through to the eventual completion of the project.

CERTIFICATION

This thesis entitled PAVEMENT FAILURE INVESTIGATION CASE STUDY:- KATABU - PAMBEGUA - JOS ROAD by AMU- NNADI, O C meets the regulations governing the award of the degree of Masters 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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ABSTRACT

Pavement Investigation or Evaluation is the study which provides information to the general investment and planning programme and maintenance phases of pavement management. It assesses the deficiencies and defects of existing sections of pavement thereby pinpointing the rehabilitation needs or otherwise.

This case study centred on a selected major highway linking Kaduna and Plateau states i.e. Katabu - Pambegua - Jos Road whose pavement has tailed and is in a very deplorable condition. The most fundamental methods of laboratory and field tests have been adopted in the study i.e. CBR and materials classification and characterisation.

Some of the major causes of failure were identified as use of very poor quality lateritic materials, poorly graded stone base aggregates, use of asphaltic concrete which excluded some aggregate fractions with the resultant reduction in stability and resistance of the asphalt. Also, the compaction of various pavement layers was quite inadequate in addition to other poor workmanship.

From the test results of the investigation, some remedial measures, ranging from complete reconstruction in some sections to crack sealing and asphaltic overlay for the restoration of both structural and functional deficiencies of the pavement have been recommended.

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ABBREVIATIONS/NOTATIONS

AASHO - American Association of State Highways Officials.

AASHTO - American Association of State Highways and Transportation Officials.

MDD - Maximum Dry Density.

OMC - Optimum Moisture Content.

ASTM - American Society for Testing Materials.

CBR - California Bearing Ratio.

PI - Plasticity Index.

LL - Liquid Limit.

GI - Group Index.

MC - Moisture Content.

BS - British Standard.

WAS(C) - West African Standard (Compaction).

DD - Dry Density.

CRM - Car Road Meter.

RCI - Riding Comfort Index.

RSE - Rolling Straight Edge.

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CHAPTER ONE

1.000 INTRODUCTION

1.100 PREAMBLE

In all highway designs, the most important and the most critically studied and analysed item, apart from the bridges, is the pavement structure. The cost of the pavement in most major road constructions is between 33.33% and 50% of the capital outlay during construction. When a highway condition deteriorates rapidly during its life span, the cost of maintaining the pavement alone is usually 80% of the total maintenance cost. Also, in the event of total failure, the pavement takes more than 90% of the cost of reconstruction/rehabilitation or overlay as the case may be.

These explain why more emphasis is laid by all highway departments of the ministries involved in civil engineering works on the structural stability of the pavement.

In Nigeria, huge sums of money are spent on highway projects yearly. In some instances, some of these roads fail soon after construction, thus negating the purpose for which such sums of money were spent.

There is, therefore, the need to pinpoint the major causes of failure or rapid deterioration of some roads/highways in Nigeria. Since most road failures are noticeable on the pavement and since any failure arising elsewhere must be transmitted solely to the pavement as failure propagates, it is imperative that the study must

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start from the investigation of the causes and modes of failure on the pavement.

1.200 STUDY TARGET:

It will be difficult and time consuming studying all roads in order to come out with the major causes and mode of failure of our roads and highways. This study therefore investigated the mode and causes of failure of a particular road to show the study method; then, using the result obtained from this particular study, arrive at very useful information on pavement structural failure and stability so as to make some useful recommendations on the use of materials.

The road chosen for this study is Katabu - Pambegua - Jos road. This is a major road linking Kaduna and Jos through Pambegua and Saminaka, and serves as an important link between Kaduna, Plateau, Bauchi, Gongola and Borno States.

1.300 DESCRIPTION OF THE EXISTING ROAD CONDITION AND PROJECT AREA.

The road which was constructed between 1979 and 1982 at present has a pavement consisting of 150 mm each of laterite base and sub - base sealed with 40 mm binder and 25 mm wearing asphaltic concrete except, between about kilometer 140 and kilometer 221 where the base is of 150 mm crushed stone. These are the generally specified standard pavement layer thicknesses. Some portions of the road have

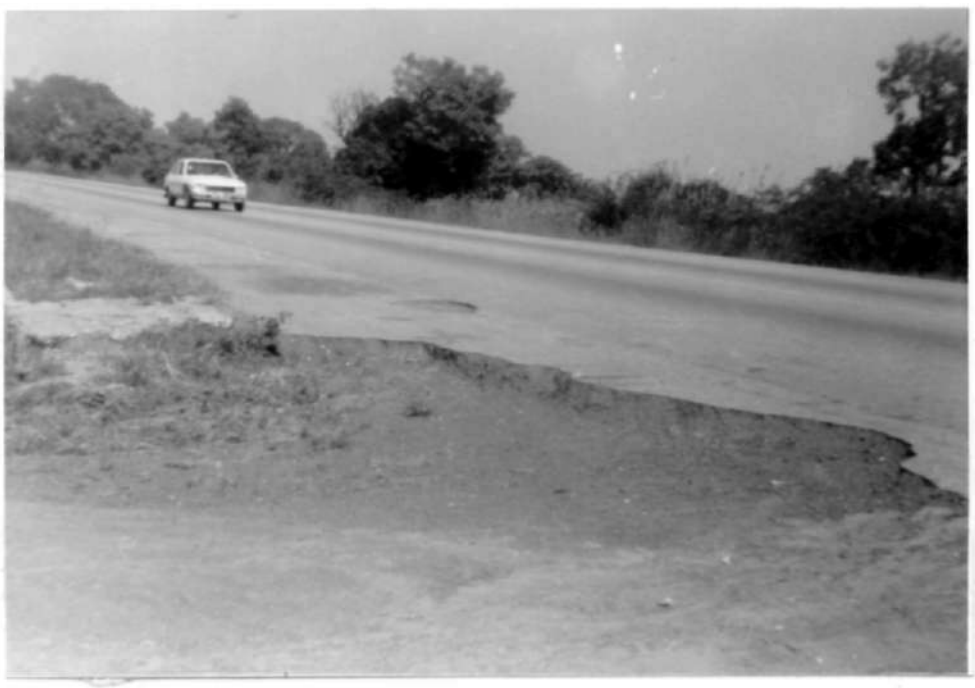


Plate 1: Surface bleeding, shoulder drop off and exposure to moisture infiltration.



Plate 2: Surface cracking, disintergration and then parmanent pavement deformat

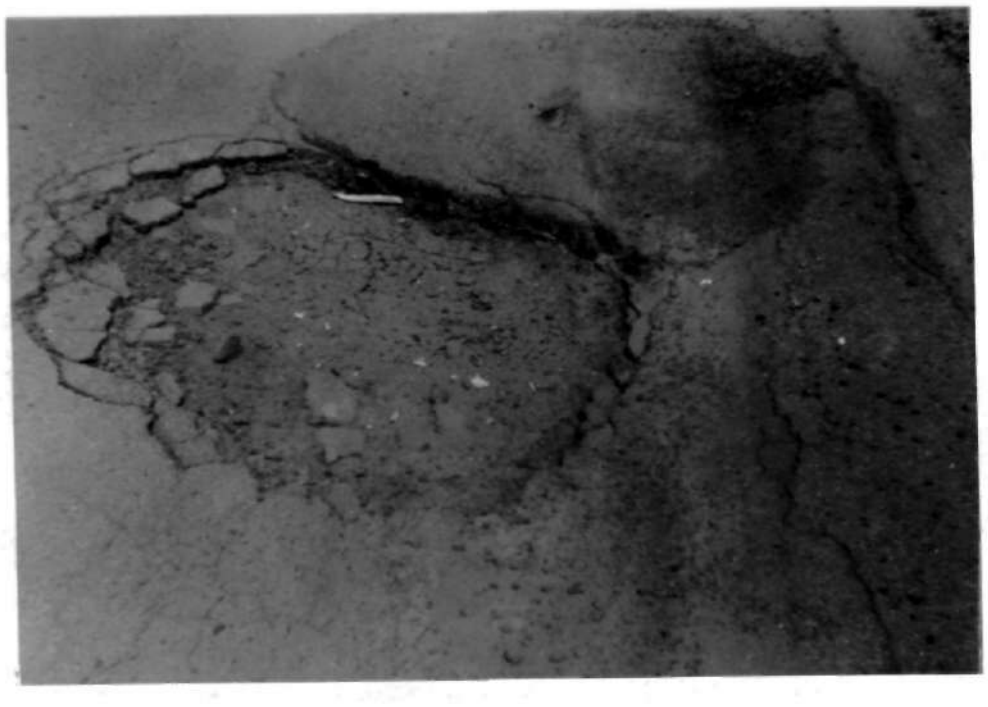


Plate 3: Surface shear, ravelling, separation, crack, disintergration, then large potholes.

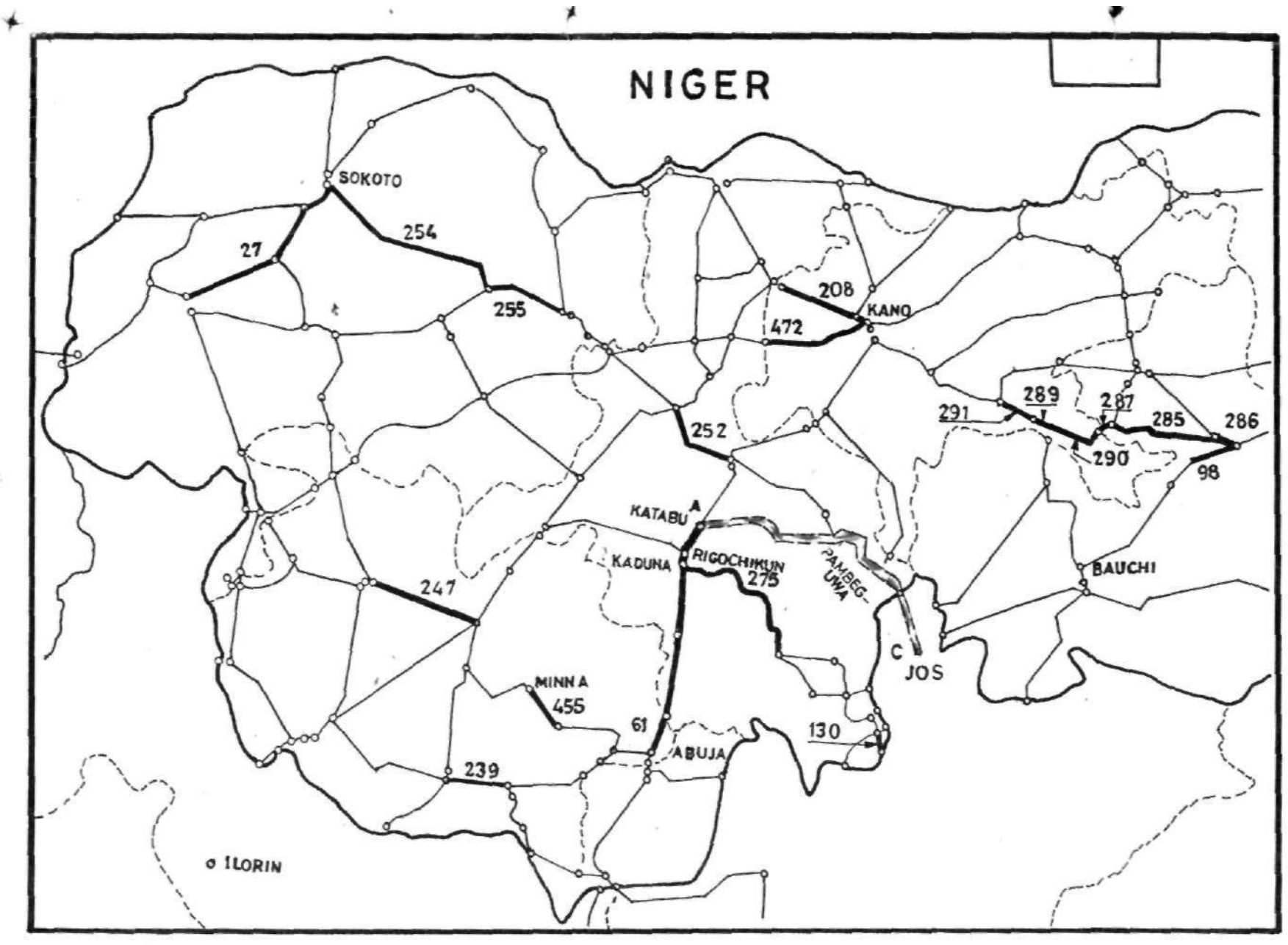


FIGURE 1:1: DESCRIPTION OF PROJECT AREA.
KATABU - PAMBEGUA - JOS ROAD

KEY:

AC = ENTIRE LENGTH OF KATABU - PAMBEGUWA - JOS HIGHWAY

1.600 METHODOLOGY.

The study of the pavement failures has been effected by adequate assessment of the pavement elements or layers of the selected road. Some tests which involve field work are classified as Field and Inspection Tests while other tests which involve investigation in the laboratory of quality and characterisation of materials are classified as Laboratory Tests. These tests are detailed below in general terms:-

1.601 Asphaltic Concrete (Wearing and Binder Courses)

The following tests were performed on recovered cores:-

(a) Laboratory Tests:-

(i) Measuring thickness of the binder and wearing courses (where seperable).

(ii) Determination of the Bulk Specific Gravity/ density of the recovered cores.

(iii) Determination of the Marshall stability.

(iv) Determination of the bitumen content by extraction.

(v) Grading test on left over aggregate after extraction.

1.602A Base:- Lateritic Base.

The following tests were performed on the lateritic base material:-

(a) Field Tests and Inspection:-

(i) Measurements of base thicknesses.

(ii) Determination of in situ dry density and moisture

content.

(b) Laboratory Tests:-

(i) Compaction tests on recovered materials.

(ii) CBR tests (soaked and unsoaked) on recovered base materials applying West African Compaction Standard.

(iii) Determination of the Atterberg Limits - Liquid, Plastic and Shrinkage Limits.

(iv) Grading tests (Particle Size Distribution) on recovered materials.

1.602B Base:- Crushed Stone Base.

The tests below were performed on the crushed stone base materials:-

(a) Field Tests and Inspection:-

(i) Measurement of base thickness.

(ii) Determination of in situ dry density and moisture content.

(b) Laboratory Tests:-

(i) Compaction and CBR tests applying modified AASHTO Compaction Standard.

(ii) Grading the aggregates of the recovered crushed stone base materials.

1.603 Sub - Base.

The following tests were performed on the sub -base:-

(a) Field and Inspection Tests.

(i) Measurement of sub - base thickness.

(ii) Determination of in situ dry density and moisture content.

(b) Laboratory Tests.

(i) Compaction tests - applying West African Compaction Standard - on recovered materials.

(ii) CBR (Soaked) test - applying West African Compaction Standard - on recovered material.

(iii) Determination of Atterberg Limits - Liquid, Plastic and Shrinkage Limits - on recovered material.

(iv) Grading tests on recovered sub - base materials.

1.604 Subgrade.

The following tests were carried out on the subgrade materials:-

(a) Field and Inspection Tests:-

(i) In situ dry density and moisture content tests.

(ii) Determination of moisture contents deep down into the the subgrade at 50cm, 90cm, 150cm and 200cm from formation level to determine the water table position if it is near the surface and the depth/extent of use of good materials.

(b) Laboratory Tests:-

(i) Compaction test - using the British Standard Compaction effort method.

(ii) Soaked CBR test - using the British Standard Compaction method.

(iii) Determination of Atterberg Limits - Liquid, plastic and Shrinkage Limits - on recovered materials.

(iv) Grading tests on recovered subgrade materials.

1.700 TRAFFIC COUNT AND TRUCK AXLE LOAD MEASUREMENTS

There is no way a failure investigation will be carried out without an investigation into the volume and distribution of traffic as well as the axle load distribution for the trucks and other heavy vehicles (truck weight). Traffic count and axle load measurements were carried out at locations along the road using Federal Ministry of Works and Housing's handy movable weigh bridge.

1.800 GENERAL REVIEW.

Finally, a general review was made of the field and laboratory test results and observations. From these, causes of failure were established and then recommendations and suggestions made based on the findings. Extent of compliance with the existing Federal Ministry of Works specification was also considered.

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CHAPTER TWO

2.000 LITERATURE REVIEW

2.100 ROAD/HIGHWAY DEVELOPMENT IN NIGERIA

It is widely recognised that the socio - economic development, growth and progress of a country are dependent on the provision of adequate transport facilities. Roads in Nigeria have developed over the past eighty years from bush paths and tracks to modern expressways and other types of highways. According to a policy outlined by Sir Percy Girouard, a transport expert and successor to Sir Federick Lugard, early efforts on improvement were directed towards the clearing of paths through the bush "say of ten to twenty feet in width" to cutting of drifts on unbridged streams and construction of bridges where practicable.[1] The policy further stated that "until the time arrives when natives will adopt wheeled transport, there would appear to be little advantage in clearing broad roads and none whatsoever in the construction of metalled ones". Therefore, no special consideration was given to pavement at all.

In 1904, a cart road for mule and ox - cart was begun soon after the seat of the Northern government was established in Zungeru, firstly to reduce the tremendous strain thrown on the inland provinces in the provision of carriers (porters) and secondly because it was hoped that the earthworks would be suitable for eventual construction of light railway. An outfit for a superintendent of Roads had been established in Calabar in the East as early as 1903. In the West, roads were built out from the railway as

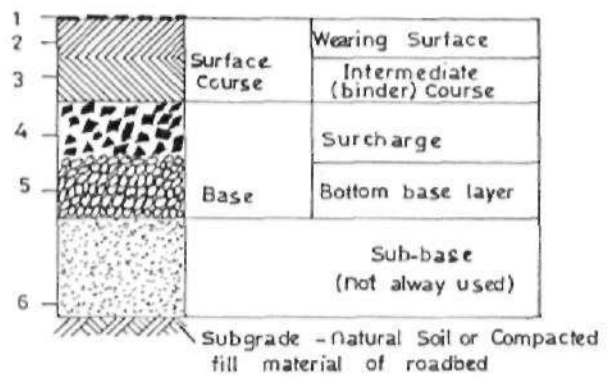
it was being extended north from Lagos. For example, in 1906 road motor services were opened from Ibadan, Oshogbo and Ede on the railway to Oyo, Ilesha and Iwo; and by 1914, about two thousand miles (3,200 kilometers) of road had been built which were motorable.

As road haulage is a most important means of transport in Nigeria, the roads themselves must not only be able to cope with the needs arising from economic expansion but should also act as catalyst to further growth. It then became necessary to improve on the road strength, hence the pavement consideration came into being.

From a total of 3,200 kilometers in 1914, the road network increased to 65,704 kilometers at the time of independence in 1960; and now to an estimated total of 120,400 kilometers, comprising both unpaved and paved roads.

2.101 PAVEMENT STRUCTURE

The pavement structure normally consists of a few layers of strong materials to ensure adequate pavement stability under traffic loads and environmental impacts. Beyond the strength to carry anticipated traffic and resist atmospheric and climatic conditions, pavement should be even, so that vehicles can move at high speeds without discomfort. The road surface texture should be rough enough to provide adequate skid resistance and also be wear resistant. In addition, the pavement should comply with



Legend : 1. surface treatment ; 2. medium textured asphalt concrete; 3-Course asphalt concrete; 4- bituminous penetrated crushed stone; 5- crushed stone; 6- sand.

fig 2.1 | pavement structure definition and composition. (2)

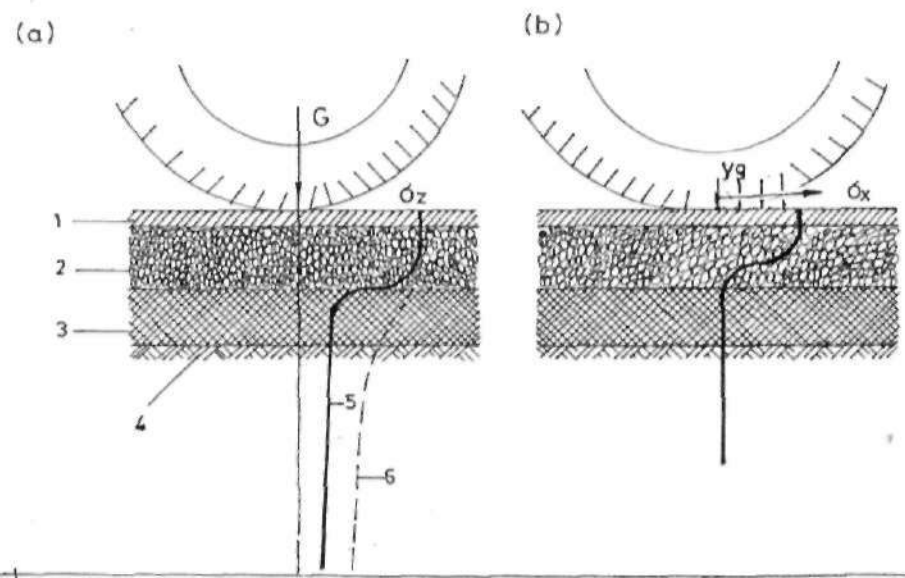


Fig. 2.2 | Distribution of (a) Vertical and (b) horizontal stresses induced by wheel loading in the multilayered pavement (2)

Legent: 1 - Surface course ; 2- base course; 3 - Subbase; 4 subgrade; 5 - actual stress profile; 6- theoretical, in elastic isotropic halfspace.

health and environmental requirements of the locality. The schematic structure of a high quality pavement is shown in Figure 2.1 (2) above.

Generally speaking, pavements may be divided into two broad classificationa, viz:- Rigid and Flexible pavements. The term rigid applies to wearing surface whose bases comprise of portland cement concrete while flexible pavements refer to all other types of pavement. There is also the composite pavement which is a combination of both rigid and flexible types. The principal elements of the pavement structure are surfacing materials, base course, sub - base course and subgrade. See Figure 2.1. The bases and sub - bases are constructed of materials of lower strength than those used for wearing surface (quality of materials decrease with increase in depth). The materials may be placed in lifts with strength of the courses decreasing away from the surface as the stresses created by wheel loads abate downwards. (See Figure 2.2) (2) above.

2.102 PAVEMENT DESIGN METHODS

The behaviour of flexible pavements under wheel loads is a fairly complicated matter which hardly lends itself to description by mathematical methods only. Consequently, no uniformly acceptable procedure exists to design and establish pavement thickness. Designers in different locations therefore employ a variety of methods for the purpose. Below are some of the widely used methods of

design:-(3)

(a) Methods derived from empirical studies of pavement performance e.g U.K. Method; Catalogue of Structures (French Method); AASHTO Method.

(b) Methods which either use or are derived from theoretical studies of the mechanical behaviour of the pavement and its elements - Analytical Method.

2.103 PAVEMENT DISTRESS

Pavement distress is the condition of a reduction in the serviceability of the pavement. Serviceability of pavements reduces with the age of the pavement. There are several types of distress which can be grouped into three main categories or classes, namely:-

(a) FRACTURE: Which is the condition of a pavement being broken apart e.g fatigue cracking, spalling, slippage, etc

(b) DISINTEGRATION: Which involves decomposition or abrading into constituent elements e.g stripping, ravelling, scaling, potholes, etc

(c) DISTORTION: This involves change in shape of pavement component from its original shape and condition such as rutting, shoulder drop off, etc

DISTRESS MANIFESTATIONS

2.104 PAVEMENT FAILURE

Failure of a pavement is generally not pronounced as in the catastrophic failure of a steel rod in tension or the collapse of a concrete beam in both tension and compression.

A pavement is considered failed if at a point certain of its characteristics such as riding quality reaches an unacceptable limit, as a result of both environmental and traffic effects or when the distress from the system exceeds an acceptable level. There are however two major types of failure:-

(a) Functional failure

(b) Structural failure

Functional failures occur if the pavement no longer can sustain or carry its function. Functional failure is an indication of a loss in performance.

Structural failure is the type whose manifestation is a breakdown of one or more of the pavement components. Structural failures may occur due to surface fatigue; failure of or shear developing in the surface layer, base, sub base or even the subgrade ; and also consolidation.

2.105 SUBGRADE FAILURE

This is usually caused by inadequate compaction and excessive moisture content. Also thin pavement layer and / or very heavy traffic loads resulting in excessive

rutting, fatigue, or cracking (alligator types).

Cracks have been classified into three main groups: classes I - III.[4]

CLASS I :- These are longitudinal cracks in the wheelpaths. They are not inter connected with short transverse cracks. They are many and often criss - cross.

CLASS II:- These are the types which have progressed into being interconnected and exhibit a grid pattern. This type of cracking is commonly refered to as Alligator Cracking. The crack pieces are always intact and disintegration is yet to start.

CLASS III:- This is progressing cracking from class II resulting in spalling occuring at the edges of the cracks. The segments of the pavement surface loosen and pieces may usually move under traffic loads. Ingress of water then occurs resulting in eventual pot holing and total failure.

2.108 TRANSIENT STRESS ON PAVEMENT UNDER LOADS

The distribution of wheel loads of the traffic carried by a normal road whose strength is subject to the effects of a range of temperature and moisture conditions, generates a very wide spectrum of transient stresses and strains within the pavement.

