ROUGHTON INTERNATIONAL

In association with
THE UNIVERSITY OF BIRMINGHAM
and
THE UNIVERSITY OF NOTTINGHAM

Report IV
Field Trials using the Modified DCP Apparatus

Appropriate and Efficient Maintenance of Low Cost Rural Roads

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Field Trials using the Modified DCP Apparatus

February 2000

The University of Nottingham
School of Civil Engineering
University Park
Nottingham
NG7 2RD
United Kingdom
www.nottingham.ac.uk/p&g

Roughton International.
321 Millbrook Road West
Southampton
SO15 OHW
United Kingdom
www.roughton.com

University of Birmingham
School of Civil Engineering
Edgbaston
Birmingham
B15 2TT
United Kingdom
www.bham.ac.uk/CivEng/

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Department for International Development
94 Victoria Street
London
SW1E 5JL
www.dfid.gov.uk

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EXECUTIVE SUMMARY

This element of the project was concerned with the evaluation and development of a pavement and material assessment apparatus in the context of low cost rural feeder roads in developing countries. The aim was to develop a simple method and procedure for the assessment of the quality of those roads. It was proposed that a simple apparatus be adopted which could be made locally at an affordable cost rather than using imported specialist apparatus, thus placing it within the reach and repair capability of poor rural district maintenance authorities.

It was firstly necessary to select an appropriate piece of equipment and then modify it. After initial investigation work, the Dynamic Cone Penetrometer (DCP) was chosen as the equipment to be modified for assessment of roads *in-situ* and of aggregate materials at source, this is discussed in Report III

It was judged that an ideal assessment procedure for the assessment of low cost rural roads should, as far as practical, comprise a method of assessing strength, stiffness (resilient modulus) and permanent deformation characteristics of the road, in-situ. The same, or similar, procedures should be applicable as a predictive tool, to assess aggregate materials at source (from borrow pits). By this means a simple evaluation technique of the basic engineering properties of the road construction material in the present works and future construction was planned.

Laboratory and field investigations in the UK allowed the modification of the apparatus to be undertaken. The principle development was the use of the ‘flat’ tips of various diameters on the DCP apparatus. This was then followed by a number of visits to developing countries to assess the equipment on different soils and establish suitable procedures.

The research demonstrated good applicability of the new techniques in certain circumstances. On crushed rock materials and in certain lateritic soils it could be implemented directly. However, the evidence for its applicability in a generic manner was not conclusive, suggesting that there may be merit in further research work in the area.

Roughton International was able to trial the new equipment on a detailed pavement evaluation project in Malawi. Pavement characteristic data from peak deflection measurements, radius of curvature measurements, and full deflection bowl measurements and routine dynamic cone penetrometer tests were conducted on a variety of pavement types throughout the country. Trial pits were excavated in the pavement and material samples tested in the laboratory. Also material borrow sources were investigated, sampled and tested in the laboratory.

The Stiffness (Resilient Moduli) of the materials is calculated from the pavement investigations and a comparison made against the parameters calculated by the work described in Report III, and previous common relationships developed by the Transport Research Laboratory. In general, the relationships described in Report III performed well against the TRL relationship.

In summary, the DCP with the newly formed relationship performed well, and with further development work and investigation could realise significant time and effort costs in obtaining the Stiffness (Resilient Modulus) parameter for pavement design, and hence pavement life.

REPORT IV – FIELD TRIALS OF MODIFIED DCP APPARATUS

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EXECUTIVE SUMMARY

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1. INTRODUCTION

As part of a Department for International Development Project (KaR 6852), Report III, initial work in the UK had taken place regarding the development of a modified Dynamic Cone Penetrometer (DCP) (see Report III) and the relation between in-situ pavement stiffness measurements and the readings obtained from the new tool. To validate the model in a live environment, pavement testing undertaken as part of the Feasibility Study (ROMARPS, Malawi) by Roughton International was modified to include field trials of the new equipment and subsequent analysis of the results.