The heaviest wheel loads in combination with extremes of temperature and adverse moisture conditions in the

stress/strain being passed on to the subgrade cause severe failures. Even when the pavement is well designed and carefully constructed, but the subgrade is of very poor quality and workmanship, a little stress when fully propagated will immediately cause failure on the sugrade which in turn results in the failure of all the pavement components being carried by the subgrade.

2.106 SUB BASE/BASE FAILURE

This may be attributed to a number of causes which include:-

(a) Use of very poor materials.

(b) Use of very thin surface layer.

(c) Inadequate compaction.

(d) Loss of lateral support to the base/sub base.

(e) Poor drainage.

The road base and/or sub base carries the surface layer
he pavement. Therefore, any failure in the base results
face failure also.

SURFACE FAILURE

ailure can occur if any of the supporting
ts fails; or when the thickness of the
igned for the unexpected load; when
terial is used or when the workmanship

e is manifested by shear failure,

subgrade produces values of stresses and strains which may approach ultimate values; while less damaging combinations will produce stress/strain values likely to contribute cummulative deformations and cracking which may lead to final failure.(5)

The early life of flexible pavements is characterised by rapid but limited permanent deformation. The normal result of this "compaction" phase is to improve the stiffness and strength of the road to an extent which depends on the type of construction and materials used.

As the degree of under design or use of poor materials increases, the proportion of damaging stress and strain increases also, and the development of distress is correspondingly more rapid until the deterioration of pavement associated with the initial compaction stage continues until a failure condition is reached. Visible evidence of failure is the development of rutting, followed by cracking and break - up of the road surface.(5)

The Nigerian standards usually specify unique or constant parameters to define test limits or values that may be safely allowed. However, the parameters that characterise quality of materials and construction practices are seldom unique. Every parameter possesses some level of randomness and, as such, the specifications should not only limit mean values but also the spread of the distribution.

2.109 MAJOR CONCLUSIONS/DEDUCTIONS FROM PREVIOUS STUDIES IN NIGERIA

CONCLUSIONS

(1) Good quality lateritic materials are not easily available in many parts of Nigeria, and when found have to be hauled over long distances. The commonly available base materials have a CBR range of between less than 40% to above 80% , and most times have excess of fines and Plasticity Index of above 12.(6)

(ii) The moisture contents in the base/sub base layers for roads studied were lower than its optimum moisture content at the end of rainy seasons, when it should be at its maximum. This factor itself permits the use of lower CBR material when test is to be carried out at its optimum moisture content.

(iii) The Federal Ministry of Works and Housing has followed the policy of adopting several worldwide accepted material and construction specifications.(7) However, care should be taken, as modifications may always be needed to adopt these standards to the particular material and environmental conditions of Nigeria. For example, a limiting value of plasticity index (PI) of subgrade may not be required in certain parts of the world, but a specification is essential in Nigeria whose subgrades are often comformed by lateritic clayey gravel deposits to control the PI of the subgrade fines.

(iv) Very poor construction practices and improper control of material quality contribute to major failures.

2.110 PAVEMENT EVALUATION TECHNIQUES

Pavement evaluation is a detailed, systematic and periodic programme of monitoring the performance of the in - service behaviour of pavements. Pavement evaluation provides information to the highway agency concerned with the administration of highways. All information necessary for proper pavement management, from the time of planning, constructuion and so on, up to the time of maintenance, rehabilitation, overlay or when the pavement might have deteriorated or failed completely. In the case of new road pavements, information from existing section serve as "feed bacK" to design and construction.

Therefore, evaluation is essential to good management. It is tied to all the phases (investment, programming, design, construction, maintenance and research) and it is impossible to operate effectively without such information, especially in very developed countries where technological advancement has made it easy and functional. In developing countries such as Nigeria it has not been very easy, and it will not be in the near future , to effectively evaluate our pavements. However, a Pavement Evaluation Unit has already been established in the Nigerian Federal Ministry of Works and Housing for this purpose. This Unit is grossly inadequate for all the road pavements in the country.

The degree of detail and frequency of measurement necessary in the pavement evaluation depends upon the situation and the particular requirements of the agency

involved. Whatever the agency, however, there should be a recognised or specific evaluation within the overall set of activities.

2.111 PURPOSE OF PAVEMENT EVALUATION

The measurement of pavement characteristics and the evaluation of the data acquired have three main objectives viz :-

(1) To check whether the intended function and expected performance are being achieved.

(2) To provide information for planning, rehabilitation/overlay or other remedial measures for the existing pavements.

(3) To provide information for improving the technology of design, construction and maintenance.

2.112 MAJOR TYPES OF PAVEMENT EVALUATION

The evaluation of pavements for the previously listed objectives can involve one or more of the following:-

(i) Structural capacity assessment.

(ii) Physical deterioration or distress evaluation.

(iii) Evaluation of user - related factors such as riding comfort, safety and appearance.

(iv) Evaluation of user - related costs and benefits associated with varying serviceability and with various rehabilitation measures.

2.113 FACTORS THAT CAUSE PAVEMENT DETERIORATION

A large number of factors acting simply or in combination can affect the rate of deterioration of a pavement and thereby affect its serviceability to users. These generally fall into the following classes:-

(i) Traffic factors.

(ii) Climatic and/ or environmental factors.

(iii) Pavement layer thickness.

(iv) Pavement layer materials and subgrade characteristics.

(v) Construction factors.

(vi) Maintenance factors.

Though not most of these are controllable, all of them need to be considered in pavement management system. The effects of these factors are various forms of deterioration, such as decreased structural capacity for carrying loads, increased roughness distress (ie cracking, disintegration, distortion, etc) and decreased skid resistance.(8)

2.114 METHODS OF EVALUATION

The evaluation of structural or load carrying capacity of a pavement can be conducted in either one or both of two basic ways. The first involves laboratory testing of the materials and use of results to estimate the structural capacity of the layers in which they are incoporated. The second is to measure the structural capacity directly by in

- place tests combined with laboratory tests, some of which are :-

Elastic layers structural analysis, for example, requires properties from tests such as:-

(i) Complex Modulus (dynamic)

(ii) Resilient Modulus (dynamic)

(iii) Flexural Stiffness

(iv) Dynamic or Static Indirect Tension

(v) Stiffness Modulus by (indirect) Nomograph means

Viscoelastic layers structural analysis, as another example, requires properties from tests such as:-

(i) Creep Compliance

(ii) Relaxation

(iii) Complex Modulus

Without extensive field correction, drawing inferences about structural capacity from laboratory tests alone can be risky. Most authorities therefore prefer direct field tests to evaluate existing pavements. Some field tests commonly used includes :-

(i) California Bearing Ratio (CBR)

(ii) Plate Loading

(iii) Benkelman Beam

(iv) Dynaflect

In this study, the CBR method in addition to other field and laboratory tests have been used to evaluate the said road pavements. The Benkelman Beam and the dynaflect have not been used mainly because both facilities are not easily available and even when available require well

trained staff to operate them.

2.115 EVALUATING PAVEMENT SERVICEABILITY

The primary operating characteristics of pavement at any particular time is the level of service provided to the users. Variation of the level of service or serviceability with time is a measure of pavement performance. There are several methods of measuring serviceability at any particular time.

In some places Riding Comfort Index (RCI) is commonly used. It is a subjective measure of the riding "quality" provided by a pavement.[8] It represents the travelling publics' opinion and is usually measured by representative user rating panels. Procedures for obtaining user opinion of pavement riding quality by constituting rating panels and having the members of these panel drive over a number of pavement sections are well established and documented in the Association of Asphalt Paving Technologists Handbook.

The Car Road Meter (CRM) is another widely used approach to measuring pavement roughness. Car road meters have become so popular recently, the most common being the Mays Rider Meter or simply Maysmeter. It is normally a devise mounted on a station wagon. It is a simple electro - mechanical devise that measures the number and magnitude of vertical deviations between the body of the automobile station wagon and the centre of the rear axle by means of a flexible cable passing over a pulley and restrained by a

tension spring. It can also be mounted on a specially designed trailer of known weight and towed by a vehicle preferably a car.

Other methods such as the US Bureau of Public Roads type of roughometer, the Rolling Straight Edge (RSE) are also available. Roughness measurements from different devises are correlated with each other for one or both of the following reason:-

(i) Using one devise to estimate the output of another

(ii) Using one devise (generally the one that provides the more accurate and repeatable output) to periodically calibrate another whose output may vary with time and use.

The major use or objective of roughness measurements is for estimating (subjectively) the Riding Comfort Index (RCI). This require quite some capital outlay and therefore were not used in this study.

2.116 EVALUATING PAVEMENT SAFETY

Evaluation of pavement safety is usually thought of in terms of skid resistance. However, there are several safety components including :-

(i) Skid Resistance.

(ii) Ruts (as they relate to accumulation of water and the consequent dangers of hydroplanning plus loss of visibility due to vehicle spray)

(ii) Light reflectivity of the pavement surface.

(iv) Lane demarcation.

(v) Debris or foreign objects (especially where airport pavements are concerned)

There are several ways of evaluating these components but they could not be used in this study because it involves enormous funds, consumes time and involves quite a large number of personnel.

2.117 EVALUATING PAVEMENT DISTRESS

This is concerned with condition survey used periodically to measure and evaluate distress. Pavement surface condition is periodically measured by most authorities in terms of the ability of the structure to continue to provide the required service to the public.

Condition survey together with RCI, Skid Resistance and other measurements are used in determining the maintenance needed to prevent accelerated future distress or to determine the rehabilitation measures needed. Componenets of the condition surveys include the measurement of various types of and degrees of distress, such as cracking, deformation, and other defects. The following general classes of factors mostly considered are (8) :-

(i) Surface defects.

(ii) Permanent deformation or distortion.

(iii) Cracking.

(iv) Patching.

CHAPTER THREE

3.100 FIELD AND LABORATORY TESTS RESULTS

3.100 BACKGROUND INFORMATION ON STUDIED ROAD

Katabu - Pambegua - Jos road was constructed between 1979 and 1982. At present, it has a pavement consisting of 150 mm each of laterite base and sub - base sealed with 40 mm binder course and 25 mm wearing course asphaltic concrete except between about kilometer 140 and kilometer 221 where the base is of 150 mm crushed stone. These are the generally specified standard pavement layer thicknesses.

Various pavement distress categories of varying magnitudes and frequencies have occurred on this road, ranging from cracking, pavement deformation such as rutting; surface defects such as ravelling, surface seperation and bleeding; pavement failures such as pot holes (including the patched ones) and base shear; and shoulder drop off, to complete break up of all pavement structures in some sections. These distresses are slight and few between Katabu and Pambegua, but from Pambegua to kilometer 184.00 and then towards Jos the pavement failures are frequent and extensive. Various rocks and rock formations abound along the route.

3.101 FIELD TESTS

3.102 INSPECTION

Before the commencement of field tests, visual inspection of the whole stretch of road was carried out and

test points or locations established on embankments and cuttings at both failed and unfailed sections of the road. The procedure adopted for the field and laboratory tests were as stipulated in the latest edition of British Standards (BS 1377) OF 1975.

3.103 CORE RECOVERY ON ASPHALT CONCRETE

Use was made of the 10cm diameter core cutter. Before its use to recover cores from selected locations, depressions on the pavements were measured by pulling a strong string across the road width and recording the depth of depressions. Cored samples were recovered at failed and good sections. For the graphical presentation of depression measurements, see Figures 3.1 A and B.

3.104 INSITU DENSITY

In situ density tests were carried out on the base, sub - base and subgrade courses using the sand replacement method. The giant bottle was used for the stone base. Samples were collected carefully from each layer and tests made as earlier enumerated in the methodology of investigation (Table 3 - 2, A - G)

3.105 BORING

Using 100mm diameter post auger (hand auger), boring into the subgrade was carried out, noting and recording the depth of changes in the soil strata and collecting samples for grading, liquid limit and plastic limit tests. Moisture content was determined at depths of 30, 60, and up to 240cm

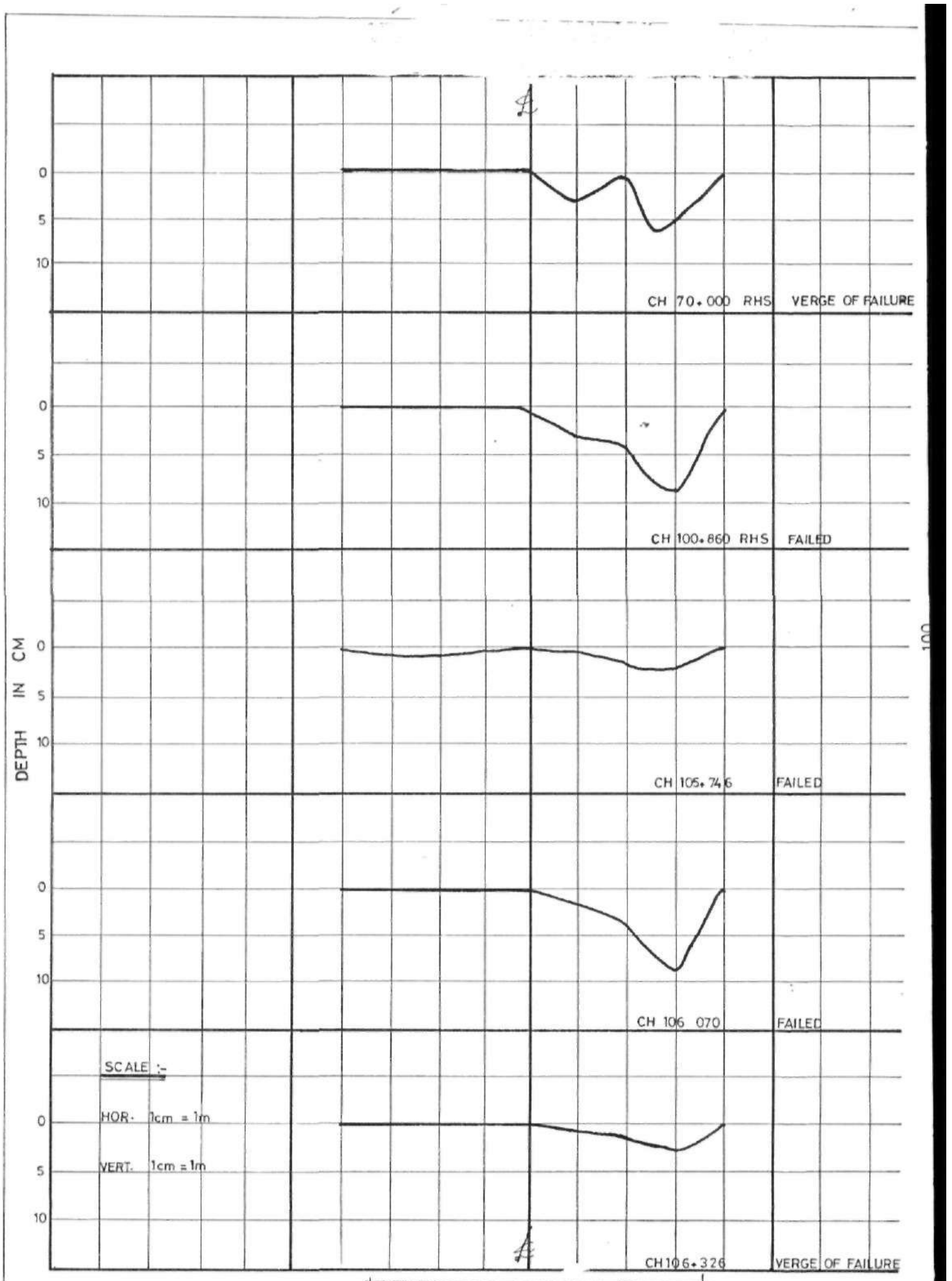


FIGURE 3 - 1 (A) SKETCH OF selected DEPRSSION

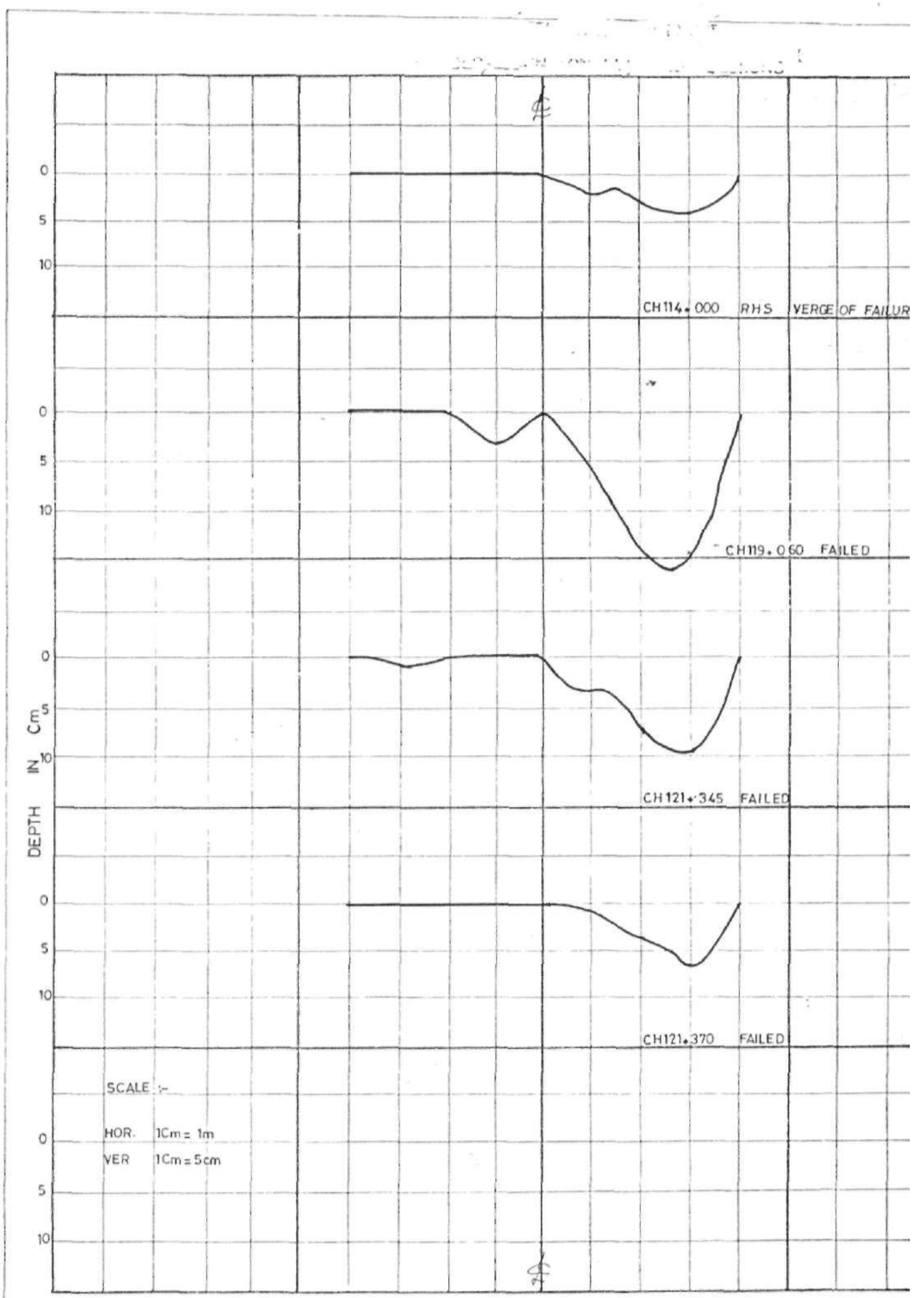


FIGURE 3 - 1 (B) SKETCH OF DEPRESSTION ON SOME SECTIONS

during the boring. For boring results and profile, see Tables 3 -1 (A - E) and Figures 3 - 2 (A - D).

3.106 WATER TABLE

Water was met in only one of the holes bored during the investigation. The investigation took place at the peak of the dry season and must have been responsible for the lack of water in most of the boreholes.

3.107 TRAFFIC COUNT AND AXLE LOAD WEIGHING

In an endeavour to assess how long. the existing pavement can sustain the volume of traffic that it is currently carrying and is expected to carry for its expected life span of 10 years, manual traffic count and axle weighing were carried out for seven days at Pambegua village using the Federal Ministry of Works and Housing movable weigh bridge . The counting started from 6am and ended at 12 midnight each day while the weighing was generally between 6am and 6pm each day except a day when weighing stopped earlier because the weigh bridge was damaged. The summary of the counting and weighing are recorded on Table (3 - 3) and (3 - 4) and Figures (3 - 4) and (3 - 5).

3.200 LABORATORY TESTS

The Federal Ministry of Works and Housing has some laboratories in Lagos and a few states such as Kaduna. The laboratory at the Pavement Evaluation Unit at Katabu is of world standard. The Highways Division of the ministry

AHMADU BELLO UNIVERSITY

SUMMARY OF BORE HOLE RESULTS

TABLE 3-1 (A)

KM	LOCATION	DEPTH IN CM	CLASSIFICATION USA (PRA)	SIEVE ANALYSIS 19mm	7	36	200	LL	PI	DEPTH IN CM	CLASSIFICATION USA	SIEVE ANALYSIS 19MM	7	36	200	LL	PI	INSTU MC -3M	-9M	+5M	REMARKS
10	051	07 - 21	A-7-6 (16)	100	85	78	74	48	25	21-36	A-7-6 (17)	100	96	93	90	51	28	17.6	18.0	17.5	Base & Subbase
		36 - 120	A-7-6 (13)	100	86	81	76	47	21												
17	966	00- 90	A-7-6 (12)	100	94	74	63	45	26	90 - 160	A-7-6 (16)	100	99	85	73	46	28	13.6	16.8	14.6	
		160 - 240	A - 4 (4)	100	99	73	53	27	10												
24	167	00 - 26	A-7-6(4)	100	77	50	42	42	20	26- 113	A-7-6(2)	100	95	47	37	41	20	13.8	11.1	18.0	
		113 - 240	A-7-6(18)	100	98	80	71	54	34												
31	920	06 - 21	A-7-6(6)	100	75	57	48	42	20	21- 36	A - 6 (2)	100	71	52	40	40	13	16.7	17.7	18.4	Base & Subbase
		36 - 108	A-7-6(6)	97	80	56	47	46	20	108-240	A-7-6 (17)	100	98	93	88	47	30				
44	650	09 - 45	A-7-6(8)	100	82	63	52	45	21	45- 60	A-2-7(0)	100	62	44	35	42	11	13.3	14.5	17.7	Base & Subbase
		60 - 107	A-6 (10)	100	93	77	55	33	24	107 - 274	A-7-6 (13)	100	89	68	60	52	26				
52	055	10- 25	A-2-6(2)	100	61	41	33	38	19	25 - 55	A- 2-6(1)	98	55	35	27	33	16	13.8			Base & Subbase
		55 - 130	A - 6 (9)	100	99	78	67	33	17												Rock Laterite met.
70	00	10 - 25	A-7-5(4)	97	74	55	48	44	12	25- 40	A-7- 6 (13)	100	98	96	94	47	19				Base & Subbase
		40 - 123	A-6 (10)	100	88	81	76	34	14	123 - 140	A- 6 (2)	94	50	40	30	40	13				
78	220	07 - 20	A-7-6(4)	100	67	46	37	52	23	20- 97	A - 2 - 6(2)	100	69	49	35	36	18	14.2	11.0	17.6	
		97 - 110	A-4 (4)	99	88	67	55	40	2	110- 134	A-7- 6 (9)	100	96	82	65	42	18				
		134- 150	A - 6 (8)	100	95	85	69	35	15	150 - 260	A-6 (9)	100	99	87	70	33	14				
100	018	09 - 24	A- 2-6(1)	99	61	44	35	30	15	24 - 39	A-6 (2)	99	69	49	40	29	13	9.4	6.7	7.5	Base & Subbase
		39 46	A-6 (6)	99	80	61	54	34	16	46 155	A-6(2)	100	82	65	58	38	20				

SUMMARY OF TEST RESULTS

TABLE 3-2 (A)

LOCATION KM	PAVEMENT LAYER	FIELD LABORATORY RESULTS																			INSITU RESULTS							REMARKS
		B.S.					W.A.S.					SIEVING % PASSING				LL.	PI=(LL-PL)	L/S	CLASSIFICATION U.S.(P.R.A)	THICKNESS OF BASE COURSE			INSITU DENSITY				
		MDD	OMC	C.B.R % AT OMC	C.B.R % SOAKING 4 DAYS	M.C AFTER SOAKING	MDD	OMC	C.B.R % AT OMC	C.B.R % SOAKED 24 HRS	M.C AFTER SOAKING	3/4"	NO 7	NO 36	NO 200					BEGINNING OF WORKS		END OF WORKS	DD	MC	% COMP	DATE	
3+000	BASE COURSE						1.98	12.0	93			96	33	17	12	32	10	8	A-2-4(0)			20.0	2.02	9.43	102	8-2-88	R.H.S
	SUB BASE						1.96	12.7		53	14.9	97	48	32	24	32	7	9	A-2-6(0)			15.0	1.98	10.11	101	"	CUT SECTION
	SUB GRADE	2.04	11.5		42	14.1						95	37	19	14	36	13		A-2-6(0)				2.05	8.85	100	"	UNFAILED
10+051	BASE COURSE						1.81	15.0	30			100	85	78	74	48	25	15	A-7-6 (16)			15.6	1.73	15.52	96	3-2-88	R.H.S.
	SUB BASE						1.80	15.5		20	17.5	100	96	93	90	51	28	13	A-7-6 (17)			15.0	1.76	17.60	98	"	CUT SECTION
	SUB GRADE	1.71	18.8		8	19.6						100	86	81	76	47	21		A-7-6 (13)				1.64	18.02	96	"	FAILED
17+966	BASE COURSE						1.89	13.0	65			100	77	51	35	38	15	13	A-2-6 (1)	15.0			1.88	11.96	99	8-2-88	L.H.S.
	SUB BASE						1.91	12.4		42	14.2	100	76	49	36	37	14	9	A-6 (1)	15.0			1.93	11.68	101	"	EMBANKMENT
	SUB GRADE	1.90	13.3		13	15.4						100	75	52	41	42	25		A-7-6 (5)				1.84	12.48	97	"	UNFAILED
24+167	BASE COURSE						1.98	11.5	44			100	77	50	42	42	20	13	A-7-6(4)			15.0	2.06	11.82	104	9-2-88	R.H.S.
	SUB BASE						1.95	11.20		14	14.1	94	78	57	51	37	22	11	A-6 (7)			15.0	1.93	12.39	99	"	EMBANKMENT
	SUB GRADE	1.78	14.0		4	18.5						100	98	79	65	35	25		A-6 (12)				1.69	14.19	95	"	FAILED
31+920	BASE COURSE						1.88	13.6	51			100	75	57	48	42	20	12	A-7-6 (6)	15.0			1.91	14.44	102	9-2-88	L.H.S.
	SUB BASE						1.87	13.7		46	16.2	100	71	52	35	40	13	10	A-2-6 (1)	15.0			1.84	16.85	98	"	CUT SECTION
	SUB GRADE	1.78	15.8		20	17.6						97	80	56	47	46	20		A-7-6 (6)				1.73	17.65	97	"	FAILED
44+650	BASE COURSE						1.85	14.0	47			100	82	63	52	45	21	13	A-7-6 (8)			15.0	1.92	12.26	104	20-1-88	RHS
	SUB BASE						1.93	12.5		25	14.7	100	62	44	35	42	11	13	A-2-7 (0)			15.0	1.90	13.30	98	"	EMBANKMENT
	SUB GRADE	1.74	14.6		7	20.6						100	95	86	75	33	24		A-6 (14)				1.58	16.17	91	"	FAILED
	BASE COURSE																										
	SUB BASE																										
	SUB GRADE																										

SUMMARY OF TRAFFIC COUNT

FROM MONDAY 6th MARCH — SUNDAY 13th MARCH 1988

TABLE: 3-3

LOCATION: PAMBEGUWA

TYPE OF VEHICLES	MONDAY 7 MARCH	TUESDAY 8 MARCH	WEDNESDAY 9 MARCH	THURSDAY 10 MARCH	FRIDAY 11 MARCH	SAT 12 MARCH	SUN 13 MARCH	REMARKS
PASSENGAR & PRIVATE CARS	610	718	785	798	954	1017	691	PEAK ON SATURDAY
LIGHT & MEDIUM COMMERCIAL VEHICLES	106	49	41	31	50	47	35	PEAK ON MONDAY
TRAILERS	58	47	43	73	51	57	68	PEAK ON THURSDAY
TANKERS		10	6	16	11	6	0	PEAK ON THURSDAY

SUMMARY OF AXLE WEIGHING

TABLE: 3-4

DAY & DATE	PERIOD	CONF:G	VEHICLE TYPE	TOTAL NO COUNTED	TOTAL NO WEIGHED	TOTAL EQUA FACTOR	MEAN EQUA FACTOR	COMPUTED STANDARD AXLES	DAILY TOTAL NO OF STANDARD AXLES	REMARKS
MON MARCH 7th	6cm-12pm COUNTING 6am-6pm	1.2	5 – 7 TON TRAILER	106	24	14.271	0.596	63.03		
		1.2 – 22		58	36	439,809	12.217	708.58	771.6	
TUE MARCH 8th	"	1.2	5-7 TONS TRAILERS	49	26	32.179	1.238	60.65		
		1.2 - 22		57	36	340.154	9.449	538.52	599.2	
WED MARCH 9th	"	1.2	5-7 TONS TRAILERS	40	7	6.139	0.877	35.08		WEIGHING STOPPED EARLIEAR
		1.2 – 22		50	9	62.805	6.98	348.52	384.00	
THUR MARCH 10th	"	1.2	5 - 7 TONS	31	18	20.81	1.156	35.84		OTHERWISE
		1.2 - 22	TRAILERS	73	40	937.256	23.43	1710.49		WEIGHING
		1.2 - 22	TANKERS	16	9	236.491	26.28	420.44	2166.77	WAS
FRI MARCH 11th	"	1.2	5 – 7 TONS	50	16	54.48	3.41	170.28		HITCH
		1.2 - 22	TRAILERS	51	31	829.014	26.74	1363.86		FREE
		1.2 - 22	TANKERS	11	2	78.599	39.30	432.29	1971.19	
SAT MATCH 12th	"	1.2	5 -7 TONS	47	20	57.412	2.87	134.92		
		1.2 - 22	TRAILERS	63	24	688.485	28.69	1807.27	1942.19	
SUN MARCH	"	1.2	5 -7 TONS	34	11	32,155	2.923	99.38		
		1.2 - 22	TRAILERS	69	37	1882.574	50.88	3510.75	3610.13	

GRAPH SHOWING THE TRAFFIC VOLUME

Fig 3-4

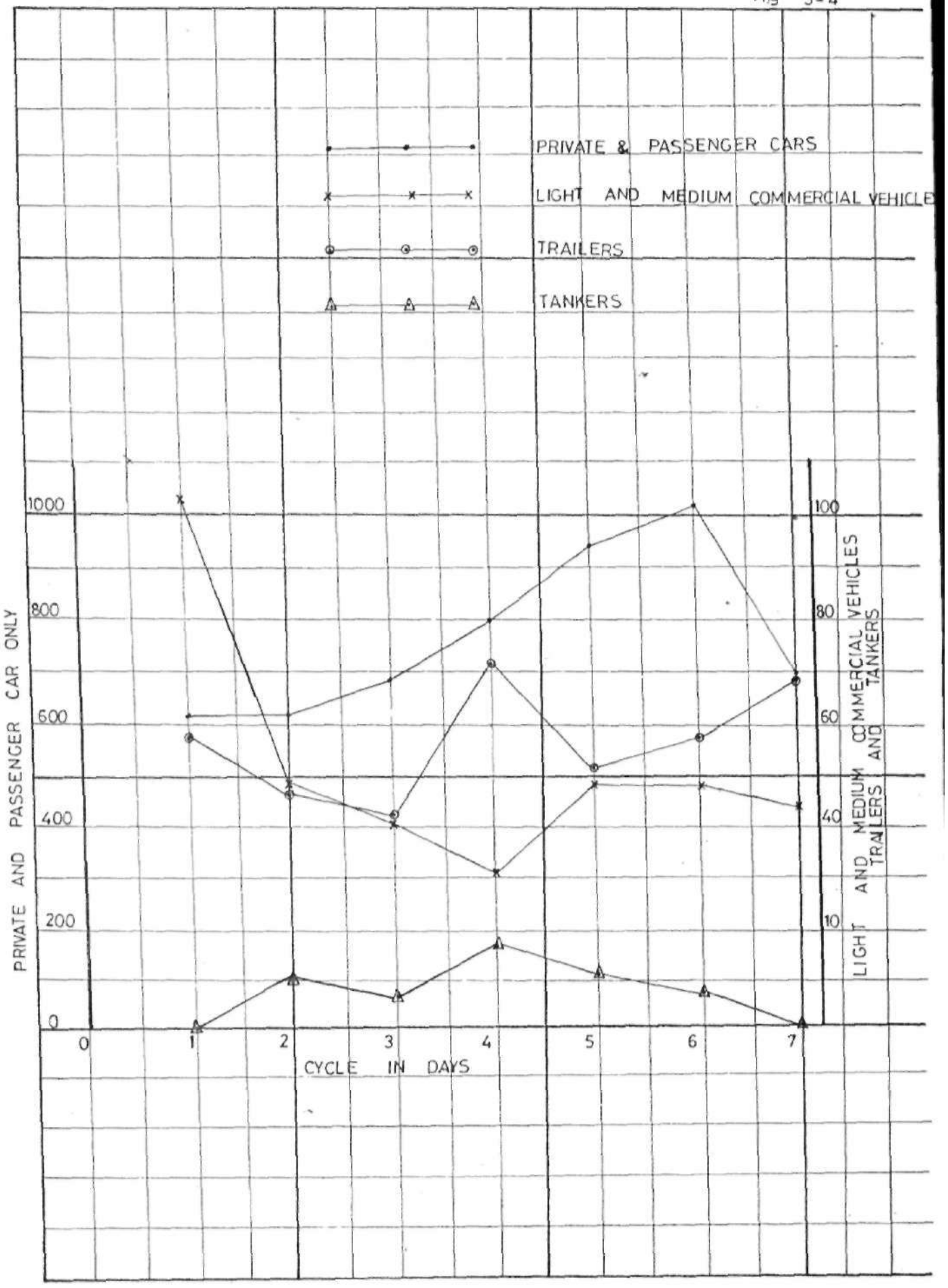


Fig. 3_5

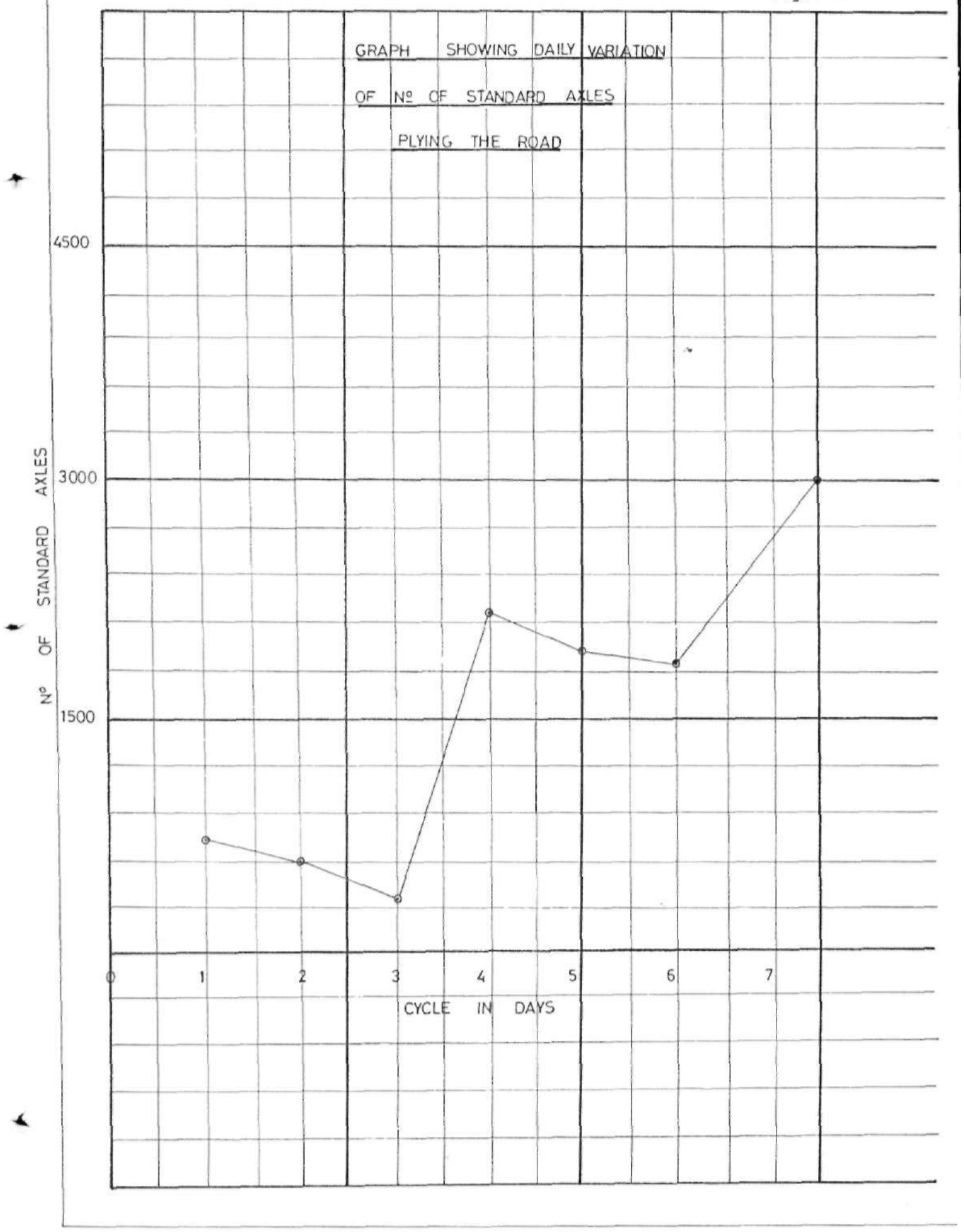
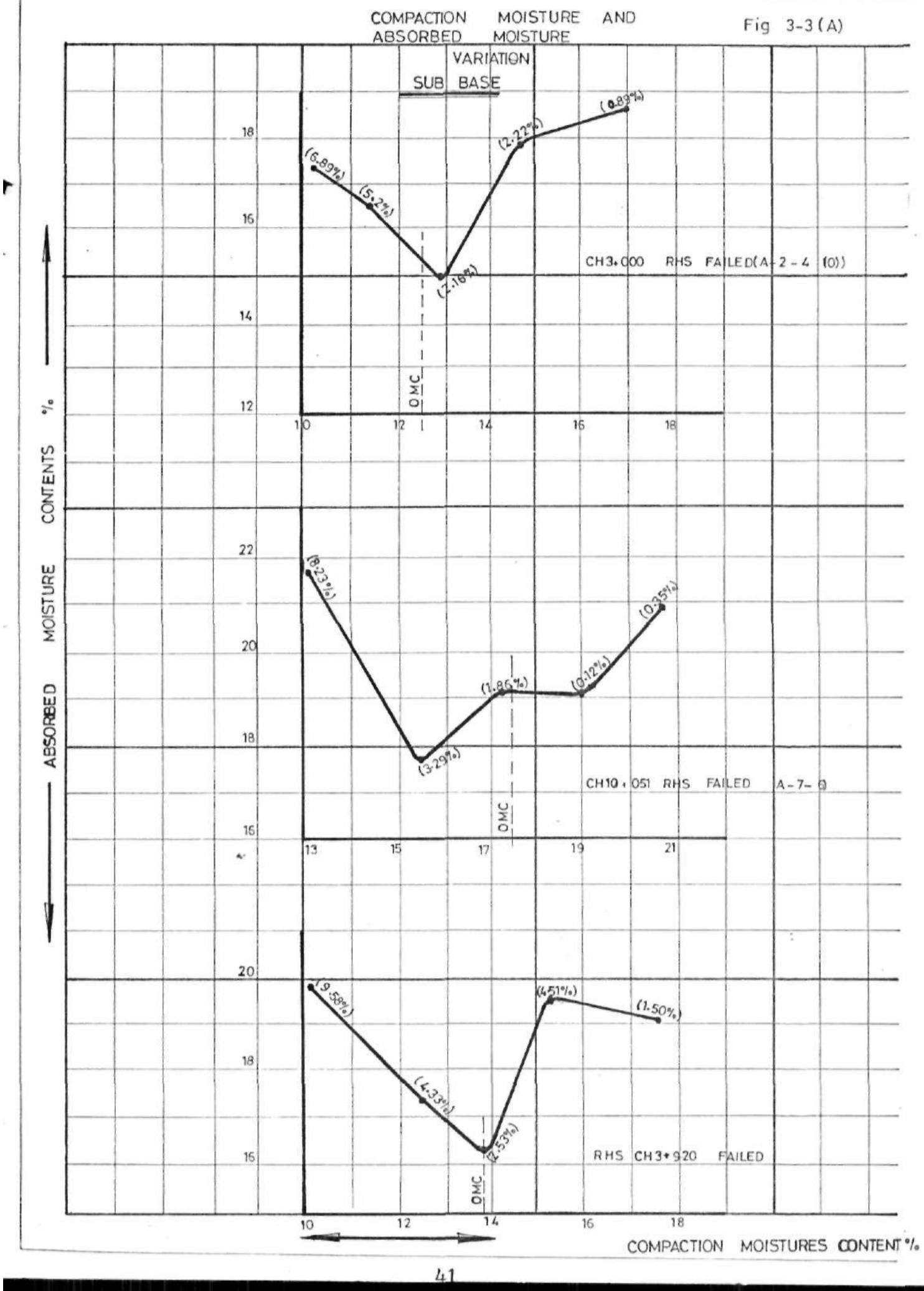

GRAPH SHOWING DAILY VARIATION
OF Nº OF STANDARD AXLES
PLYING THE ROAD
Nº OF STANDARD AXLES
4500
3000
1500
0
1
2
3
4
5
6
7
CYCLE IN DAYS

Fig 3-3 (A)


COMPACTION MOISTURE AND ABSORBED MOISTURE VARIATION
SUB BASE
CONTENTS % ABSORBED MOISTURE
(6.89%)
(5.2%)
(2.16%)
(2.22%)
(0.89%)
CH3.000 RHS FAILED(A-2-4 (0))
OMC
(8.23%)
(3.29%)
(1.86%)
(0.12%)
(0.35%)
CH10.051 RHS FAILED A-7-6
(9.58%)
(4.33%)
(2.53%)
(4.51%)
(1.50%)
RHS CH3+920 FAILED
COMPACTION MOISTURES CONTENT %

also maintains well equiped laboratories on sites of any on going project.

In this study, the laboratory in Dumbi site in use for the on going Kaduna - Kano road dualization project was used for all the laboratory tests.

3.201 ASPHALTIC CONCRETE CORES

The density of the recovered cores were determined by immersion while the specific strength (where possible) was measured by Marshall method. Using the hot extraction method, the bitumen content was determined and the aggregate left over were graded to ascertain the conformity with the specified grading. The result of the tests are shown on Table (3 - 5). Note that before the determination of both density and strength values, the thickness of each core was measured and recorded. See also Figures 3 - 6 (A - D).

3.202 ATTERBERG LIMITS ON BASE, SUB -BASE COURSE AND SUBGRADE MATERIALS.

Liqiud and Plastic Limit tests were performed on the lateritic base, sub - base and subgrade soils recovered from the boreholes. The shrinkage limit tests were limited to the lateritic base and sub - base materials only. The results are presented in Tables 3 - 1 (A - B) and 3 -2 (A -G).

TABLE 3 - 5

SUMMARY OF BITUMINOUS TESTS KATABU - PAM. - JOS Road.

NO.	Chainage.	Type of Coredsample			Average thickness of sample tested. (Calculated)	Bulk Density of sample Tested Mg/m^3	Marshall Test Results			Bitumen Content % of mixture	REMARKS From the field observations
		Binder Course	Wearing Course	Combined Course			Marshall Stability Unadjusted Kg.	Adjusted Kg.	Flow mm		
1.	Km3 + 000	Binder —	— Wearing	—	42.49mm 29.01mm	2.35 2.30	420.00Kg 187.00Kg	953.00Kg 851.00kg	4.10mm 2.90mm		
2.	Ditto	Binder —	— Wearing	—	37.20mm 29.84mm	2.37 2.31	288.00Kg 187 00Kg	872.00Kg 851.00Kg	3.10mm 1.90mm		Unfailed Sections
3.	Ditto	Binder —	— Wearing	—	19.19mm 49.04mm	2.34 2 32	NOT SUITABLE FOR TEST 420 00Kg	701.00Kg	4.30mm		
4.	Km10 + 051	Binder	— Wearing	—	40.33mm 30.34mm	2.40 2.24	379.00Kg 240.00Kg	948.00Kg 1000.00Kg	2.90mm 3.20mm		SUSPECTED BURNT ASPHALT FAILED SECT.
5.	Ditto	Binder —	— Wearing	—	51.88mm 18.00mm	2.40 2.21	552.00Kg NOT SUITABLE FOR	811.00Kg TEST	4.10 mm		FAILED SECTIONS
6.	Ditto	Binder —	— Wearing	—	45.10mm 25.38mm	2.80 2.22	396.00Kg NOT SUITABLE FOR	760.00Kg TEST	4.10mm		FAILED SECTIONS
7.	Km17 + 965	Binder &	Wearing	Combined Courses	65.42mm	2.29	720.00Kg	691.00Kg	5.20mm	RESULTS UNACCEPTABLE	UNFAILED SECTIONS
8.	Ditto	Binder &	Wearing	Combined Courses	66.50mm	2.29	552.00Kg	530.00Kg	5.40mm		UNFAILED SECTIONS
9.	Ditto	Binder &	Wearing	Combined Courses	67.05mm	2.29	744.00Kg	692.00Kg	4.50mm		DITTO
10.	Km24 + 167 RHS	Binder —	— Wearing	—	52.06mm 48.75mm	2.33 2.24	653.00kg 240.00Kg	959.00kg 410.00kg	4.10 mm 5.40mm	RESULTS UNACCEPTABLE	FAILED SECTIONS
11.	Km24 + 167	Binder	— Wearing	—	52.08mm 52.10mm	2.35 2.25	475.00kg 504.00kg	698.00kg 741.00kg	5.50mm 3.50mm		DITTO
12.	Ditto	Binder —	— Wearing	—	50.76mm 50.32	2.12 2.25	638 00 324.00Kg	995.00kg 505.00kg	4.60mm 4.50mm	— —	
13.	Km70 + 000 RHS	Binder —	— Wearing	—	40.68mm 52.00mm	2.32 2.31	528.00Kg 492.00Kg	1,319.00Kg 723.00Kg	4.20mm 3.16mm	5.09 5.37	ON THE VERGE OF FAILURE
14.	Ditto	Binder —	— Wearing	—	41.53mm 46.98	2.31 2.31	360.00Kg 444.00Kg	817.00kg 794.00Kg	4.27mm 3.50mm	5.45 5.80	DITTO
15.	Ditto	Binder —	— Wearing	—	49.68mm 45.71	2.32 2.31	451.00Kg 379.00Kg	704.00kg 728.00Kg	4.70mm 3.50mm	5.55 6.34	DITTO
16.	Km100 + 018	Binder &	Wearing	Combined Courses	55.02mm	2.33	600.00Kg	792.00Kg	4.60mm		
17.	Ditto	Binder —	— Wearing	—	34.39mm 33.03mm	2.37 2.32	250.00Kg ~~~~	891.00Kg 1256.00Kg	2.40mm 3.70 mm		
18.	Ditto	Binder —	— Wearing	—	38.62mm 28.49mm	2.40 2.30	264.00Kg 300.00Kg	734.00Kg 1499.00Kg	3.30mm 3.90mm		

3.203 GRADING TESTS.

Grading tests were performed on the base, sub -base and subgrade soils recovered from the boreholes using the wet sieving method. Grading test was performed on the stone base material. Results of these are shown in Tables 3 - 1 (A -E), 3 - 2 (A - G) and also Figure 3 - 7 (A -D) for stone base.

3.204 COMPACTION MOISTURE CONTENT COMPARED WITH ABSORBED MOISTURE CONTENT AFTER SOAKING

The variation between the compaction moisture content and the absorbed moisture content after soaking is graphically illustrated using each soil group of the sub - base and subgrade. Excess moisture over and above compaction moisture content is shown or written in bracket on the graph shown in Figure 3 - 3 (A - D).

3.300 CURRENT FEDERAL MINISTRY OF WORKS AND HOUSING SPECIFICATION.

The current Federal Ministry of Works and housing specifications that were used to evaluate the materials encountered in study are summerised below in Tables 3.7 (A - D) for each pavement element, starting with the subgrade.

3.301 SUBGRADES.

TEST	SPECIFICATION	PAGE No
Compaction	100% of MDD @ British standard effort	166
C.B.R.	Must be equal to or greater than 10% (48 hours soaking)	
% Passing sieve No 200	Not more than 35%	

Table 3.7 (A) : Specification for subgrades

3.302 SUB - BASE.

TEST	SPECIFICATION	PAGE No
Thickness	Not more than 0.013m (0.5") less than design thikness at any point	172
Compaction	Not less than 100% of maximum density at West African standard compactive effort	171
Laboratory C. B. R.	Not less than 30% after a maximum of 24 hours soaking at W. A. or Modified AASHTO compaction.	169
Plasticity Index	Materials with P.I. greater than 12 must be disallowed.	169
Liquid Limit	Materials with L.L greater than 30 may be disallowed at the engineer's descretion.	169
% passing sieve No 200	This must not be more than 30%	169

Table 3 - 7 (B) - Specification for Sub - base course.