Much of the pavement testing involved thinly surfaced pavements, where the new tool was primarily involved with data collection on unsurfaced roads. Nevertheless, it was felt that the opportunity to try and link work carried out in the UK, with overseas conditions was a worthwhile task to undertake. The trials comprised DCP testing with a small flat tip and a standard DCP tip in conjunction with the Consultants standard testing, as listed in section 1.1

1.1. Methodology

The Roughton International pavement team were undertaking a rehabilitation design program which required DCP testing on over 1100 km of road in varying states of distress and construction.

Sample lengths were identified along the ROMARPS project roads with, depending on the length of the road, 1 to 9 lengths selected as being a typical representation of the current state of the road. The sample lengths were on average 1-2 km long. In each of the sample lengths, certain tests were performed. These tests were:

Test	Frequency	Variable Measured/Deduced
Roughton Deflection Bowl	One per sample length	Mr of each layer
Radius of Curvature	Every 100m	Mr*
Peak Deflection	Every 100m	Mr*
DCP Testing	Every 100m, + extras	In situ CBR
Trial Pit Excavation	One per sample length	Material Identification, Lab CBR, PSD

* equivalent of a semi-infinite half-space

1.2. Information on Malawi

1.2.1. General

Malawi is a landlocked country located in Southern Africa, it is bordered by Mozambique, Tanzania and Zambia. The total area of Malawi is 118,480 km^2 of which the total land area is 94,080 km^2. See Figure 1-1.

Figure 1-1 - Generalised Map of Malawi and Southern Africa

ROUGHTON INTERNATIONAL in association with The University of Nottingham	FIELD TRIALS OF MODIFIED DCP EQUIPMENT
THE REPUBLIC OF MALAWI NATIONAL ROADS AUTHORITY	TITLE: SOUTHERN AFRICA INDICATING LOCATION OF MALAWI

The climate is tropical with the rainy season from November to May and the dry season from May to November, hence out testing programme in August was in the middle of the dry period. The general terrain is described as a narrow elongated plateau with rolling plains, rounded hills and some mountains. Lake Malawi forms the majority of the Eastern border in a Rift Valley. The lowest point is the junction of the Shire River and international boundary with Mozambique, which is 37 m above sea level. The highest point is Mount Mlanje Sapitwa, which is 3,002 m above sea level. Our standard DCP testing was carried out country wide, with specialised testing occurring in the south and central areas.

The major natural resources are limestone and little exploited deposits of uranium, coal, and bauxite.

Agriculturally, the country's land use is divided as follows:

- Arable land 25%
- Meadows and pastures 20%
- Forest and woodland 50%
- Other 5%
- Irrigated land 200 km^2 (1989 est.)

1.2.2. Environment

The major reported current environmental issues are deforestation; land degradation; water pollution from agricultural runoff, sewage, industrial wastes and the siltation of spawning grounds of endangered fish populations. There are no major natural hazards in Malawi.

Malawi has signed international environmental agreements on Biodiversity, Climate Change, Endangered Species, Environmental Modification, Hazardous Wastes, Marine Life Conservation, Nuclear Test Ban, Ozone Layer Protection, and has signed, but not ratified - Desertification, Law of the Sea.

1.2.3. People

The population of Malawi is 9,452,844 (July 1996 est.) with a population growth rate of 1.71% (1996 est.) comprising the ethnic divisions of Chewa, Nyanja, Tumbuko, Yao, Lomwe, Sena, Tonga, Ngoni, Ngonde, Asian and European. English and Chichewa are the two official languages, but other languages are important regionally.

The country is divided into 24 administrative divisions: Blantyre, Chikwawa, Chiradzulu, Chitipa, Dedza, Dowa, Karonga, Kasungu, Lilongwe, Machinga (Kasupe), Mangochi, Mchinji, Mulanje, Mwanza, Mzimba, Ntcheu, Nkhata Bay, Nkhotakota, Nsanje, Ntchisi, Rumphi, Salima, Thyolo and Zomba.