3.303 BASE COURSE (LATERITIC).

TEST	SPECIFICATION	PAGE No
Thickness	Minimum of 15cm and not more or less than 0.07 design thickness.	172
Compaction	Not less than 100% of MDD at Modified AASHTO stnadard compaction:	171
C. B. R.	Not less than 80% at W.A standard or Mod. AASHTO standard (unsoaked)	169
Plasticity Index	Materials with P.I. greater than 12 may be disallowed at the engineer's descretion.	169
Liquid Limit	Materials with L.L greater than 30 may be disallowed at the engineer's descretion.	169
% passing sieve No 200	This must not be more than 16%	

Table 3-7(C) :- Specification for Base Course (larteritic)

3.304 BASE COURSE (STONE BASE)

TEST	SPECIFICATION	PAGE No
Compaction	Same for lateritic base.	171
Laboratory CBR	Same for lateritic base	169
Plasticity Index	This is to be non - plastic	169
Liquid Limit	As high as will give maximum compaction.	169

Table 3 - 7 (D) :- Specification for Stone Base.

Part of this specification is simplified and presented in tabular form and shown hereunder.

STANDARD COMPACTION TEST AND PROCEDURES

FEDERAL MINISTRY OF WORKS

TYPE OF TEST AND B.S. 1377-1975	SIZE OF MOULD	RAMMER		No. OF LAYERS	BLOWS PER LAYER	MATERIAL SPECIFICATION GENERAL
ORDINARY B.S.(PROCTOR)	A) B.S Mould Type A 1) 105mm ϕ 2) 1155mm ht 3) Ext collar 50mm	2.5kg (5.5 lbs)	300 (12 inches)	3	27	SUB-GRADE:- Not more than 35% passing No. 200 seive C.B.R- ≥ 10% 48 hour soaked B.S.(ORD) compaction.
	B) C.B.R Mould Type B 1) 152mm ϕ 2) 127mm ht 3 Ext. collar 50mm	2.5 kg (5.5lbs)	300 (12 inches)	3	62	
	Note :- For WASC and modify AASHO Same mould.					
WEST AFRICAN STANDARD COMPACTION (WASC)	AS C.B.R.-B Type mould	4.5kg (10 lbs)	450 (18 inches)	5	25	SUB-BASE :- 1. Not more than 30% passing No. 200 seive 2. Liquid limit ≤ 30 3. Plasicity Index < 12 4. C.B.R - 24hours soaked >30% (WASC COMPACTION.
MODIFY AASHTO COMPACTION	As B.S - B Type mould	4.5kg (10 lbs)	450 (18 inches)	5	55	
B.S. HEAVY COMPACTION	AS B.S.- A Type mould	4.5kg (10lbs)	450 (18inches)	5	27	BASE (1), (2), (3), same as sub-base. 4. C.B.R. Unsoated ≥ 80% (WASC AASHO OR B.S. HEAVY) COMPACTION.
	AS C.B.R.-B Type mould	4.5kg (10lbs)	450 (18inches)			

CHAPTER FOUR

4.000 INFERENCES AND EVALUATION OF THE ROAD PAVEMENT

These comments on the quality of construction materials and the general performance of the pavement are based on comparism of results and / with the Federal Minisbtry of Works and Housing Specificationns for Roads in Nigeria.

4.100 INFERENCES FROM TEST RESULTS

4.101 ASPHALTIC CONCRETE

During the investigation it was observed that in most cases the laid asphalt concrete may have been over heated and this might have contributed to failure in sections that are of good base and sub - base materials and are fairly well compacted (Km 114 - 228) as compared with the results obtained at Km 60 + 000; 70 + 000; 100 + 008 and Km 128 + 051 with very poor materials and inadequate compaction, yet clasified as unfailed (good). Because over heated asphalt becomes brittle on laying, little settlement on the pavement results in the breaking up of the asphalt under wheel load. This in addition to reasons listed below, may have been the cause of early failure.

4.101B ASPHALT THICKNESS

The specified thickness are 40mm binder and 25 mm wearing. From the thickness measurements, it was observed

that the asphaltic thicknesses were quite variable. In some sections, a single layer of either the binder course or wearing course was laid instead of two. In some areas the single layer of only binder course of 65 mm thickness was laid with the resultant rough and hard textured uncomfortable surface. In others, the sinlgle layer is the wearing grade asphalt concrete of 65 mm or less in thickness. The result in this case was a very non - stable asphalt concrete layer because the stability which would have been given by the coarser aggregates in the binder course is not there. It is also more difficult to reach the required compaction for a wearing grade of asphalt concrete thicker than 25mm. Yet in other sections where both binder and wearing courses were laid, the thicknesses were less than 40mm or 25mm for binder and wearing courses respectively, as specified.

4.102 BITUMEN CONTENT

The weraing course has an average bitumen content of 5.08% as against 6.0% design bitumen content, while the binder course has an average of 5.03% as against 5.5% as designed, for areas that have been recently overlaid; and less 3% - 4% in other areas. From test results it was confirmed that the bitumen content for both binder and wearing courses were within the specified range for the recent overlay only.

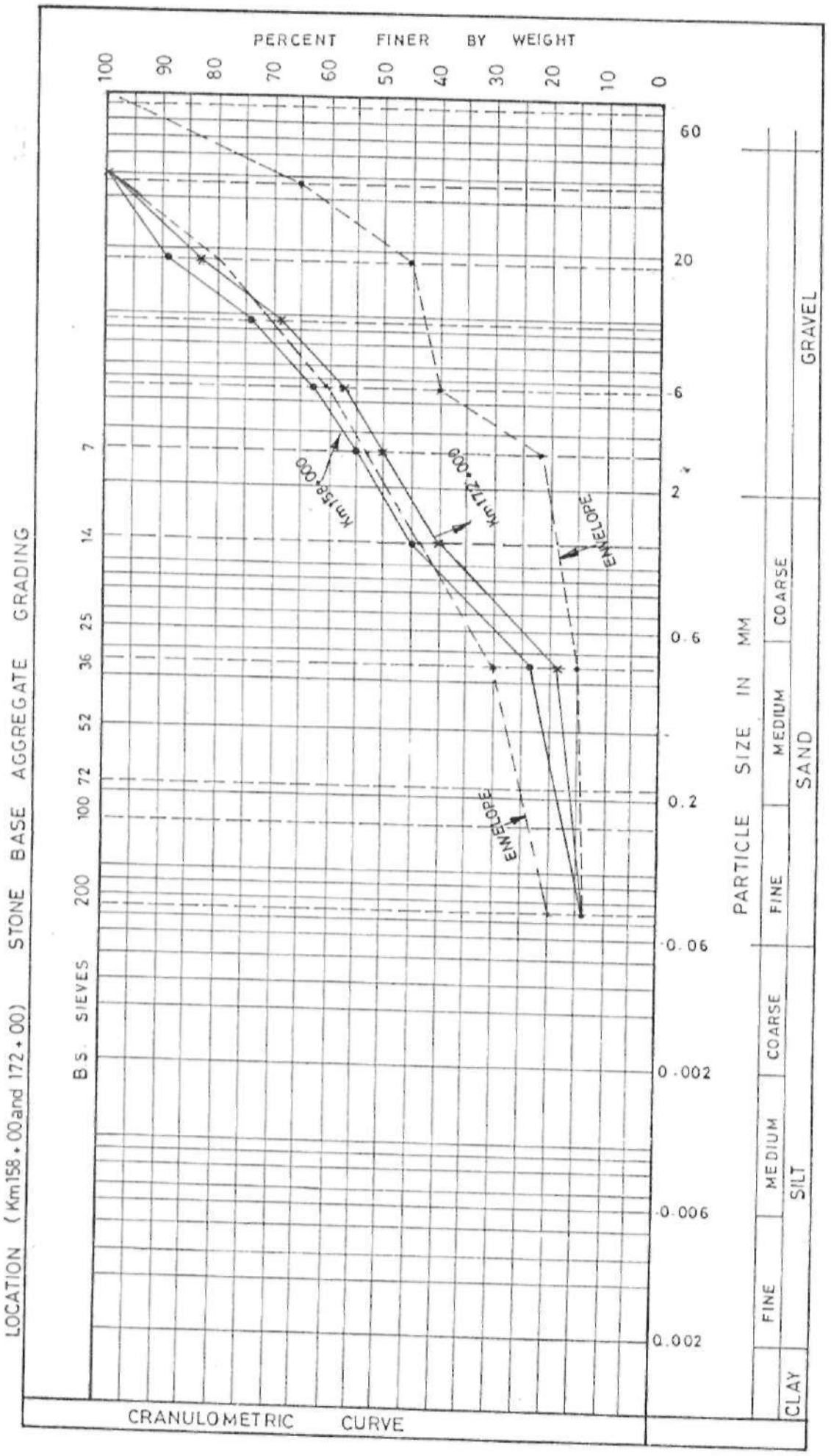

AGGREGATE GRADING
STONE BASE AGGREGATE GRADING
LOCATION (Km158+00and 172+00)
PERCENT FINER BY WEIGHT
100
90
80
70
60
50
40
30
20
10
0
B.S. SIEVES
200
100
72
52
36
25
14
7
60
20
6
2
0.6
0.2
0.06
0.002
0.006
0.002
Km158+000
Km172+000
ENVELOPE
ENVELOPE
PARTICLE SIZE IN MM
FINE
MEDIUM
COARSE
FINE
COARSE
MEDIUM
FINE
CLAY
SILT
SAND
GRAVEL
CRANULOMETRIC CURVE
STONE BASE AGGREGATE GRADING

FIG. 3-7 A

Modified AASHTO effort had been used. Such compaction would, however, have resulted in the reduction in the relative compaction.

4.203 LIQUID LIMIT, PLASTICITY INDEX

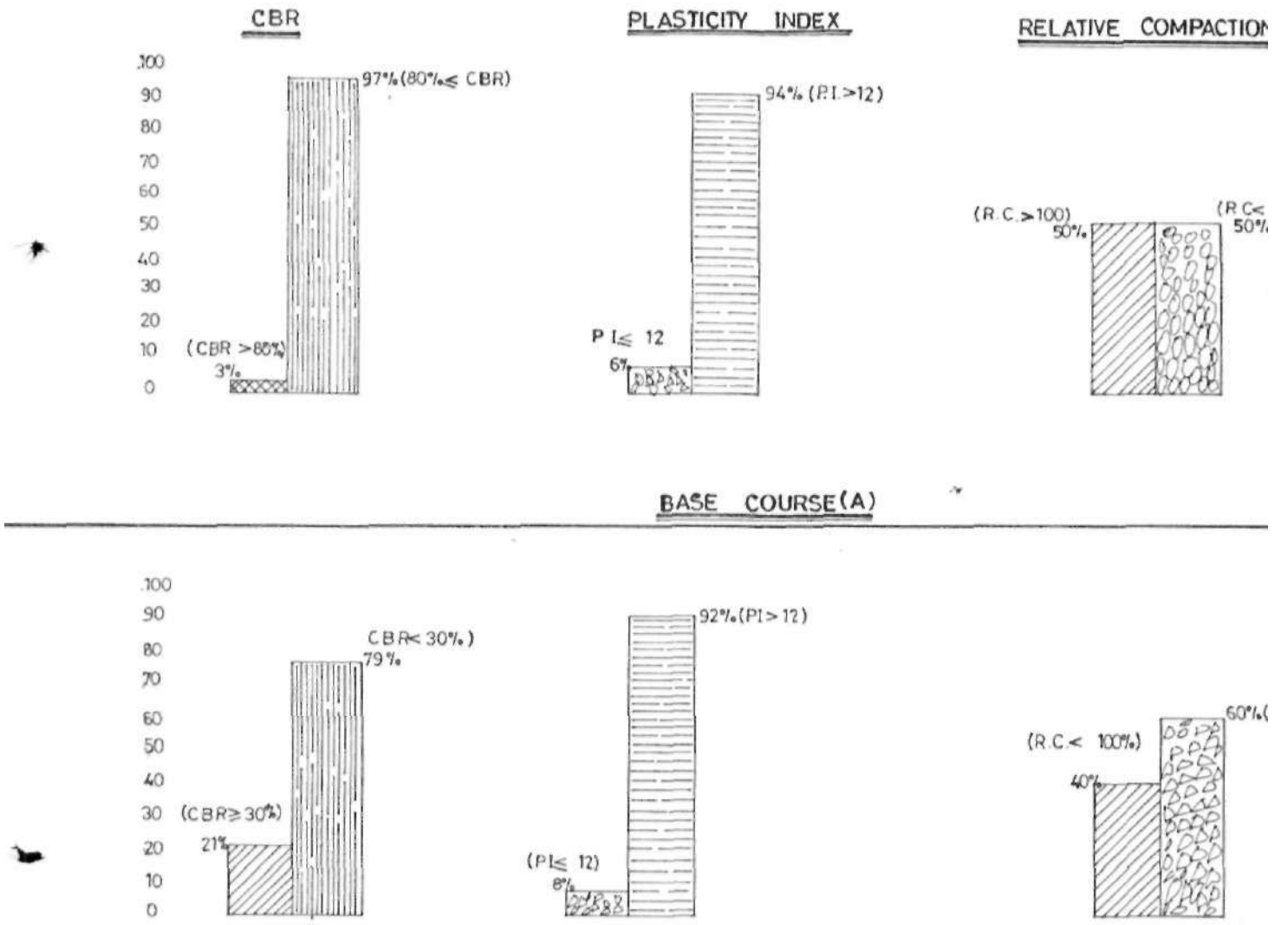
As can be seen from Figure (3 - 8)A, not up to 3% of the materials met the Federal Ministry of Works and Housing Specification of not more than 12% Plasticity Index. Also, in most cases the results indicated that the Liquid Limit exceeded the 30% limit. This confirms again that very poor clayey lateritic materials were used for the base course.

4.204 RELATIVE COMPACTION

From Figure (3 - 8)A, it can be seen that only about 50% of the results reached the desired and specified relative compaction of not less than 100%. The Relative compaction ranged from 91% to 107%. Out of 38 results only 19 reached the 100% relative compaction requirement. From these results, it is obvious that there had been no good compaction.

4.205 PERCENTAGE PASSING SIEVE No 200

The percentage of fines (those components passing the No 200 sieve) has a string of effects on the performance of the base material. Some fines is required to allow for effective compaction to an appripriate density. Too much fines will result in the reduction in the possible maximum density and strength and increase the susceptiblity to weakening from water infiltration or seepage.



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Fig. 3-8(A-C) Distribution / Varition of CBR, P.I., Relative Compaction and Fine Passing Sieve no. 200, For Base, Subbase and Subgrade Courses

Figure (3 - 8)A also indicates that less than 30% met the Federal Ministry of Works and Housing Specification of not more than 16% passing sieve No. 200 for base materials.

4.300 SUB - BASE MATERIALS

One of the purposes of the sub - base is to permit the building of relatively thick pavement at low cost. Thus, the quality of the sub - base course can vary within wide limits as long as thickness design criteria are fulfilled. Although base course materials should be of higher quality than sub - base materials, the limits for Plasticity Index and percentage passing sieve No. 200 (fines) must be controlled and never be allowed to exceed specification requirements.

4.302 LABORATORY CBR/STRENGTH TESTS

Figure (3 - 8)B shows also the parameters in respect of the sub - base materials. As can be seen in the figure and from other relevant tables, only about 21% of the results of tests reached the CBR value specified (30%). The CBR ranged from from 9% to 53% (soacked). Only nine out of 38 location tests met the minimum value specified. This shows that the sub - base materials also were of very poor quality.

4.303 LIQUID LIMIT, PLASTICITY INDEX

The liquid limit of the sub - base ranged from 29% to 52% while the plasticity index ranged from 7% to 33%. From Figure (3 - 8)B it can be seen that only 7.9% of the results

met the the specification of P.I. of not more than 12. The foregoing also confirms the fact that very poor materials had been used for the sub - base.

Also, the percentage of materials passing sieve No. 200 (fines) is quite high in the result. More than 60% of recorded cases show fine percentages of more than 40% which is a further confirmation that poor materials were used.

4.304 RELATIVE COMPACTION

The relative compaction of the sub - base materials varies from 86% to 106%. Only 15 out of the thirty eight locations or 40% had relative compaction of 100% and above. The result confirms that sub - base was also very poorly compacted.

4.400 SUBGRADE MATERIALS

The strength of subgrade, normally determines the thickness of the pavement. Hence, it is very desirable that materials for subgrade should be of fairly good quality, so that the pavement thickness and therefore the pavement cost will be reduced. However, when not very fair materials are available, care must be taken to ensure that the compaction achieved is very high.

4.401 RELATIVE COMPACTION

The relative compaction of subgrade ranged from 85% to 105%. Only 9 out of the 38 records/results of the test met the 100% relative compaction specified. This is only about 24% of the total location tests. From the previous records

in chapter three, on test results of subgrade, sub -base and base course, it is noticeable that the most poorly compacted is subgrade. (See Figure 3 - 8 C)

4.402 LABORATORY CBR/STRENGTH

Though no specified strength is recommended for subgrade materials, it is still worthwhile to analyse the CBR values obtained from the compaction tests. The subgrade values ranged from 4% to 42%. Some of these values are satisfactory except in a few locations where low values ranging from 4% to only 9% were obtained. It is worthwhile to note that these low values affected twelve tested locations. Six of them fell under poorly compacted subgrade and six under well compacted subgrade. There is definitely no doubt that the poorly compacted subgrade with low CBR values have had and will continue to have adverse effects on the pavement unless remedial measures are taken immediately (See Figure 3 - 8 C).

4.500 WATER TABLE, DRAINAGE, PERCHED WATER TABLES; UNDERGROUND WATER

It has been previously mentioned that water was found in only one of the boreholes probed and at a depth of about 2.3 meters. The fact that no water was found in other holes does not rule out the problem of perched water table or underground water during the rainy season, because of the hilly terrain of the area, since these holes were probed

during the dry season.

It was observed that surface dressing in some sections was not scarified before placing the stone base. This could result in localised slip surface or perched water table beneath the stone base if rain water percolates through the cracks on the asphaltic concrete.

The drains were overgrown with weeds while most of the existing culverts were silted up and turn outs are non - functional. From observations, test results and interviews with the local people, water poses a great problem to the road during the rainy season. Tables of recommendations and interviews are shown in Tables 3 - 6 (A - G).

4.600 COMPACTION MOISTURE/ABSORBED MOISTURE AND OPTIMUM MOISTURE CONTENT RELATIONSHIP

Changes in moisture content can affect the density and hence the strength of soil. The changes of moisture content can be seen from Figure 3 - 3 (A - D). This shows the importance of the compaction of construction materials to optimum moisture content of the compactive effort used. The graph in Figure 3 - 3 (A - D) shows the relationship between OMC and Absorbed Moisture Content. The rate of absorption of water diminishes as compaction moisture content approaches the optimum value. Also clayey materials compacted to moisture content lower than optimum moisture content swells more than those compacted to optimum. This will affect the pavement drastically during the cycle of wetting and drying if care is not taken to reduce water percolating into the

pavement during the rainy season.

In most cases observed from field and laboratory results, the pavement insitu moisture was generally lower than the optimum. This will result in more moisture being absorbed. The only way of preventing these adverse effects of percolating and underground water is the introduction of deep drain and adequate turn outs or proper sealing of the pavement.

4.700 ASSESMENT BASED ON TRAFFIC COUNT AND AXLE WEIGHING

From the results of the traffic count and axle weighing conducted, the road can be classified as a primary road i.e. 100 - 500 commercial vehicles per day. The average daily number of standard axles computed during the weighing was $1635 = 0.60 \times 10^6$ standard axles. Using this value and the Figure 3 in Road Note 31 and using minimum subgrade CBR value of 8%, the pavement thickness is estimated at 100mm. This is less than that provided by the specification. This shows overdesign, yet the 150mm pavement failed prematurely. There must therefore be other reasons for the failure.

It is pertinent to note however, that the study of the traffic parameter has not been elaborate. The design life was 10 years, but the road failed barely two years after construction, during which time the maximum traffic already carried would be a negligible percentage of what the pavement ought to carry and withstand for 10 years.

Brief study on the traffic count/ truck loads was just

to indicate its importance in the scheme of things in pavement studies.

5.103 POOR QUALITY ASPHALT CONCRETE

The quality of both the wearing and binder courses of the asphalt concrete was not very satisfactory.

The use of stone / aggregate materials that have poor grading (i.e. not falling into the specified envelope), low bitumen content and possibly the overheating of the asphalt mix resulted in poor quality of asphaltic concrete used. Also laying of very thin asphalts in a few places, or one lift asphalt concrete wearing course in place of two layers binder and wearing courses have often resulted in early cracking and scaling off, ravelling and loss of adequate compaction and stability.

5.104 POOR DRAINAGE

To some degree, the poor drainage facilities have contributed in the overall early failure of roads.

5.200 RECOMMENDATIONS

In general, federal highway pavements, just like the one investigated, are under designed for the quality of materials and the axle loading they are supposed to carry.

The combination of under - designed thickness, poor quality materials and inadequate construction control have directly contributed to the many early failures in this road.

The following recommendations are therefore arrived at from the investigation. It may be applicable to several other road pavements which have all failed too soon after construction:-

(1) There should be regular maintenance of roads before sever crackings and potholes appear. Seal coats should be applied to prevent infiltration of water through cracked surfaces. This is especially important due to the water susceptibility of the materials used for bases and sub - bases.

(2) Special attention should be given to quality control to ensure that the specification requirements are fully met, so that strength and quality of the pavements will be of the best standard.

(3) All pavements should be designed to carry the number of axle loads the particular highway is expected to carry during its design life span. The general specification of 15cm sub - base and base courses in all federal highways should be avoided, since this in a way implies that roads have the same traffic volume and that the same type of materials are obtainable everywhere.

(4) Regulation of axle loading on the federal roads in order to reduce the rapid rate of damage currently caused by possible overloaded axles is highly recommended, even though this has not been thoruoghly looked into in this

study, but obvious.

With reference to the road investigated, the following remedial measures are recommended:-

The maintenance of the road should immediately commence to avoid further serious deterioration.

All failed sections established as having poor materials should be dug to at least one meter deep (1.00m) (if the subgrade is also weak) and carted to waste, before being backfilled and given good compaction in layers with good quality material, since use of poor materials was identified as the major cause of failure.

No activity should be carried out, that does not meet the specification requirements. That is the compaction, CBR, Density, Moisture Content, Percentage Passing Sieve No 200, Plasticity Index, etc should all be controlled. Same is applicable to the stone base areas. Also the asphalt overlay material should be of the best standard and quality, and overheating must be avoided.

Adequate turn - out and other drainage facilities should be provided, in order to control the drainage problem. These should be periodically and regularly maintained to ensure good performance always.

Depending on the availability of immediate fund, it will be beneficial if the whole stretch of the road is given an asphalt overlay, when most failed sections must have been put to good shape by patching up potholes,

regulating/levelling all rough surfaces and seal coating others.

It is believed that, if these are done, a new and stable road will be the result.

SUMMARY OF RECOMENDATIONS RESULTING FROM INTERVIEW / OBSERVATION TEST RESULTS

KATABU - PAMBEGUWA - JOS Road

TABLE 3-6 (A)

LOCATION	% PASSING SIEVE 200			CLASSIFICATION			CBR % AT OMC			RELATIVE COMPACTION %			EXISTING ROAD CONDITION	RECOMMENDATION
	BASE	SUB-BASE	SUB-GRADE	BASE	SUB-BASE	SUB-GRADE	BASE	SUB-BASE	SUB-GRADE	BASE	SUB-BASE	SUB-GRADE		
Km3+000 RHS	12	24	14	A-2-4 (0)	A-2-4 (0)	A-2-6 (0)	93	53	42	102	101	100	Cut Section Unfailed	Drainage to be improved.
Km10 + 051	74	90	76	A-2-6 (16)	A-7-6 (17)	A-7-6 (13)	30	20	8	96	98	96	Cut Section failed Poor Compaction and material.	Drainage is satisfactory, Failed section to be dugged out and replaced with good material.
Km17+ 966	35	36	41	A-2-6 (1)	A-6 (1)	A-7-6 (5)	65	42	13	99	101	97	Unfailed Section Embankment, Poor material Compaction, Fair.	Collection of water will persist during the raining season. Turn out is recommend for both side of the road.
Km24+167 RHS	42	51	65	A-7-6 (4)	A-6 (7)	A-6 (12)	44	14	4	104	99	95	Embankment Failed. Poor material used. Subgrade compaction is poor.	Drainage to be improved with turn out. Repairs as contained in the recommended measures.
Km31 920 LHS	48	35	47	A-7-6 (6)	A-2-6 (1)	A-7-6 (6)	51	46	20	102	98	97	Cut and failed section. Compaction is Fair.	Drainage to be improved with turnout.
Km44+650 RHS	52	35	75	A-7-6 (8)	A-2-7 (0)	A-6 (14)	47	25	7	104	98	91	Embankment. Failed, water logged area.	Drainage to be improved.
Km52+056 LHS	33	27	29	A-2-6(2)	A-2-6 (1)	A-2-6 (1)	75	40	22	97	86	89	Cut Unfailed. Good material used but Compaction was poor.	Rock laterite is evident. Drainage with turn outs to reduce under ground water effect during the raining S.
Km60+000	64	66	74	A-7-6 (9)	A-6 (10)	A-6 (10)	58	18	9	98	106	97	Embankment Unfailed. Poor material and Compaction.	Drainage to be improved.