1.2.4. Economy

Landlocked, Malawi ranks among the world's least developed countries. The economy is predominately agricultural, with about 90% of the population living in rural areas. Agriculture accounts for 31% of GDP and 90% of export revenues. The economy depends on substantial inflows of economic assistance from the IMF, the World Bank, and individual donor nations. The new government faces strong challenges, e.g., to spur exports, to improve educational and health facilities, and to deal with environmental problems of deforestation and erosion. Drought hurt the 1994 economy, with GDP down by 12.4%. Good weather and a strong tobacco crop resulted in an upturn in 1995. In December 1995, donors pledged $332 million in aid for 1996.

2. PAVEMENT INVESTIGATIONS

2.1. Construction Materials

Laterite Gravels

The Precambrian plains of Malawi contain a widespread but relatively unpredictable distribution of concretionary nodular laterite deposits. In particular, laterite gravels are associated with the Kasungu/Lilongwe Plains, the Mchinji Plain and the Zomba Plain. However, scattered and localised occurrences of laterite gravel have been located in almost all areas of gentle relief that are underlain by the Precambrian Basement Complex. Laterite gravels are the product of tropical weathering and their formation involves the concentration of hydrated oxides of iron and aluminium into cemented nodules under conditions of fluctuating groundwater level and high temperature. In Malawi laterite deposits are frequently found beneath the gently sloping banks of “dambos” that drain elevated plains.

The laterite gravels in Malawi appear to exhibit two origins, some have developed *in situ* and some have probably been eroded from a higher level plateau or pediment and transported by erosion to their current location. Transported laterites are likely to be those that contain a mixture of vein quartz fragments and concretionary nodules.

Laterite gravels in the study area tend to occur beneath 0.5 to 2.0 m of sandy or clayey overburden and the exploitable deposits typically vary in thickness from 0.5m to 1.5 m. They are sometimes associated with strongly cemented “caprocks” which may be difficult to work or remove.

Concretionary laterites are a traditional source of road making gravel in Africa and are perhaps most widely used for lightly trafficked gravel roads, a purpose for which they are well very suited. Nodular laterites in the project area are typically reddish brown slightly clayey or clayey sandy medium sized subrounded gravels. Individual particles are relatively weak (easily broken with a hammer) and the plasticity of the fine fraction varies from less than 6% in sandy deposits to greater that 25%. Natural (“as-dug”) laterite pavement materials may produce high laboratory soaked CBR strengths (60 – 100%) despite comprising relatively high plasticity fines and so warrant consideration as potential sources of “as-dug” base course material provided a reduction in the PI and particle strength specification is acceptable under the expected drainage and traffic conditions. The performance characteristics of plastic laterite pavement materials can be improved by stabilisation with lime (or cement provided PI is not excessive). In East Africa lime stabilised plastic laterites (PI up to 25%), locally referred to as “murram”, are the most widely used base materials for bituminous surfaced medium volume roads.

Much research has been undertaken in Malawi (UK Transport Research Laboratory - TRL), Kenya (ie Low Volume Roads Study) and other African countries to investigate the use of plastic laterite materials as bases for bitumen surfaced roads. “In service” performance of laterite road sections has typically been surprisingly good. It has not been possible to establish conclusively the reason for the satisfactory performance but evidence indicates that the construction procedure adopted is significant, Charman 1995.

Weathered Gneiss/Granite Gravels

Ancient (Precambrian) crystalline granitic gneiss and true granite are the most widespread rock types found in Malawi. When exposed to tropical weathering these rocks will often suffer decomposition which extends to several metres beneath the ground surface.

A deposit is said to be completely weathered when all the rock is decomposed or disintegrated to soil but the original fabric is evident. Such deposits generally comprise weak particles in a clayey (often micaceous) matrix. Completely weathered materials are usually of limited thickness over less weathered rock and are treated as overburden or used as general fill.

Moderately to highly weathered gneisses and granites have been exploited in gravel pits on a small scale in Malawi to supply gravel wearing course material, shoulder material and subbase. The workable materials are typically of limited thickness and poor quality, but may still be important material sources particularly in rugged mountainous terrain where there are no better alternative sources of easily excavated material.