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APPENDIX

SUMMARY OF BORE HOLE RESULTS

TABLE 3-1 (B)

KM	LOCATION	DEPTH IN CM	CLASSIFICATION USA (PRA)	SIEVE ANALYSIS				LL	PI	DEPTH IN CM	CLASSIFICATION USA	SIEVE ANALYSIS				LL	PI	INSTU MC			REMARKS
				19mm	7	36	200					19MM	7	36	200			-3M	-9M	+5M	
106	070	10·5-30·5	A-7-6 (8)	100	73	59	50	48	20	30.5-126	A-6 (10)	100	92	77	66	40	19	12·6	13·9	-	
	✓	126 - 146	A- 6 (8)	100	92	77	66	36	16												
108	860	00 - 15	A -7-6 (2)	100	63	46	36	44	20	15 - 38	A- 6 (4)	100	93	65	52	36	13	13·7	14·7		
	✓	38 - 122	A- 7- 6 (10)	100	89	70	60	44	20	122 - 175	A-6 (4)	100	95	69	52	29	12				
144	00	10 25	A- 2-6 (1)	100	60	42	35	38	17	25- 4	A- 2-6(1)	97	77	46	33	37	14	10·7	11·1		
	✓	46 - 115	A- 6 (6)	100	96	68	51	33	18												Rock laterite met.
119	060	00- 30	A - 2-7 (1)	100	69	43	35	41	15	30 - 105		100	69	44	37	37	17	12·2	15·6	17·6	
	✓	105 - 230	A-7-6 (2)	100	90	47	38	41	13												Water Table 2·30m
121	335	10- 27	A-2-6 (1)	100	65	39	32	40	13	27- 44	A-7-6 (5)	100	87	52	44	43	21				Base & Subbase
	✓	44 - 98	A - 4 (4)	100	92	68	54	29	8	98 - 112	A- 6 (9)	100	99	77	66	33	18				Hard Pan layer met.
135	608	06 - 21	A - 6 (6)	100	91	73	51	33	18	21 - 36	A-7-6(4)	98	19	5	38	50	24				Base & Subbase
	✓	36 - 126	A - 6 (0)	99	98	85	60	36	20												
142	468	06 - 13	A- 1-b(0)	89	55	23	5	NP	NP	13- 45	A- 7- 6(8)	99	88	60	50	45	25				Stonebase& Subbase
	✓	45 - 70	A-7-6 (10)	100	93	73	73	45	23	70 168	A-7-6 (14)	100	99	88	76	46	22				
	✓	168 198	A-7 - 6(19)	100	99	81	74	55	30												
155	00	08- 38	A- 7 - 6(10)	100	93	78	65	41	20	38 - 138	A-7-6 (10)	100	95	73	52	51	27				
		138 - 198	A-7-6 (10)	100	87	68	50	50	28	198 - 243	A- 6 (9)	100	99	87	67	34	17				

SUMMARY OF BORE HOLE RESULTS

TABLE 3-1(C)

KM	LOCATION	DEPTH IN CM	CLASSIFICATION USA (PRA)	SIEVE ANALYSIS 19mm	7	36	200	LL	PI	DEPTH IN CM	CLASSIFICATION USA	SIEVE ANALYSIS 19MM	7	36	200	LL	PI	INSTU MC .3M	.9M	+5M	REMARKS
156	427	07 - 40	A-7-6 (7)	100	87	67	48	47	21	40 60	A-7-5 (4)	99	83	64	43	48	17				
〃	〃	60 - 150	A - 6 (9)	100	90	66	53	40	23												
158	00	08 - 18	A-1-b(0)	89	55	23	4	NP	NP									15.0	12.3	18.0	Surface dressing
〃	〃	19 - 34	A-7-6 (8)	100	94	67	55	45	21												Beneath Stone base
〃	〃	34 - 175	A-7-6 (10)	100	86	63	56	42	24												
161	00	07 - 78	A-7-6 (5)	100	94	67	52	42	15												
162	00	08 - 23	A - 6 (8)	100	93	73	57	38	17	23 - 40	A-7-6 (9)	100	92	71	54	41	23	16.3	15.4	18.0	
〃	〃	40 124	A-7 - 6(15)	100	99	89	81	46	24	124 - 220	A-7-6 (12)	100	93	70	54	43	36				
163	750	06 - 21	A-7-6 (4)	100	91	66	51	42	14	21 - 82	A-6(8)	100	98	81	63	33	15				
〃	〃	82 - 140	A-7- 6 (15)	100	98	84	76	47	26	140 - 210	A - 4 (7)	100	95	80	63	27	9				
〃	〃	210 - 230	A- 6 (5)	100	73	53	46	35	20												
172	00	10 - 19	A - 1 - a (0)	83	50	20	5	NP	NP									12.6	13.7	16.9	Stone base
〃	〃	19 - 34	A - 6 (10)	100	88	65	55	40	25												Subbase
〃	〃	34 - 180	A - 6 (12)	100	95	73	63	37	26	180 - 240	A- 6 (11)	100	98	83	72	35	21				
181	830	06 - 13	A - 1 - a(0)	90	34	12	5	NP	NP									14.0	15.8	19.9	Stone base
〃	〃	13 - 28	A - 7 - 5 (5)	99	80	64	56	43	12												Subbase
〃	〃	28 - 44	A- 7 - 5 (8)	98	90	71	57	45	17	44 - 70	A- 7- 6 (8)	100	96	70	61	43	16				
〃	〃	70 - 114	A-4 (7)	100	100	88	68	26	5	114 - 150	A - 6 (8)	100	95	77	65	34	16				
〃	〃	150 - 230	A-7-6-(20)	100	100	95	89	65	43												

SUMMARY OF BORE HOLE RESULTS

TABLE 3-1(D)

KM	LOCATION	DEPTH IN CM	CLASSIFICATION USA (PRA)	SIEVE ANALYSIS 19mm	7	36	200	LL	PI	DEPTH IN CM	CLASSIFICATION USA	SIEVE ANALYSIS 19MM	7	36	200	LL	PI	INSTU MC -3M	-9M	+5M	REMARKS
183	181	08 - 20	A - 1 - a(0)	88	50	23	9	NP	NP									14.6	15.3	20.7	Stone base
		20 - 28	A-7 - 6 (12)	100	81	64	55	53	27												Sub base
		28 - 51	A - 6 (10)	100	98	80	70	38	18	51 - 170	A - 6 (9)	100	100	81	65	37	17				
		170 - 250	A-7- 6 (16)	100	86	67	61	59	29												
188	00	08 - 18	A - 1 - a(0)	76	36	15	6	NP	NP	18 - 33	A - 6 (5)	97	76	53	43	34	21	10.6	10.1	16.1	Stone Base /Subbase
		33 - 107	A - 6 (6)	99	87	65	48	34	20	107 - 150	A - 4 (1)	100	94	63	41	21	4				
		150 - 190	A-7 - 6 (15)	100	99	82	66	48	33												
194	307	08 - 17	A - 1 - a (0)	76	35	14	4	NP	NP	17 - 32	A- 7- 6 (9)	98	75	53	46	52	33	14.5	16.6	20.0	Stone Base/Subbase
		32 - 82	A-7- 6 (8)	100	91	66	52	42	23	82 - 153	A - 6 (7)	100	98	80	64	27	13				
		153 - 200	A-7 - 6 (20)	100	98	87	79	60	46												
206	00	08 - 18	A - 1 - a (0)	68	28	14	5	NP	NP	18 - 33	A - 7-6 (11)	100	85	66	58	44	25	12.4	12.0	12.8	Stone Base / Subbase
		33 118	A-7- 6 (15)	100	97	84	79	42	28	118 - 175	A - 6 (14)	100	97	80	76	40	26				
220	00	08 - 18	A - 1 - a(0)	64	40	18	7	NP	NP	18 - 33	A-7 - 6 (12)	100	84	63	53	47	31	9.3			Stone Base / Subbase
		33 - 75	A - 6 (3)	88	66	49	40	34	18												Rock layer met.
222	282	06 - 21	A - 2-6 (2)	97	53	38	31	34	21	21 - 36	A - 6 (9)	100	84	63	53	32	24	11.1			Base / Subbase
		36 - 80	A - 6 (6)	95	68	52	45	35	22												Hard Layer met.
227	968	07 - 22	A- 2- 7 (2)	97	63	43	35	45	20	22 - 37	A-7- 6 (12)	97	79	66	57	45	27	18.2	16.7	20.7	Base / Subbase
		37 - 75	A-7-6 (13)	98	89	62	54	52	31	75 - 200	A - 7 - 6 (18)	100	92	77	72	52	38				

SUMMARY OF BORE HOLE RESULTS

TABLE 3-1(E)

KM	LOCATION	DEPTH IN CM	CLASSIFICATION USA (PRA)	SIEVE ANALYSIS 19mm	7	36	200	LL	PI	DEPTH IN CM	CLASSIFICATION USA	SIEVE ANALYSIS 19MM	7	36	200	LL	PI	INSTU MC .3M	.9M	+5M	REMARKS
230	028	06 - 21	A-2-7 (0)	90	46	31	22	41	18	21-36	A - 6 (11)	99	82	66	59		24	17.1	20.0		Base / Subbase
		36-75	A- 6 (9)	100	83	69	58	38	21	75 120	A-7-6 (1)	100	62	46	37	41	15				Hard Layer met.
236	019	09 - 24	A- 2-7 (1)	100	67	47	35	43	17	24-39	A - 2-7 (1)	99	71	46	35	44	17	17.3	13.2		Base / Subbase
		39-90	A - 2-7 (1)	93	64	46	35	47	16												Hard Layed met.

SUMMARY OF TEST RESULTS

TABLE 3 - 2 (B)

LOCATION KM	PAVEMENT LAYER	FIELD LABORATORY RESULTS																			INSITU RESULTS						REMARKS
		B.S.					W.A.S.					SIEVING % PASSING				L.L.	PI=(LL-PL)	L/S	CLASSIFICATION US (PRA)	THICKNESS OF BASE COURSE			INSITU DENSITY				
		MDD	OMC	C.B.R % AT OMC	C.B.R % SOAKED 48 HRS	M.C AFTER SOAKING	MDD	OMC	C.B.R % AT OMC	C.B.R % SOAKED 48 HRS	M.C AFTER SOAKING	B/4"	NO 7	NO 36	NO 200					FORM OF	℄	WORS OF	DD	M.C	% COMP	DATE	
52 + 056	BASE COURSE						2.04	9.5	75			100	61	41	33	38	19	13	A-2-6(2)	15.0			1.98	11.11	97	9-2-88	L.H.S
	SUB BASE						2.01	10.2		40	11.4	98	55	35	27	33	16	9	A-2-6(1)	15.0			1.93	13.78	86	"	CUT SECTION
	SUB GRADE	1.92	12.0		22	16.6						98	52	37	29	38	19		A-2-6(1)				1.70	14.27	89	"	UNFAILED
60+000	BASE COURSE						1.92	13.0	55			100	55	44	34	40	20	13	A-2-6(2)			17.0	1.82	12.43	95	27-1-88	R.H.S
	SUB BASE						1.92	13.0		26	14.6	98	80	68	52	39	24	10	A-6 (8)			16.0	1.93	10.17	101	"	EMBANKMENT
	SUB GRADE	2.04	8.8		15.0	10.7						100	99	77	44	22	6		A-4 (2)				2.01	6.54	99	"	UNFAILED
70+000	BASE COURSE						1.88	14.0	40			97	74	55	48	44	12	13	A-7-5(4)			15.0	1.85	1534	98	10-2-88	R.H.S.
	SUB BASE						1.74	18.0		22	21.4	100	98	96	94	47	19	10	A-7-6(13)			15.0	1.78	14.60	102	"	CUT SECTION
	SUB GRADE	1.85	14.5		10	17.5						100	88	81	76	34	14	1	A-6 (10)				1.83	15.71	99	"	UNFAILED
78+220	BASE COURSE						1.98	13.4	42			100	67	46	37	52	23	13	A-7-6(3)			15.0	1.93	12.10	97	"	R.H.S.
	SUB BASE						1.86	13.8		9	16.8	100	84	67	52	45	23	13	A-7-6(9)			15.0	1.88	13.55	101		EMBANKMENT
	SUB GRADE	1.78	14.2		7	17.8						99	88	67	55	40	2		A-6 (4)				1.82	14.20	102		FAILED
90+000	BASE COURSE						1.88	13.5	30			100	75	57	51	44	13	13	A-7-5(4)			15.0	1.72	9.89	91	10-2-88	R.H.S.
	SUB BASE						1.91	12.8		26	16.1	100	79	59	49	44	16	13	A-7-6(5)			15.0	1.78	8.84	93	"	EMBANKMENT
	SUB GRADE	1.92	12.0		12	16.5						99	71	52	42	48	22		A-7-6(4)				1.74	8.47	91	"	UNFAILED
100+018	BASE COURSE						2.03	9.9	55			93	61	44	35	30	15	10	A-2-6(1)	15.0			2.05	9.80	101	11-2-88	L.H.S.
	SUB BASE						1.98	11.0		25	13.5	99	69	49	40	29	13	10	A-6 (2)				1.92	9.43	97	"	CUT SECTION
	SUB GRADE	1.90	12.0		15							99	80	61	54	34	16		A-6 (6)				1.92	12.71	101	"	UNFAILED
	BASE COURSE																										
	SUB BASE																										
	SUB GRADE																										

SUMMARY OF TEST RESULTS

TABLE 3 - 2 (C)

LOCATION KM	PAVEMENT LAYER	FIELD LABORATORY RESULTS																		INSITU RESULTS							REMARKS
		B.S.					W.A.S.					SIEVING % PASSING								THICKNESS OF BASE COURSE			INSITU DENSITY				
		MDD	OMC	C.B.R % AT OMC	C.B.R % SOAKED 24 HRS	M.C AFTER SOAKING	MDD	OMC	C.B.R % AT O.M.C	C.B.R % SOAKED 24 HRS	M.C AFTER SOAKING	B¼"	NO 7	NO 36	NO 200	L.L.	PI(LL-PL)	L/S	CLASSIFICATION US (P.R.A)	E ORN OF KM	CM	WORS OF KM	DD	M C	% COMP	DATE	
105 + 364	BASE COURSE						1·83	13.2	58			100	89	74	64	51	23	13	A-7-6 (9)			15.0	1.79	14·95	98	10-2-88	R·H·S
	SUB BASE						1·88	11·7		18	13.7	100	91	79	66	40	20	13	A-6 (10)			15.0	1.99	12·60	106	"	EMBANKMENT
	SUB GRADE	1·80	13.2		10	15.8						100	98	87	74	37	16		A-7-6 (8)				1·74	13.90	97	"	FAILED
106+070	BASE COURSE						1·90	12·8	40			100	73	59	40	48	20	11	A-7-6 (8)			15,0	1.92	+12.94	101	11-12-88	R.H.S.
	SUB BASE						1·93	12.5		37	15.5	100	71	54	42	40	19	10	A-6 (3)			15.0	1.89	13,0	98	"	EMBANKMENT
	SUB GRADE	1.81	13·7		10	5·1						100	92	77	66	36	16		A-6 (8)				1·67	17.20	92	"	FAILED
108+860	BASE COURSE						1·95	12.5	31			100	63	46	36	44	20	11	A-7-6 (2)	15.0			1.85	13·00	95	14-12-88	L.H.S.
	SUB BASE						1.89	12·7		10	13.8	100	93	65	52	36	13	10	A-6 (4)	17.0			1·73	14.87	92	"	CUT SECTION
	SUB GRADE	1·80	13.5		8	17.5						100	89	70	60	44	20		A-7-6 (10)				1.84	13,69	102	"	FAILED
114+000	BASE COURSE						2·07	9·5	70			100	60	42	35	38	17	12	A-2-6 (1)			15.0	2.12	9.85	102	11-2-88	R.H.S.
	SUB BASE						1.96	10.0		30	10·7	97	77	46	33	37	14	12	A-2-6 (1)			15.0	1.94	10.68	98	"	HIGH EMBANKMENT
	SUB GRADE	1·90	111·3		13	13.2						99	79	44	34	41	17		A-2-7 (1)				1.89	10.96	99	"	VERGE FAILURE
119+060	BASE COURSE						1·97	10·5	25			100	69	43	35	41	15	10	A-2-7 (1)			15·0	1.99	13·0	101	15-12-88	R.H.S.
	SUB BASE						1·94	11·20		18	14·2	100	58	38	32	41	22	10	A-2-7 (2)			15·0	2·04	12·21	105	"	EMBANKMENT
	SUB GRADE	1·94	12·0		10	12·7						100	69	44	37	37	17		A-6 (2)				1·92	11·51	99	"	FAILED
121 +335	BASE COURSE						1·98	10·30	25			100	65	30	32	40	13	12	A-2-6 (1)			17·0	2·00	7·84	101	"	R.H.S.
	SUB BASE						1·89	11·50		13	13·1	100	87	52	44	43	21	12	A-7-6 (3)			17·0	1·94	10·44	103	"	EMBANKMENT
	SUB GRADE	1·91	12·0		5	13·7						100	92	68	54	29	8		A-4 (4)				1·92	10·21	101	"	FAILED
	BASE COURSE																										
	SUB BASE																										
	SUB GRADE																										

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SUMMARY OF TEST RESULTS

TABLE 3-2 (D)

LOCATION KM	PAVEMENT LAYER	FIELD LABORATORY RESULTS																	INSITU RESULTS							REMARKS
		B.S.					W.A.S.					SIEVING % PASSING				L.L.	PI=(LL-LP)	L/S	CLASSIFICATION US(P.R.A)	THICKNESS OF BASE COURSE			INSITU DENSITY				
		MDD	OMC	C.B.R % AT OMC	C.B.R % SOAKING 48 HRS	M.C AFTER SOAKING	MDD	OMC	C.B.R % AT OMC	C.B.R % SOAKED 24 HRS	M.C AFTER SOAKING	B/4"	NO 7	NO 36	NO 200					E.O.RN. OF	C.B.R	WORS. OF	DD	MC	% COMP	DATE	
128+051	BASE COURSE						1.99	10.5	40			99	64	51	43	34	19	10	A-6 (5)			12.0	1.87	9.14	94	12-2-88	R.H.S
	SUB BASE						1.92	12.0		23	14.3	100	74	61	56	37	23	11	A-6 (9)			15.0	1.94	10.47	101	"	CUT SECTION
	SUB GRADE	1.98	11.7		14	12.1						100	59	43	37	35	18		A-6 (2)				1.86	9.44	94	"	UNFAILED
135+608	BASE COURSE						1.90	11.50	47			100	91	73	51	33	18	11	A-6 (5)			15.0	1.97	8.79	1.04	18-12-88	R.H.S,
	SUB BASE						1.92	10.50		17	13.5	98	79	52	38	50	24	13	A-7-6 (4)			15.0	1.93	9.4	101	"	EMBANKMENT
	SUB GRADE	1.79	13.5		6	16.7						99	93	77	64	36	20		A-6 (10)				1.79	12.75	100	"	FAILED
142+468	BASE COURSE								43			89	55	23	5	NP	NP		A-1- (0)			7.0	NOT	TESTED		7-1-88	STONE BASE
	SUB BASE						1.90	12.2		19	13.4	99	88	60	50	45	25	11	A-7-6 (8)			15.0	1.84	12.14	97	"	EMBANKMENT
	SUB GRADE	1.80	16.0		6	16.9						100	93	75	62	45	23		A-7-6 (11)				1.80	14.28	100	"	R.H.S. FAILED
155+000	BASE COURSE						1.87	13.6	60			100	93	78	65	41	20	11	A-7-6 (10)			15.0	1.85	14.47	99	8-1-88	R.H.S.
	SUB BASE						1.79	15.0		16	9.4	100	95	73	52	51	27	10	A-7-6 (10)			15.0	1.77	16.43	99	✓	EMBANKMENT
	SUB GRADE	1.75	16.0		12	21.0						100	87	68	50	50	28	12	A-7-6 (10)				1.63	18.16	93	✓	FAILED
156+427	BASE COURSE						1.86	13.6	35			100	87	68	48	47	21	11	A-7-6 (7)			16.0	1.83	14.21	98	11-1-88	R.H.S.
	SUB BASE						1.88	13.0		25	14.7	100	81	56	38	40	18	11	A-6 (3)			17.0	1.75	14.75	93	✓	EMBANKMENT
	SUB GRADE	1.76			15	17.7						99	83	64	43	48	17		A-7-5 (4)				1.63	16.12	93	✓	FAILED
158+000	BASE COURSE						2.08	3.9				89	55	23	4	NP	NP		A-1-b (0)	10.0			2.12	1.37	102	2-2-88	STONE BASE
	SUB BASE						1.85	12.7		26	15.8	100	94	67	55	45	21	13	A-7-6 (8)	15.0			1.89	15.0	102	✓	6 D. LHS
	SUB GRADE	1.85	12.7		12	14.4						100	89	58	46	36	18		A-6 (4)				1.83	12.25	99		UNFAILED
	BASE COURSE																										
	SUB BASE																										
	SUB GRADE																										

SUMMARY OF TEST RESULTS

TABLE 3-2 (E)

LOCATION KM	PAVEMENT LAYER	FIELD LABORATORY RESULTS																			INSITU RESULTS							REMARKS
		B.S.					W.A.S.					SIEVING % PASSING				L.L.	PI(LL-PL)	L/S	CLASSIFICATION U.S(P.R.A)	THICKNESS OF BASE COURSE			INSITU DENSITY				
		MDD	OMC	C.B.R % AT OMC	C.B.R % SOAKED 96 HRS	M.C AFTER SOAKING	MDD	OMC	C.B.R % AT OMC	C.B.R % SOAKED 96 HRS	M.C AFTER SOAKING	3/4"	NO 7	NO 36	NO 200					E.O.R.N. OF ROAD	C/L	W.O.R.S. OF ROAD	DD	M.C	% COMP	DATE	
161+000	BASE COURSE						1.82	13.5	37			100	94	67	52	42	15	12	A-7-6 (5)			15.0	1.85	13.94	102	12-1-88	R.H.S
	SUB BASE						1.83	12.5		28	16.4	100	92	71	54	44	21	12	A-7-6 (8)			15.0	1.65	17.09	70	✓	EMBANKMENT
	SUB GRADE	1.73	15.5		15	17.0						100	92	73	59	43	14		A-7-6 (7)				1.63	17.00	94	✓	FAILED
162+000	BASE COURSE						1.84	12.4	30			100	99	73	57	38	17	11	A-6 (7)			15.0	1.76	16.45	96	13-1-88	R.H.S
	SUB BASE						1.79	14.0		17	17.30	100	99	83	68	41	23	11	A-7-6 (12)			17.0	1.68	16.44	94	✓	EMBANKMENT
	SUB GRADE	1.77	14.7		7.	16.6						100	93	77	63	44	23		A-7-6 (11)				1.63	15.41	92	✓	FAILED
163+750	BASE COURSE						1.89	12.2	35			100	91	66	51	42	14	10	A-7-6 (4)			15.0	1.90	14.40	101	14-1-88	R.H.S.
	SUB BASE						1.81	14.0		15	18.2	100	82	64	50	36	15	11	A-6 (5)			15.0	1.80	14.51	99	✓	EMBANKMENT
	SUB GRADE	1.80	14.0		12	16.9						100	86	64	51	42	17		A-7-6 (5)				1.86	12.97	103	✓	FAILED
172+000	BASE COURSE						2.11	4.38				83	50	20	5	NP	NP		A-1-a(0)			9.0	1.97	1.68	93	13-2-88	STONE BASE
	SUB BASE						1.92	11.50		18	12.9	100	88	65	55	40	25	12	A-6 (10)			15.0	1.95	11.11	102	✓	EMBANKMENT SAMINAKA VILLAGE
	SUB GRADE	1.87	11.8		15	14.4						100	87	56	49	42	25		A-7-6 (8)				1.82	12.57	97	✓	UNFAILED
181+830	BASE COURSE											90	34	12	5	NP	NP		A-1-a (0)			7.0	NOT	TESTED		21-1-88	STONE BASE
	SUB BASE						1.89	12.3		20	14.9	99	80	64	56	43	12	11	A-7-6 (6)			15.0	1.84	15.42	97	✓	EMBANKMENT
	SUB GRADE	1.78	13.6		8	16.9						98	90	71	57	45	17		A-7-6 (8)				1.68	13.96	94	✓	R.H.S. FAILED
183+181	BASE COURSE						2.18	3.5				88	50	23	9	NP	NP		A-1-a (0)			12.0	2.18	0.98	100	22-1-88	STONE BASE
	SUB BASE						1.88	13.2		18	17.6	100	81	64	55	45	17	13	A-7-6 (7)			8.0	1.84	14.57	98	✓	EMBANKMENT
	SUB GRADE	1.76	15.0		5	15.2						100	98	80	70	38	18		A-6 (10)				1.84	18.47	105	✓	R.H.S. FAILED
	BASE COURSE																										
	SUB BASE																										
	SUB GRADE																										

SUMMARY OF TEST RESULTS

TABLE 3-2 (F)

LOCATION KM	PAVEMENT LAYER	FIELD LABORATORY RESULTS																		INSITU RESULTS							REMARKS
		B.S.					W.A.S.					SIEVING % PASSING				LL	PI=(LL-LP)	LS	CLASSIFICATION US(P.R.A)	THICKNESS OF BASE COURSE			INSITU DENSITY				
		MDD	OMC	C.B.R % AT OMC	C.B.R % SOAKING 48 HRS	M.C. AFTER SOAKING	MDD	OMC	C.B.R % AT OMC	C.B.R % SOAKED 24 HRS	M.C. AFTER SOAKING	3/4"	NO 7	NO 36	NO 200					BORN OF	7/8	WORS OF	DD	MC	% COMP	DATE	
188+000	BASE COURSE						2.14	4.14				76	36	15	6	NP	NP		A-1-a (0)	10.0			1.99	2.29	93	13-2-88	LHS S/BASE
	SUB BASE						1.94	11.5		16	13.2	97	76	53	43	34	21	10	A-6 (5)	15.0			2.06	10.64	106	✓	EMBANKMENT
	SUB GRADE	1.90	10.9		7	12.6						99	87	65	48	34	20		A-6 (6)				1.81	9.23	95		UNFAILED
194+307	BASE COURSE						2.06	4.39				76	35	14	4	NP	NP		A-1-a(0)			9.0	2.05	1.82	100	15-2-88	RHS S/BASE
	SUB BASE						1.91	11.0		14	14.7	98	75	53	46	52	33	11	A-7-6 (9)			15.0	2.00	11.78	105	✓	EMBANKMENT WATER LOGGED
	SUB GRADE	1.83	12.8		12	15.3						100	91	66	52	42	23		A-7-6 (8)				1.76	17.16	96	✓	FAILED SECTION
206+000	BASE COURSE						2.17	4.22				68	28	14	5	NP	NP		A-1-a (0)			10.0	2.32	0.73	107	15-2-88	RHS S/BASE
	SUB BASE						1.80	16.0		30	17.6	100	85	66	58	44	25	11	A-7-6 (11)			15.0	1.70	12.44	94	✓	EMBANKMENT
	SUB GRADE	1.79	13.7		13	17.3						100	97	84	79	42	28		A-7-6 (15)				1.62	10.45	85	✓	UNFAILED
220+000	BASE COURSE						2.06	4.19				64	40	18	7	NP	NP		A-1-a(0)	10.0			2.16	0.78	105	16-2-88	LHS S/BASE
	SUB BASE						1.91	12.4		22	14.4	88	66	49	40	47	31	12	A-7-6 (6)	15.0			1.88	9.25	98	✓	LEVEL GROUND
	SUB GRADE	1.82	12.7		14	15.1						100	85	60	43	34	13		A-6 (4)				1.64	9.42	90	✓	UNFAILED
222+282	BASE COURSE						1.99	11.3	35			97	58	38	31	34	21	10	A-2-6(2)			15.0	2.00	10.92	101	16-2-88	RHS
	SUB BASE						1.93	11.50		18	14.6	100	84	63	53	32	24	9	A-6 (9)			15.0	1.83	11.12	95	✓	EMBANKMENT
	SUB GRADE	1.75	15.6		14	20.6						100	88	74	68	52	20		A-7-6 (13)				1.66	13.24	95	✓	FAILED
227+965	BASE COURSE						1.96	12.0	52			97	63	43	35	45	20	10	A-2-7 (2)			15.0	1.97	13.32	101	16-2-88	R.H.S
	SUB BASE						1.87	13.0		27	16.6	97	79	66	57	45	27	12	A-7-6 (12)			15.0	1.78	18.24	95	✓	EMBANKMENT
	SUB GRADE	1.80	15.2		10	18.5						98	89	62	54	52	31		A-7-6 (13)				1.77	18.05	98	✓	FAILED
	BASE COURSE																										
	SUB BASE																										
	SUB GRADE																										

SUMMARY OF TEST RESULTS

TABLE 3-2 (G)

LOCATION KM	PAVEMENT LAYER	FIELD LABORATORY RESULTS																		INSITU RESULTS							REMARKS
		B.S.					W.A.S.					SIEVING % PASSING				LL.	PI=(LL-PL)	L/S	CLASSIFICATION U.S. (P.R.A)	THICKNESS OF BASE COURSE			INSITU DENSITY				
		MDD	OMC	C.B.R % AT OMC	C.B.R % SOAKING 48 HRS	M.C AFTER SOAKING	MDD	OMC	C.B.R % AT OMC	C.B.R % SOAKED 24 HRS	M.C AFTER SOAKING	B¼"	NO 7	NO 36	NO 200					EORN OF		WORS OF	DD	M.C	% COMP	DATE	
230+028	BASE COURSE						1.96	12.0	52			90	46	31	22	41	18	12	A-2-7(0)	15.0							R.H.S. FAILED
	SUB BASE						1.84	14.7		35	17.9	99	82	66	59	39	24	9	A-6 (11)	15.0			1.85	17.06	101	✓	EMBANKMENT
	SUB GRADE	1.76	16.0		15	18.4	-					100	83	69	58	38	21		A-6 (9)				1.70	19.58	97	✓	WATER LOGGED AREA
236+019	BASE COURSE						1.90	13.6	72			100	67	52	35	43	17	9	A-2-7(1)			15.0	1.84	15.96	97	✓	R.H.S.
	SUB BASE						1.90	16.5		47	17.3	99	71	46	35	44	17	10	A-2-7(1)			15.0	1.70	17.27	89	✓	EMBANKMENT
	SUB GRADE	1.80	17.2		22	19.6						93	64	46	35	47	16		A-2-7(1)				1.73	15.80	96	✓	UNFAILED
	BASE COURSE																										
	SUB BASE																										
	SUB GRADE																										
	BASE COURSE																										
	SUB BASE																										
	SUB GRADE																										
	BASE COURSE																										
	SUB BASE																										
	SUB GRADE																										
	BASE COURSE																										
	SUB BASE																										
	SUB GRADE																										
	BASE COURSE																										
	SUB BASE																										
	SUB GRADE																										

SUMMARY OF RECOMENDATION RESULTING FROM INTERVIEW OBSERVATION TEST RESULTS — KATABU – PAMBEGUWA – JOS Road

TABLE 3 - 6 (B)

LOCATION	% PASSING SIEVE 200			CLASSIFICATION			CBR % AT OMC			RELATIVE COMPACTION %			EXISTING ROAD CONDITION	RECOMMENDATION
	BASE	SUB-BASE	SUB-GRADE	BASE	SUB-BASE	SUB-GRADE	BASE	SUB-BASE	SUB-GRADE	BASE	SUB-BASE	SUB-GRADE		
Km70 + 000 RHS	48	94	76	A-7-5 (4)	A-7-6 (13)	A - 6 (10)	40	22	10	98	102	99	Cut Unfailed Poor material used and Compaction Fail	Drainage to be Cleared and dugged and tum out to be introducedin the section.
Km78 + 220	37	52	55	A-7-6 (3)	A-7 - 6 (9)	A - 6 (4)	42	9	7	97	101	102	Embankment Failed. Base was poorly Compacted Poor material was used	Repairs to be effected Drainage to be impr-ved with turnout.
Km90 + 000 RHS	51	49	42	A - 7-5 (4)	A-7-6 (5)	A-7- 6 (4)	30	26	12	91	93	91	Embankment Failed. Poor material & poor compaction. Yet no failures.	Drainage to be impro-ved with turnout.
Km100 + 018 LHS	35	40	54	A- 2-6 (1)	A - 6 (2)	A- 6 (0)	55	25	15	101	97	101	Cut Section Untailed Poor material used as Subbase& Subgr-ade, Fail Compaction.	Drainage to be impro-ved on both sides sloping towards the nearby stream.
Km105 + 164	64	66	74	A-7-6 (9)	A - 6 (10)	A - 6 (10)	58	18	9	98	106	97	Embankment - Failed Poor material and poor compaction.	Good drainage no water problem.
Km108 + 860 LHS	36	52	60	A-7 - 6 (2)	A - 6 (4)	A-7 - 6 (10)	31	10	8	95	92	102	This is a spring near test location peak of dry season. There is high water table, Poor compaction of base and subbase.	Poor material was use-d. Area is in Cut to be raised and deep dra-in contrusted. Base & Subbase to be replace with good material.
Km114 + 000 RHS	35	33	34	A-2- 6 (1)	A - 2 - 6 (1)	A-2 - 7 (1)	70	30	13	102	98	99	Embankment verge of failure. Fair com-paction. Floor plain. High wa-ter table during the rains.	Drainage to be impro-ved, with turnouts.
Km119 + 060	35	32	37	A-2 - 7 (1)	A - 2 - 7 (2)	A - 6 (2)	25	18	10	101	105	99	Embankment - Failed. Good compaction. Strength of material is poor.	Drainage is O.K.

SUMMARY OF RECOMENDATIONS RESULTING FROM INTERVIEW / OBSERVATION TEST RESULTS

KATABU - PAMBEGUWA - JOS Road

TABLE 3 - 6 (C)

LOCATION	% PASSING SIEVE 200			CLASSIFICATION			CBR % AT OMC			RELATIVE COMPACTION %			EXISTING ROAD CONDITION	RECOMMENDATION
	BASE	SUB-BASE	SUB-GRADE	BASE	SUB-BASE	SUB-GRADE	BASE	SUB-BASE	SUB-GRADE	BASE	SUB-BASE	SUB-GRADE		
Km121 + 335	32	44	54	A-2-6 (1)	A-7-6 (5)	A-4 (4)	25	13	5	101	103	101	Embankment - failed high depression. Drainage O.K. Poor material used.	Recommend repairs to be effected.
Km128 + 051	43	56	37	A-6 (5)	A-6 (9)	A-6 (2)	40	23	14	94	101	94	Cut section untailed the road. Poor material and poor Compaction. Geological features must have sustained.	Drainage is O.K.
Km135 + 608 RHS	51	38	64	A-6 (5)	A-7-6 (4)	A-6 (10)	47	17	6	104	101	100	Embankment - failed. Water logged area. High water table is suspected. Poor material but good compaction.	Deep drains and deep cut lets for culverts recommend. The area to be reconstructed
Km142 + 468	5	50	62	A-1-b (0)	A-7-6 (8)	A-7-6 (11)	—	19	6	NOT TESTED	97	100	Embankment - failed. Poor material, fair compaction. Collection of water on drains. High water suspected.	Drains to be deepened with good turn outs.
Km155 + 000 RHS	65	52	50	A-7-6 (10)	A-7-6 (10)	A-7-6 (10)	60	16	12	99	99	93	Embankment - failed. Poor materials and poor comp. on subgrade. Laid asphalt is thin.	Drainage to be improved and the section to be reconstructed.
Km156 427	48	38	43	A-7-6 (7)	A-6 (3)	A-7-5 (4)	35	25	15	98	93	93	Embankment - failed. Poor material and very poor compaction. Water collects to a height 50cm below crown of road.	For two month Drains and outlet to culvert to be deepened. Repairs recommended.
Km158 + 000	4	55	46	A-1-b (0)	A-7-6 (8)	A-6 (4)	NOT TESTED	26	12	102	102	99	Level ground untailed. Poor material, good compaction. Drainage non functioning.	Drainage and outlets to the existing culvert to be deepened.
Km161 + 000	52	54	59	A-7-6 (5)	A-7-6 (8)	A-7-6 (7)	37	28	15	102	90	94	Embankment failed. Poor material and poor compaction. Poor drainage.	Drainage and culvert out lets to be deepened.

SUMMARY OF RECOMENDATIONs RESULTING FROM INTERVIEW / OBSERVATION TEST RESULTS

KATABU - PAMBEGUWA - JOS Road

TABLE 3-6 (D)

LOCATION	% PASSING SIEVE 200			CLASSIFICATION			CBR % AT OMC			RELATIVE COMPACTION %			EXISTING ROAD CONDITION	RECOMMENDATION
	BASE	SUB-BASE	SUB-GRADE	BASE	SUB-BASE	SUB-GRADE	BASE	SUB-BASE	SUB-GRADE	BASE	SUB-BASE	SUB-GRADE		
Km162 + 000 RHS	57	68	63	A-6 (7)	A-7-6 (12)	A-7-6 (11)	30	17	7	96	94	92	Embankment- failed. Poor material and very poorly compacted.	Drainage to be improved and fail section repaired.
Km163 + 750 RHS	51	50	51	A-7-6(4)	A-6 (5)	A-7-6 (5)	35	15	12	101	99	103	Embankment - failed. Poor material, good compaction.	Drainage to be improved to link the existing culvert.
Km181 + 830 RHS	5	56	57	A-1-a(0)	A-7-6 (6)	A-7-6 (8)	NOT TESTED	20	8	NOT TESTED	97	94	Embankment - failed. Poor material for subbase and subgrade. Poor compaction. Water logged area.	Drainage to be deepened, and turn outs introduced.
Km106 + 070 RHS	40	42	66	A-7-6 (8)	A-6 (3)	A-6 (8)	40	37	10	101	98	92	Embankment - failed. Area is underlaid with rock laterite. Water collects on drain High water table suspect	Drainage to be improved.
Km183 + 181 RHS	9	55	70	A-1-a (0)	A-7-6 (7)	A-6 (10)	NOT TESTED	18	5	100	98	105	Embankment - failed. Poor material used for subbase and subgrade Existing drainage is silted up.	Drainag to be improved and is to drain in-to th existing culv. Turn out to culvert to be widened & deepened
Km188 + 000 LHS	6	43	48	A-1-a(0)	A-6 (5)	A-6 (6)	NOT TESTED	16	7	93	106	95	Embankment- unfailed Poor material used for subbase and subgrade. Poor compaction.	Drainage to be improved and turn out provide.
Km194+307 RHS	4	46	52	A-1-a(0)	A-7-6(a)	A-7-6 (8)	NOT TESTED	14	12	100	105	96	Embankment- failed. Poor material used for subbase and subgrade. Poor compaction on subgrade. Water logged.	Section, drainage to be improved. Culvert turn out to be improved too.
Km206 + 000 RHS	5	58	79	A-1-a(0)	A-7-6 (11)	A-7-6 (15)	NOT TESTED	30	13	107	94	85	Embankment unfailed Poor material and poor compaction. Drainage O.K.	NIL.

SUMMARY OF RECOMENDATIONS RESULTING FROM INTERVIEW/ OBSERVATION TEST RESULTS

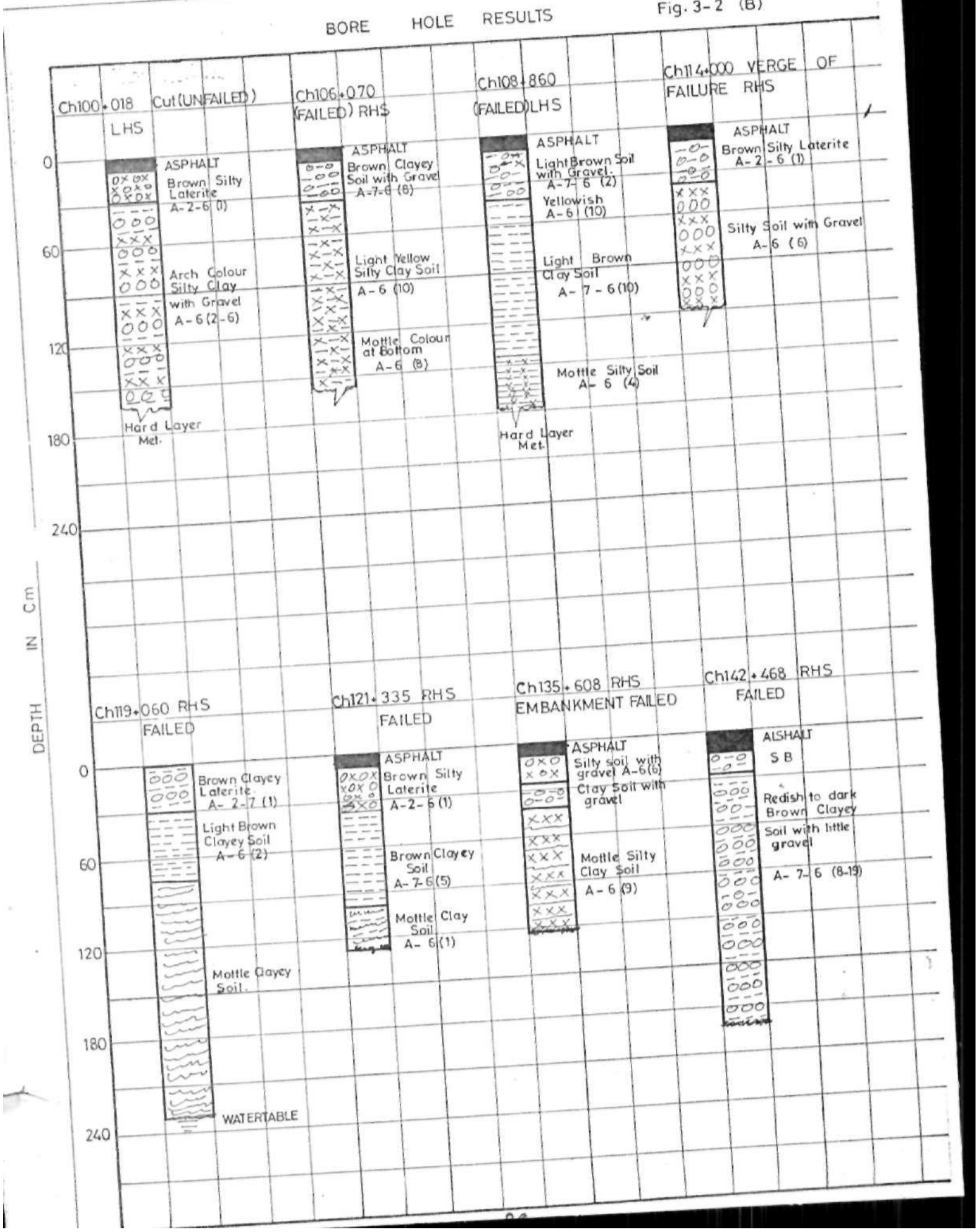
KATABU – PAMBEGUWA – JOS Road

TABLE 3-6 (E)

LOCATION	% PASSING SIEVE 200			CLASSIFICATION			CBR % AT OMC			RELATIVE COMPACTION %			EXISTING ROAD CONDITION	RECOMMENDATION
	BASE	SUB-BASE	SUB-GRADE	BASE	SUB-BASE	SUB-GRADE	BASE	SUB-BASE	SUB-GRADE	BASE	SUB-BASE	SUB-GRADE		
Km220+000 LHS	7	40	43	A-1-a(0)	A-7-6 (6)	A-6 (4)	NOT TESTED	22	14	105	98	90	Level ground untailed. Poor material and poor compaction. Poor drainage.	Drainage to be improved with turnouts.
Km222+282 RHS	31	53	68	A 2 6 2	A 6 a	A-7-6 (13)	35	18	14	101	95	95	Embankment failed. Poor material and compaction.	Drainage to be improved and repairs effected.
Km227+965 RHS	35	57	54	A-2-7 (2)	A-7-6 (12)	A-7-6 (13)	52	27	10	101	95	98	Embankment-failed. Poor materials used as subbase and Subgrade, water collects on the drains Poor compaction.	Drainage to be improved with turnouts. Repairs to be effected
Km230+028 LHS	22	59	58	A-2-7(0)	A-6 (11)	A-6 (9)	52	35	15	98	101	97	Embankment-failed. Poor material, Fair compaction. Water collects on the drains	Drainage to be deepened and number of Culverts within the area to be increased. Collection of water complained by Aruna village inhabitants.
Km236+019	35	35	35	A-2-7(1)	A-2-7 (1)	A-2-7 (1)	72	47	22	97	89	96	Embankment-Unfailed. Poor Compaction. Drainage O.K.	NIL.

BORE HOLE RESULTS

Fig. 3-2 (B)



BORE HOLE RESULTS

Fig. 3-2 (C)

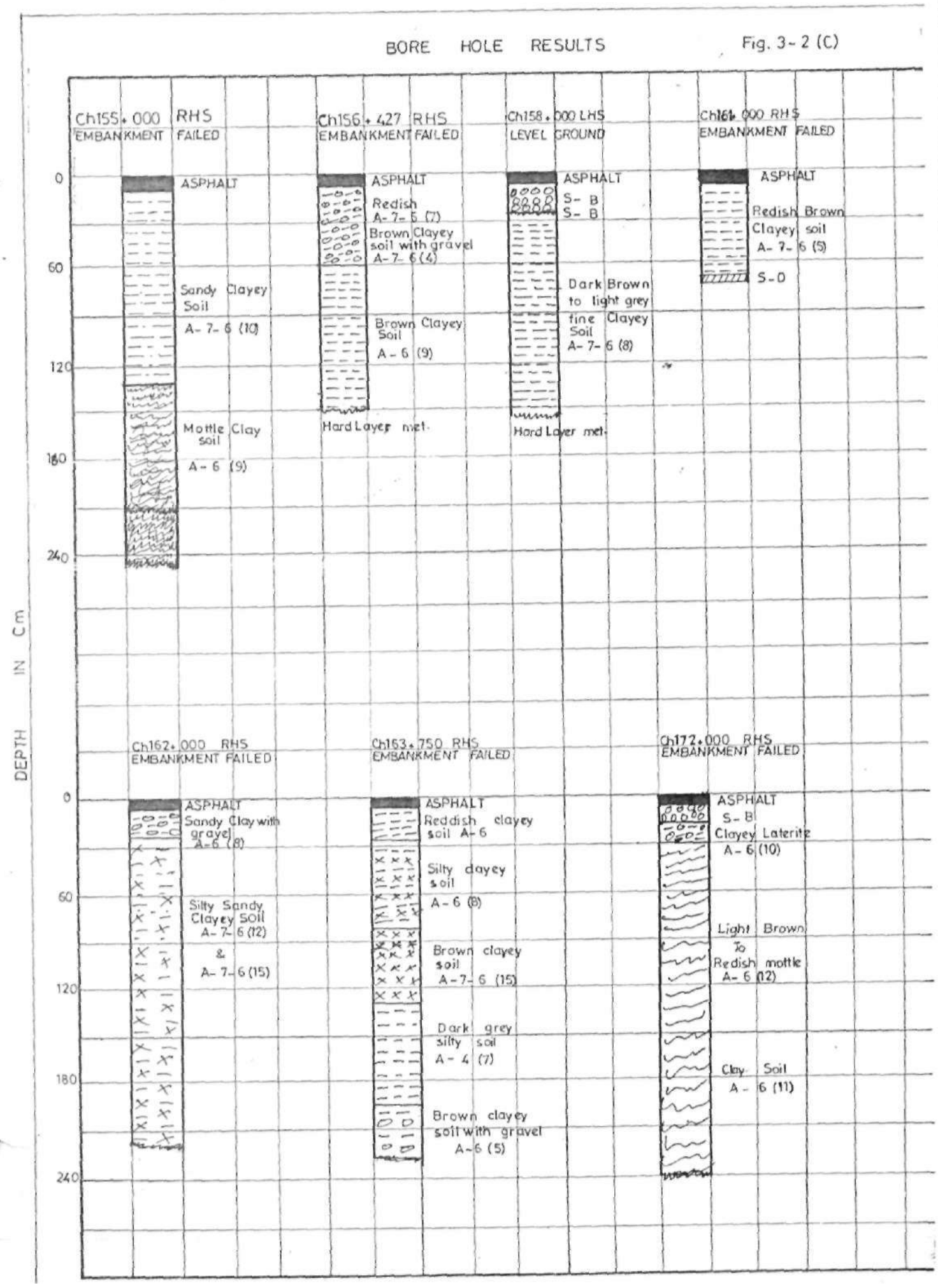


Fig. 3-2 (D)

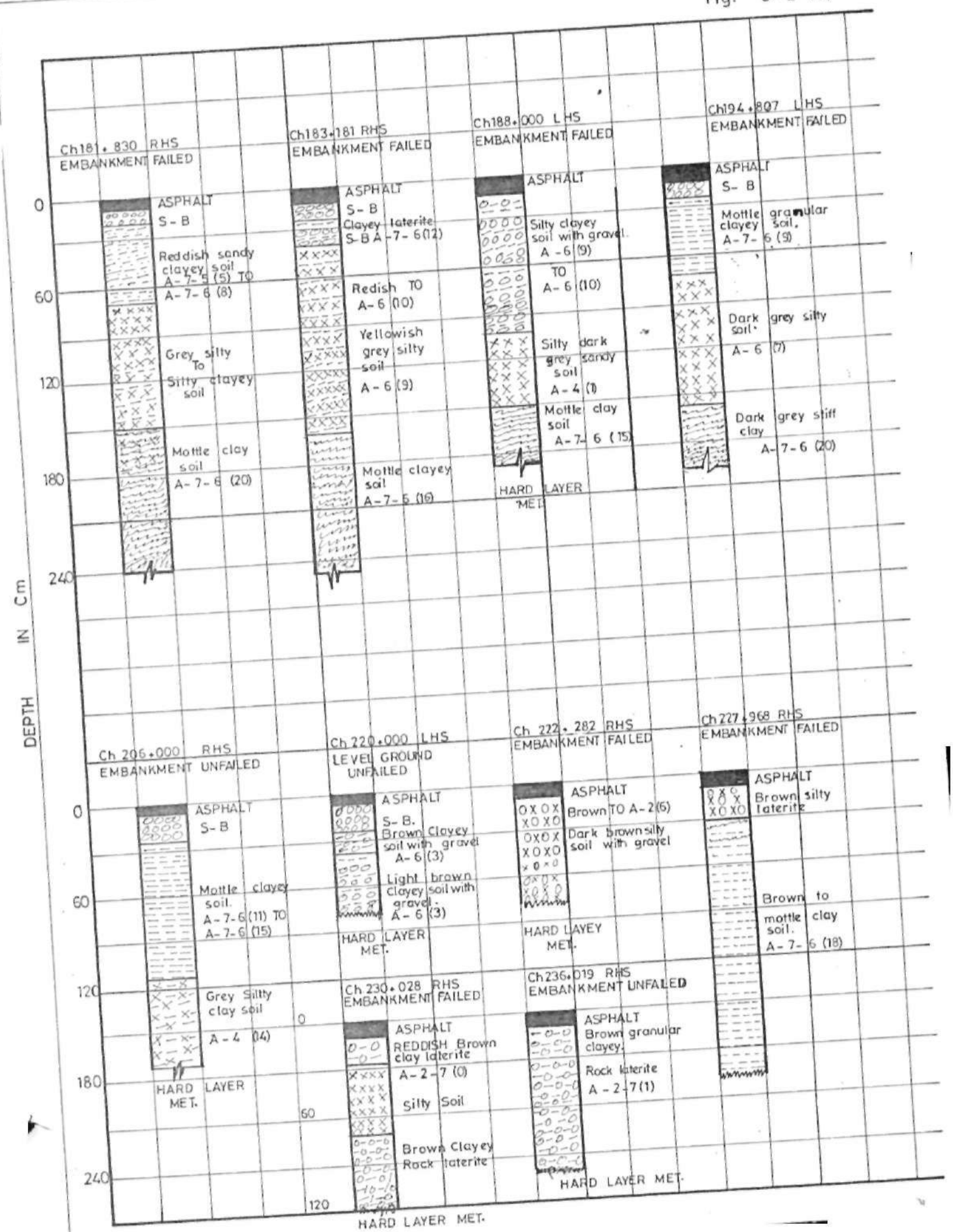

DEPTH IN CM
0
60
120
180
240
Ch181+830 RHS
EMBANKMENT FAILED
ASPHALT
S-B
Reddish sandy clayey soil A-7-5 (5) TO A-7-6 (8)
Grey silty To Silty clayey soil
Mottle clay soil A-7-6 (20)
Ch183+181 RHS
EMBANKMENT FAILED
ASPHALT
S-B
Clayey laterite S-B A-7-6(12)
Redish TO A-6 (10)
Yellowish grey silty soil A-6 (9)
Mottle clayey sail A-7-5 (16)
Ch188+000 LHS
EMBANKMENT FAILED
ASPHALT
Silty clayey soil with gravel A-6 (9) TO A-6 (10)
Silty dark grey sandy soil A-4 (1)
Mottle clay soil A-7-6 (15)
HARD LAYER MET.
Ch194+807 LHS
EMBANKMENT FAILED
ASPHALT
S-B
Mottle granular clayey soil, A-7-6 (9)
Dark grey silty soil A-6 (7)
Dark grey stiff clay A-7-6 (20)
Ch 206+000 RHS
EMBANKMENT UNFAILED
ASPHALT
S-B
Mottle clayey soil. A-7-6 (11) TO A-7-6 (15)
Grey Silty clay soil A-4 (04)
HARD LAYER MET.
Ch 220+000 LHS
LEVEL GROUND UNFAILED
ASPHALT
S-B.
Brown Clayey soil with gravel A-6 (3)
Light brown clayey soil with gravel. A-6 (3)
HARD LAYER MET.
Ch 230+028 RHS
EMBANKMENT FAILED
ASPHALT
REDDISH Brown clay laterite A-2-7 (0)
Silty Soil
Brown Clayey Rock laterite
HARD LAYER MET.
Ch 222+282 RHS
EMBANKMENT FAILED
ASPHALT
Brown TO A-2(6)
Dark brown silty soil with gravel
HARD LAYEY MET.
Ch236+019 RHS
EMBANKMENT UNFAILED
ASPHALT
Brown granular clayey.
Rock laterite A-2-7(1)
HARD LAYER MET.
Ch227+968 RHS
EMBANKMENT FAILED
ASPHALT
Brown silty laterite
Brown to mottle clay soil. A-7-6 (18)

Fig 3-3 (B)

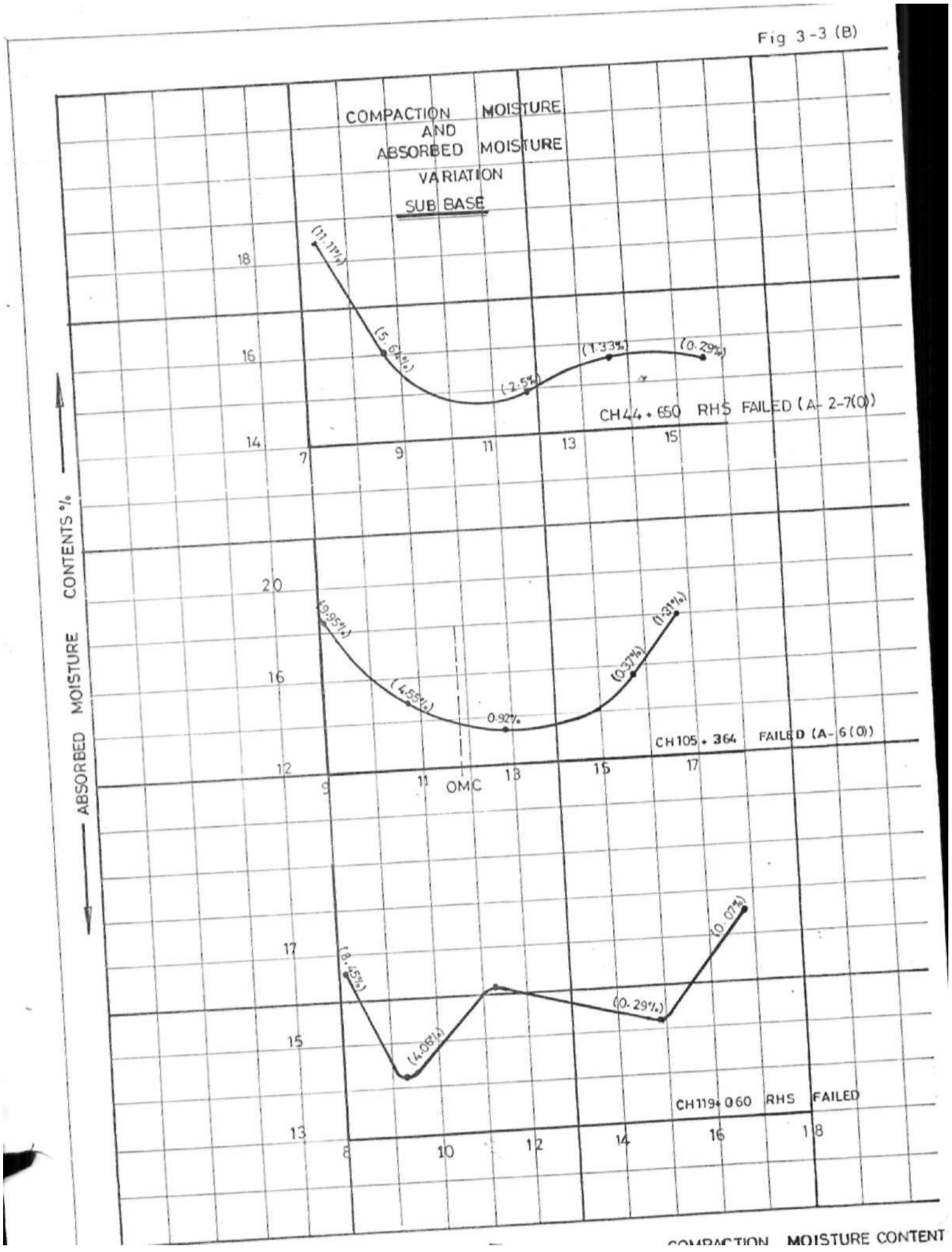
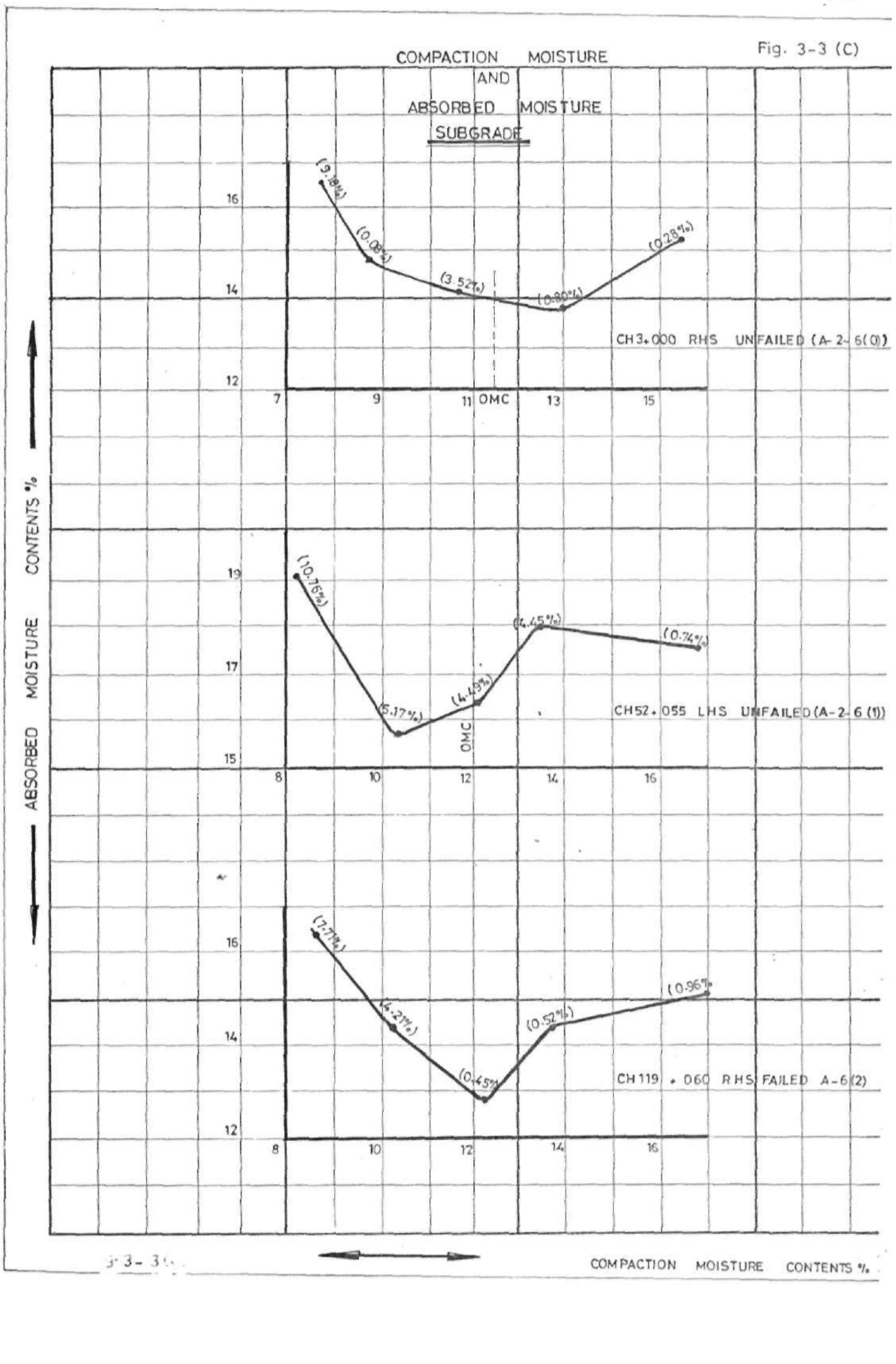

COMPACTION MOISTURE AND ABSORBED MOISTURE VARIATION
SUB BASE
ABSORBED MOISTURE CONTENTS %
MOISTURE CONTENT
OMC
(11.11%)
(5.64%)
(2.5%)
(1.33%)
(0.29%)
CH44+650 RHS FAILED (A-2-7(0))
(9.95%)
(4.55%)
0.92%
(0.37%)
(1.31%)
CH105+364 FAILED (A-6(0))
(8.45%)
(4.08%)
(0.29%)
(0.07%)
CH119+060 RHS FAILED

Fig. 3-3 (C)


COMPACTION MOISTURE AND ABSORBED MOISTURE SUBGRADE
(9.18%)
(0.08%)
(3.52%)
(0.90%)
(0.28%)
CH3+000 RHS UNFAILED (A-2-6(0))
16
14
12
7
9
11 OMC
13
15
(10.76%)
(5.17%)
(4.49%)
(4.45%)
(0.74%)
CH52+055 LHS UNFAILED (A-2-6 (1))
19
17
15
OMC
8
10
12
14
16
(7.71%)
(4.27%)
(0.45%)
(0.52%)
(0.96%)
CH119+060 RHS FAILED A-6(2)
ABSORBED MOISTURE CONTENTS %
COMPACTION MOISTURE CONTENTS %

COMPACTION MOISTURE AND ABSORBED MOISTURE VARIATION

Fig 3-3(D)

SUB GRADE

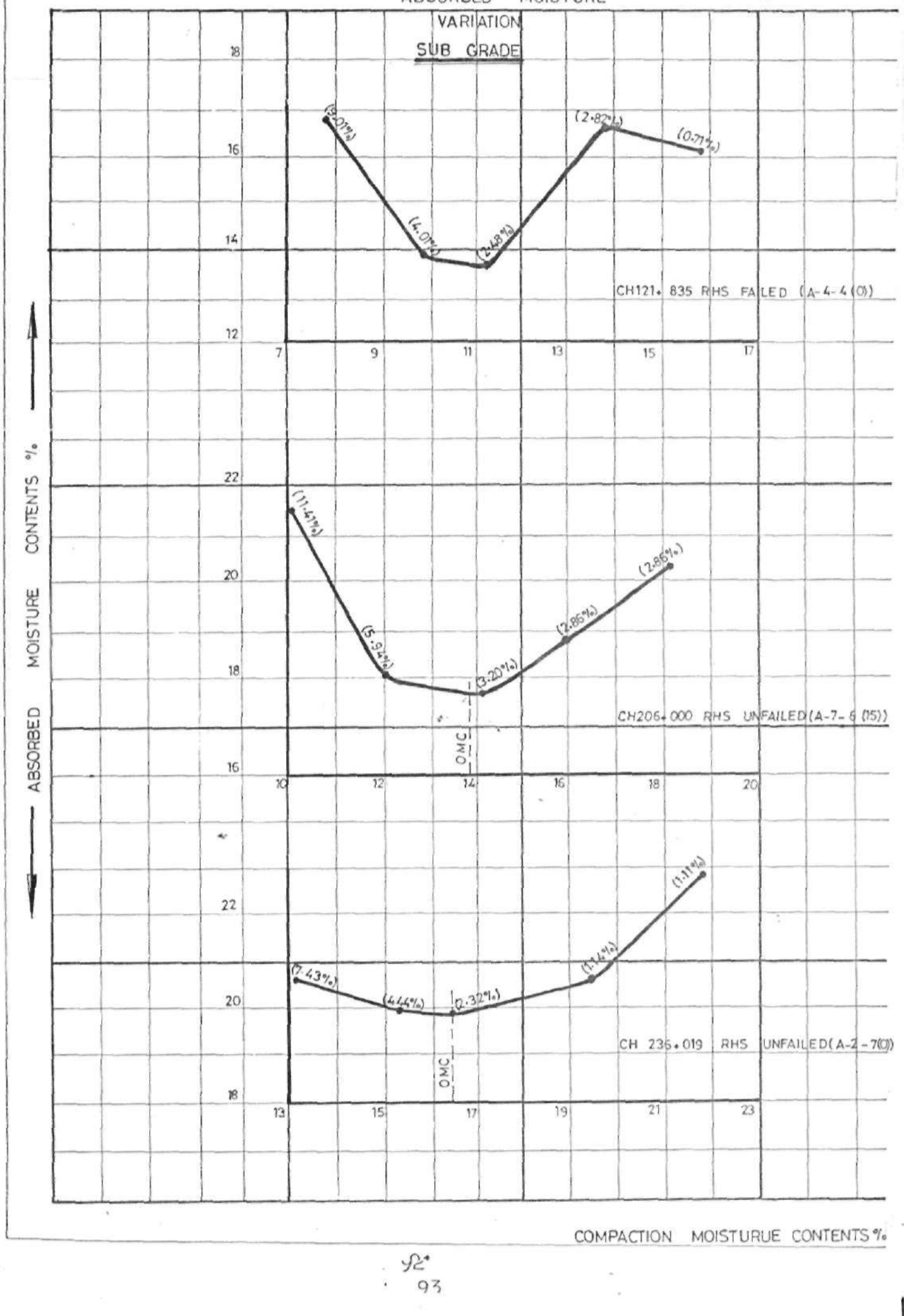
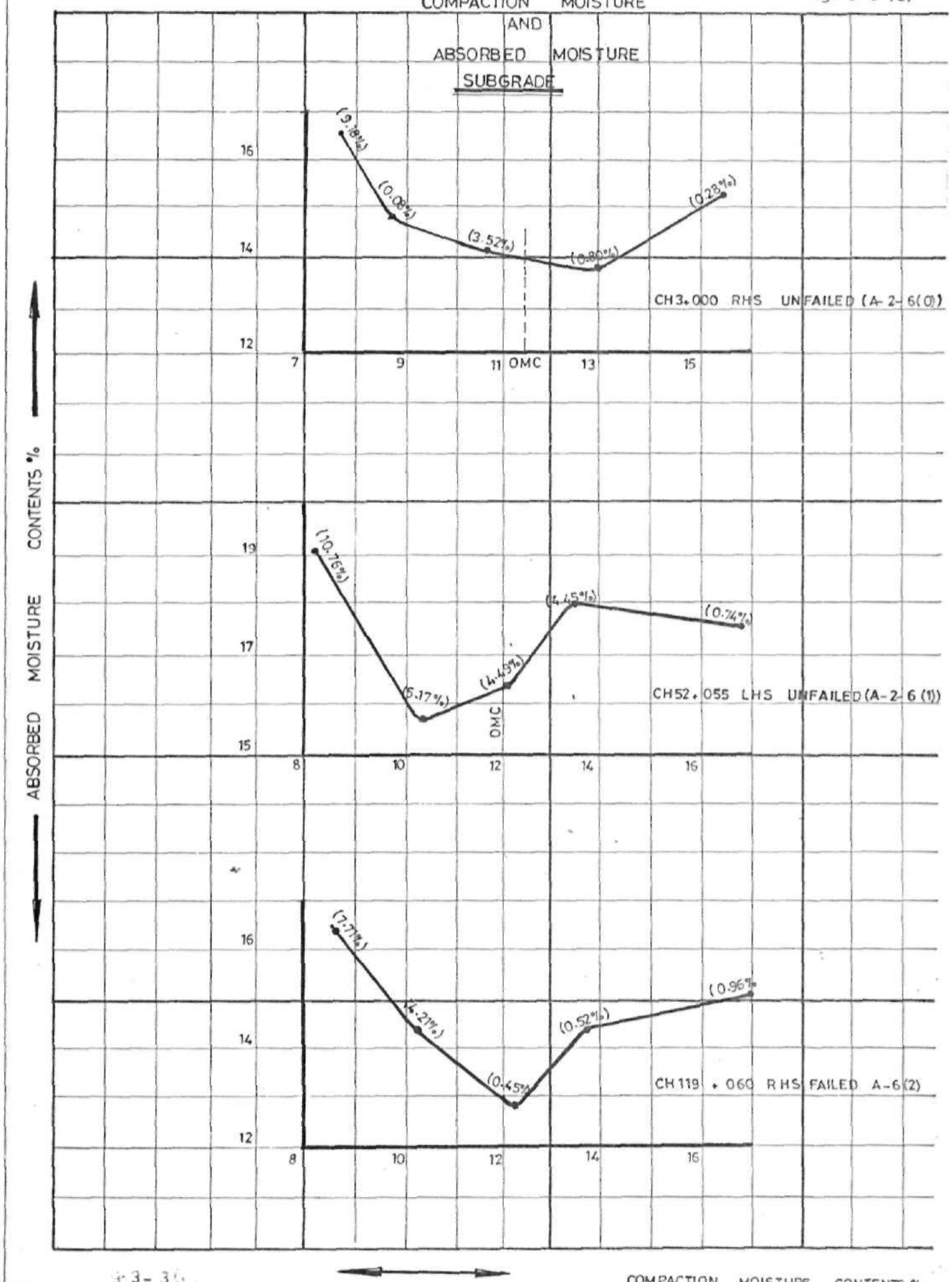


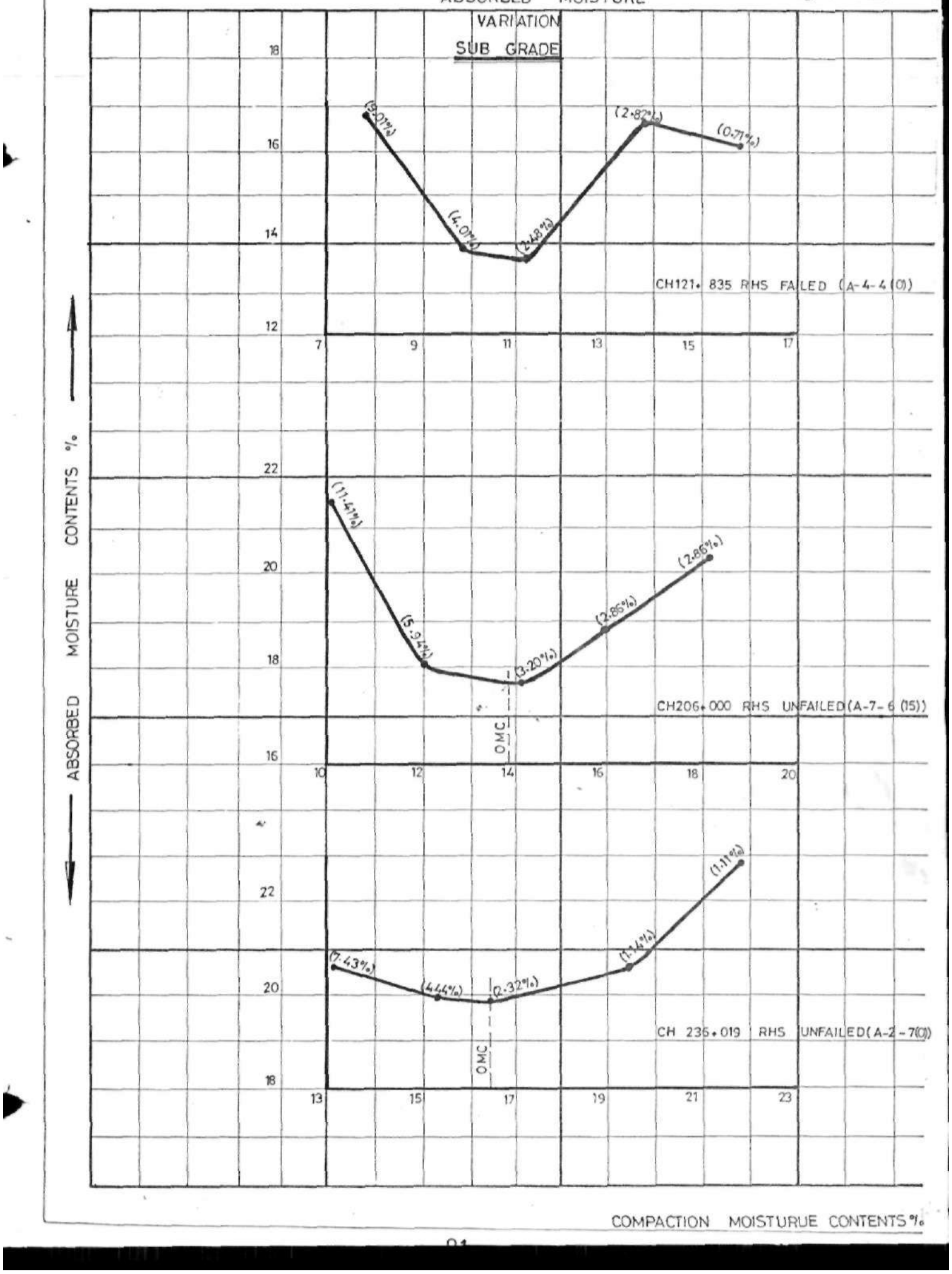
Fig. 3-3 (C)


COMPACTION MOISTURE AND ABSORBED MOISTURE SUBGRADE
ABSORBED MOISTURE CONTENTS %
COMPACTION MOISTURE CONTENTS %
(9.18%)
(0.08%)
(3.52%)
(0.80%)
(0.28%)
CH3+000 RHS UNFAILED (A-2-6(0))
16
14
12
7
9
11 OMC
13
15
(10.76%)
(5.17%)
(4.49%)
(4.45%)
(0.74%)
CH52+055 LHS UNFAILED (A-2-6 (1))
19
17
15
OMC
8
10
12
14
16
(7.71%)
(4.21%)
(0.45%)
(0.52%)
(0.96%)
CH 119 + 060 R HS FAILED A-6(2)

COMPACTION MOISTURE AND ABSORBED MOISTURE VARIATION

Fig 3-3 (D)

SUB GRADE



LOCATION (Km60 + 000)

HOT ROLLED ASPHALT

3.81cm — 5.08 cm WEARING COURSE

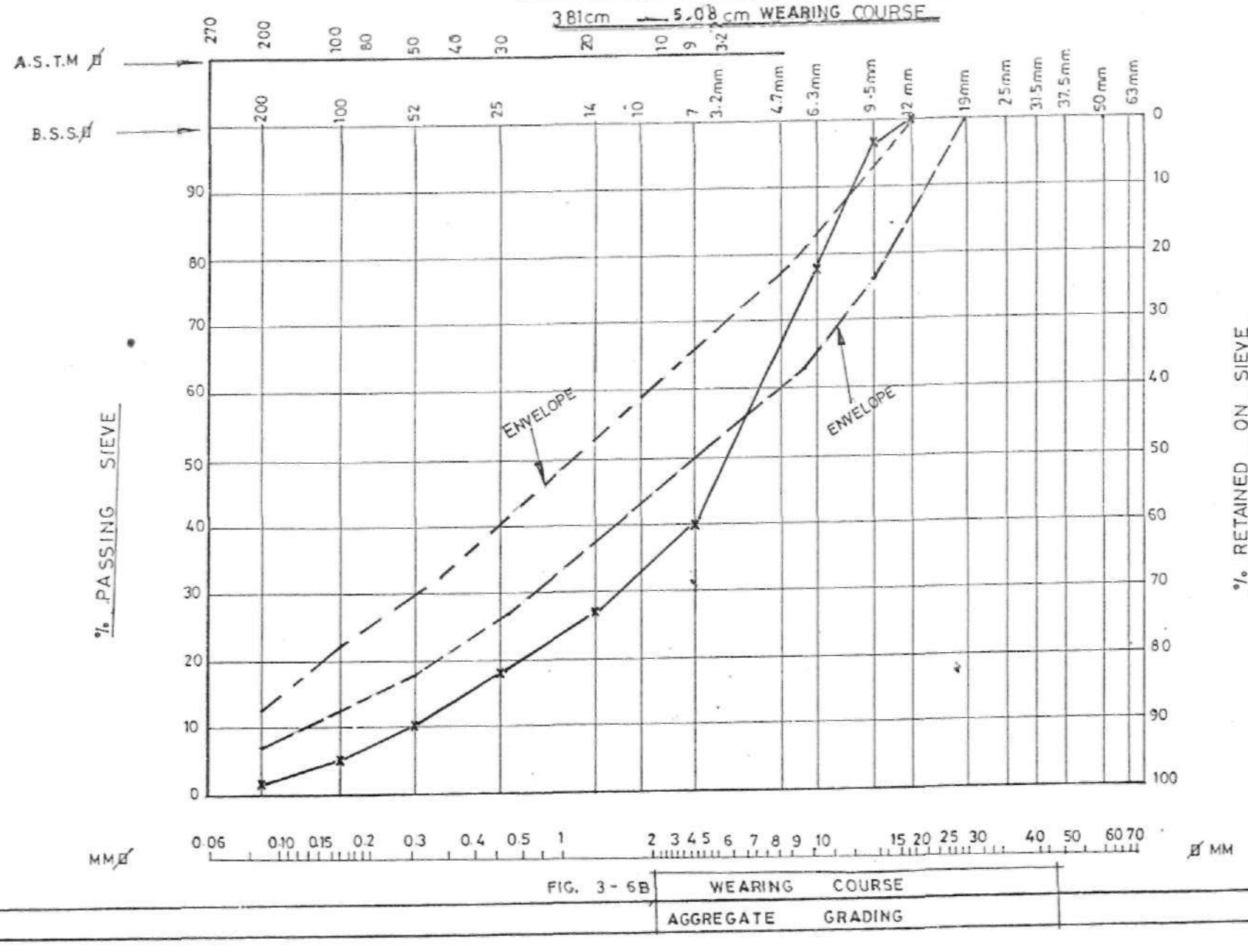


FIG. 3 - 6B WEARING COURSE AGGREGATE GRADING

LOCATION (Km 70+000)

HOT ROLLED ASPHALT

3.81cm — 5.08 cm WEARING COURSE

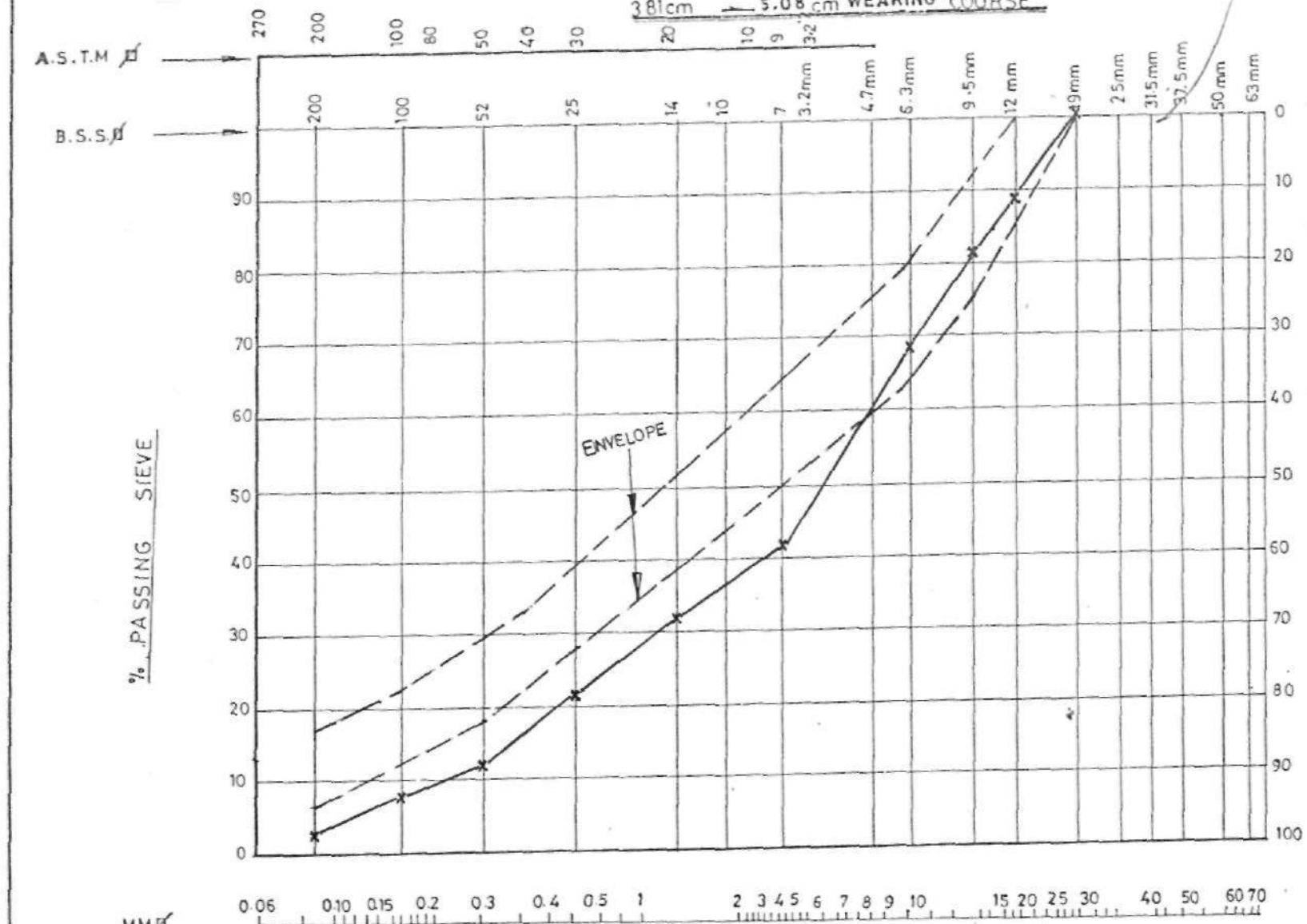


FIG. 3 - 6 C | WEARING COURSE AGGREGATE GRADING

LOCATION (Km 100 + 008)

FIG. 3 - 6(D)

HOT ROLLED ASPHALT

3.81cm — 6.35cm BINDER COURSE

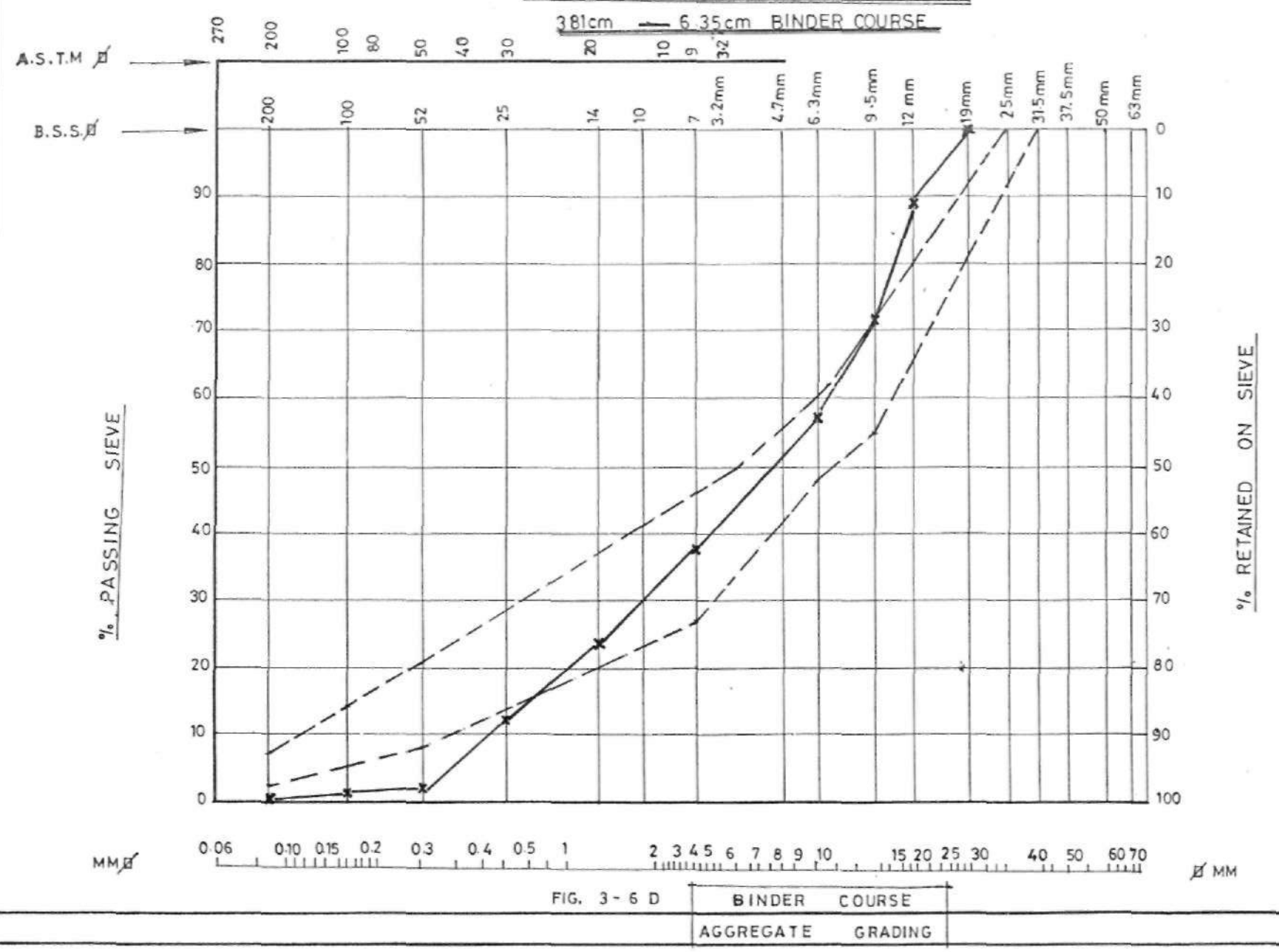


FIG. 3 - 6 D

BINDER COURSE AGGREGATE GRADING

Fig. 3-7B

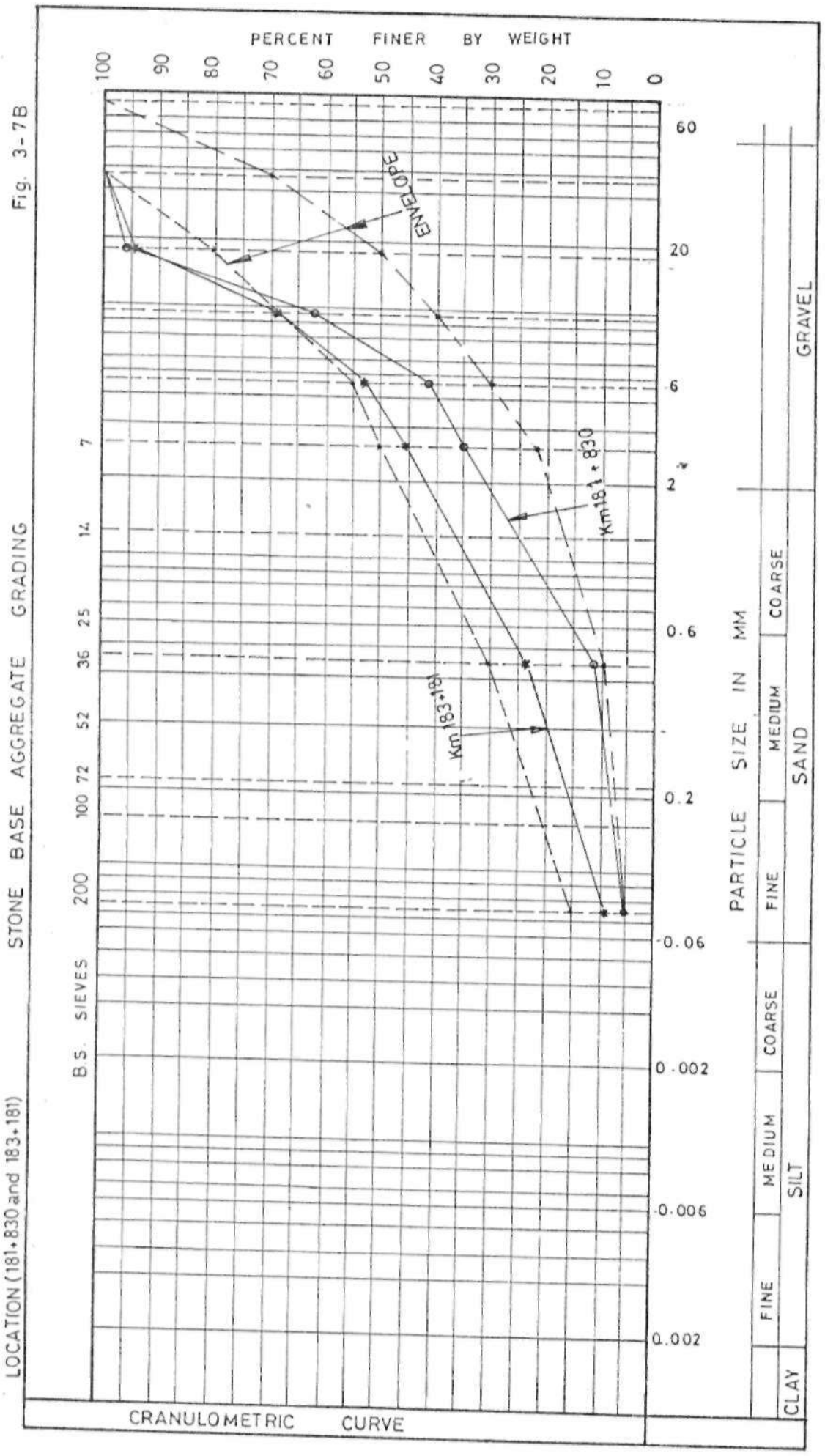

STONE BASE AGGREGATE GRADING
LOCATION (181+830 and 183+181)
PERCENT FINER BY WEIGHT
100 90 80 70 60 50 40 30 20 10 0
B.S. SIEVES
200 100 72 52 36 25 14 7
ENVELOPE
Km 181+830
Km 183+181
60 20 6 2 0.6 0.2 0.06 0.002 0.006 0.002
PARTICLE SIZE IN MM
GRAVEL
COARSE
MEDIUM
FINE
SAND
COARSE
MEDIUM
FINE
SILT
CLAY
CRANULOMETRIC CURVE

Fig. 3-7 (C)

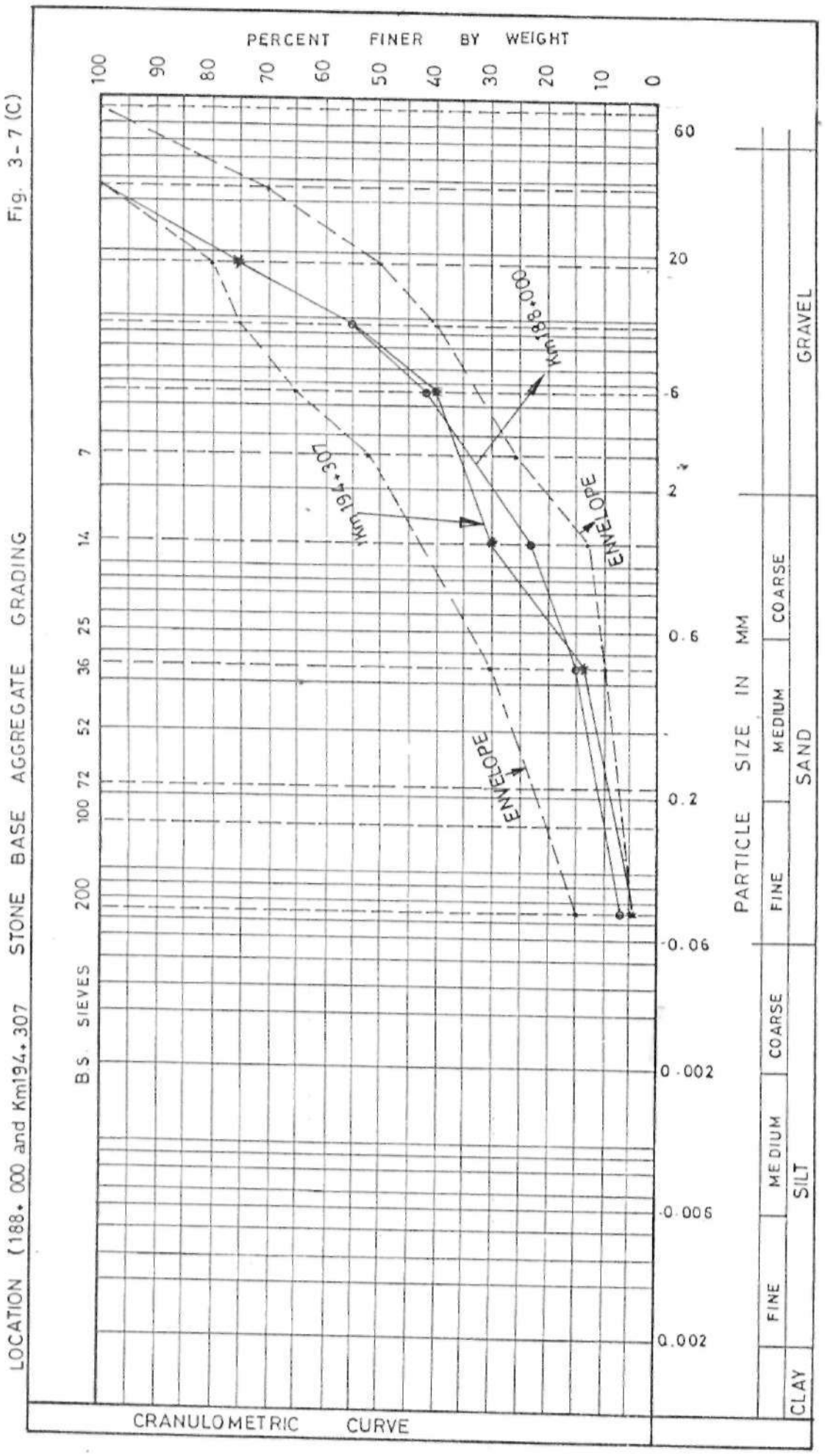
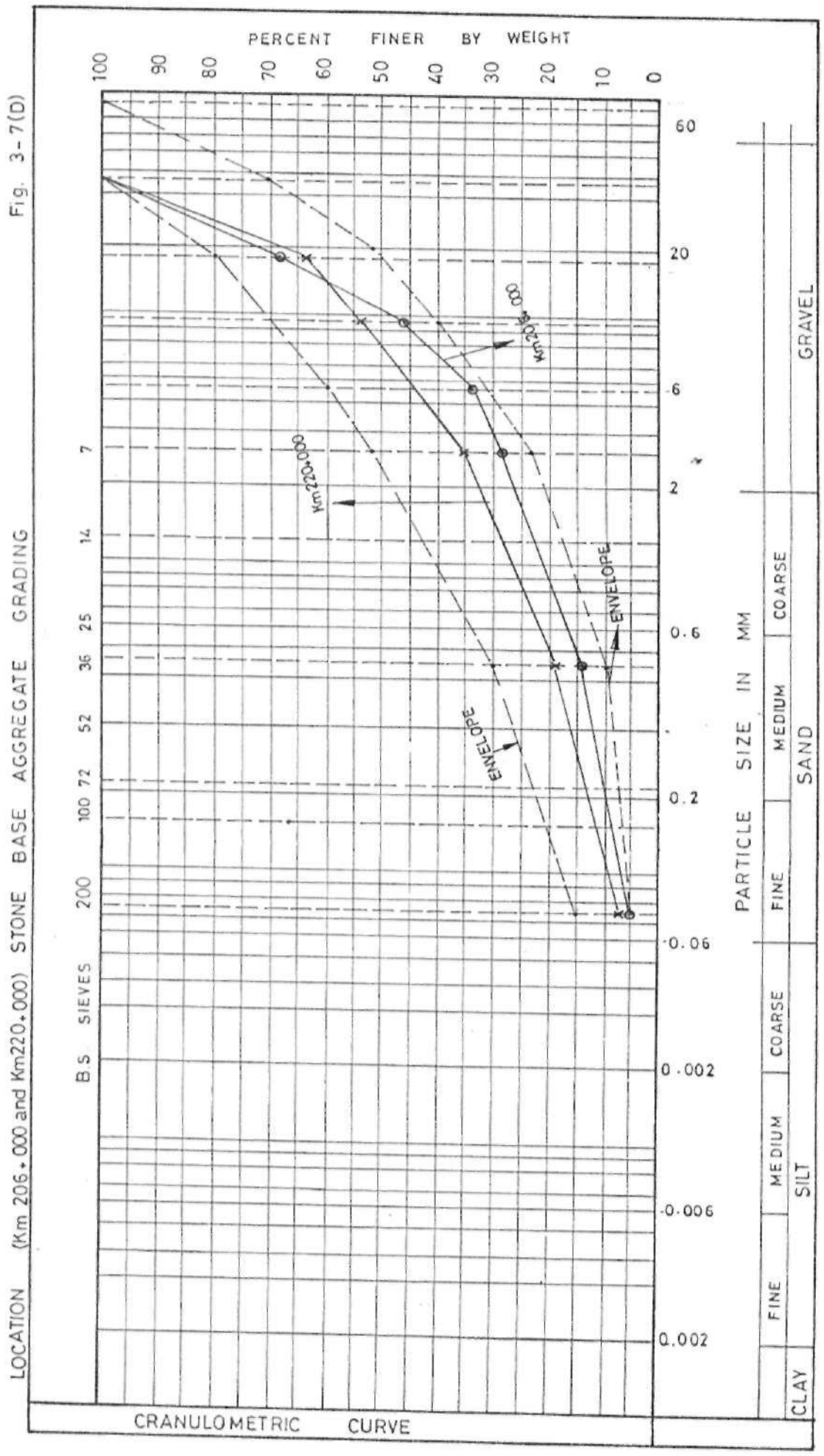

LOCATION (188+000 and Km194+307 STONE BASE AGGREGATE GRADING
PERCENT FINER BY WEIGHT
100
90
80
70
60
50
40
30
20
10
0
B.S. SIEVES
200
100
72
52
7
14
25
36
60
20
6
2
0.6
0.2
0.06
0.002
0.006
0.002
PARTICLE SIZE IN MM
Km 188+000
Km 194+307
ENVELOPE
ENVELOPE
CLAY
FINE
MEDIUM
COARSE
SILT
FINE
MEDIUM
COARSE
SAND
GRAVEL
CRANULOMETRIC CURVE

Fig. 3-7(D)


LOCATION (Km 206+000 and Km220+000) STONE BASE AGGREGATE GRADING
PERCENT FINER BY WEIGHT
100
90
80
70
60
50
40
30
20
10
0
BS SIEVES
7
14
25
36
52
100
72
200
60
20
6
2
0.6
0.2
0.06
0.002
0.006
0.002
Km 206+000
Km220+000
ENVELOPE
ENVELOPE
PARTICLE SIZE IN MM
COARSE
MEDIUM
FINE
GRAVEL
COARSE
MEDIUM
FINE
SAND
MEDIUM
FINE
SILT
CLAY
CRANULOMETRIC CURVE