Weathered rock gravel deposits are highly variable in engineering terms, primarily because of lack of uniformity in terms of clay content, particle strength and particle size distribution. The individual gravel particles are weathered to differing degrees and as a result the decomposing crystalline structure shows a great range in strength from very weak and friable to moderately strong. In addition, significant quantities of mica may be found in the sand size fraction of weathered gneiss gravels. Highly micaeous materials have poor compactive properties, since the mica flakes inhibit effective compaction and may be associated with the formation of shear planes during the compactive process.

<u>Vein Quartz Gravels</u>

Vein quartz gravels are found in association with weathered gneiss and granite in the Precambrian terrains. They are found at shallow depth and exploitable deposits range in thickness from 0.5 m to a maximum of 1.5m. Vein quartz gravels typically comprise clayey sandy angular gravels and are primarily transported soils. The gravel fragments being derived from quartz veins in the bedrock. These gravels represent the accumulations of resistant rock fragments concentrated together as a result of the abrading and sorting actions of slope-wash erosion. During transport weak crystalline mother rock fragments are broken down, whilst the strong durable vein quartz fragments remain little affected. Inevitably quartz gravels contain some strong crystalline mother rock, but deposits have been described as quartz gravels when more that about 60% of the fragments are quartz. Where deposits comprise about 50/50 quartz and gneiss they have been described as quartz/gneiss gravels.

Natural quartz gravels are usually reasonably well graded materials with high particle strength, but they typically contain a clayey binder fraction with a Plasticity Index (PI) in excess of 12% and sometimes greater than 25%. As a result soaked CBR strengths can be expected to be less than required for high strength (CBR> 80%) base course construction. However selected deposits may be suitable for construction of strong lime or cement stabilised layers.

<u>Pebble Gravels</u>

Pebble gravels are water worn (alluvial) rounded gravel and cobble deposits that may be found in recent river bed and terrace deposits and as weathered or uncemented conglomerate deposits.

Along the study roads exploitable river bed and terrace deposits tend to comprise sand (alluvial sands are considered as a separate materials category) with only a small proportion of rounded gravel. Where alluvial sand and gravel deposits can be located they represent potential sources of “as dug” subbase material provided that they comply with the plasticity (PI<12%) and grading characteristics defined in ORN 31. Coarse cobbley river deposits offer potential as sources of crushed base and subbase material when the particles are strong and sound (no such deposits have been identified for use in the ROMARP rehabilitation works).

Sandy and clayey quartz pebble deposits are found in the north east of Malawi, where they are associated with the outcrop of Tertiary sedimentary deposits. In the vicinity of the Karonga to Songwe road (No.1) there are several deposits of clayey well graded rounded to angular gravel with cobbles which have been used to supply subbase material and represent potential sources of lime or cement treated base course. These alluvial materials are derived from conglomerates and gravels deposited in the Miocene to Pleistocene epochs.

Sands

In the rift valley regions there are some areas where there are no rock or gravel deposits occurring in close proximity to project roads (ie the Mangochi road). However, in these areas there are typically large deposits of readily exploitable sand in river beds and along the shores of the rift valley lakes.

These alluvial and lacustrine sand deposits are typically slightly silty (non plastic to low plasticity) well graded quartz/gneiss sands with some fine gravel. Such deposits may sometimes be suitable for use as untreated subbase and will usually be suitable for construction of cement or bitumen emulsion treated subbase and base layers.

It is understood that bitumen stabilised sand has not been used to date in the construction of road pavements in Malawi. Good specification guidelines are given in the Kenya Road Design Manual for sand bitumen mixes for base.

Hard Rocks

Malawi is generally well endowed with resources of widely jointed hard rock suitable for production of crushed pavement aggregates. Indeed, sources of crushed stone pavement material have been identified within economical haulage distances along all of the project roads investigated.

The most common type of hard rock exploited in existing quarries is granitic gneiss. When quarry sites have been carefully selected, fresh (unweathered) granitic gneiss will typically be sufficiently strong to satisfy the requirements for the supply of sealing aggregates. Some gneiss deposits are foliated in which case there may be a preferred fracture orientation during crushing which may tend to produce flaky aggregate particles. Strength problems may sometimes be associated with black crystalline biotite gneisses, but durability is usually sufficient for graded crushed stone base course production.

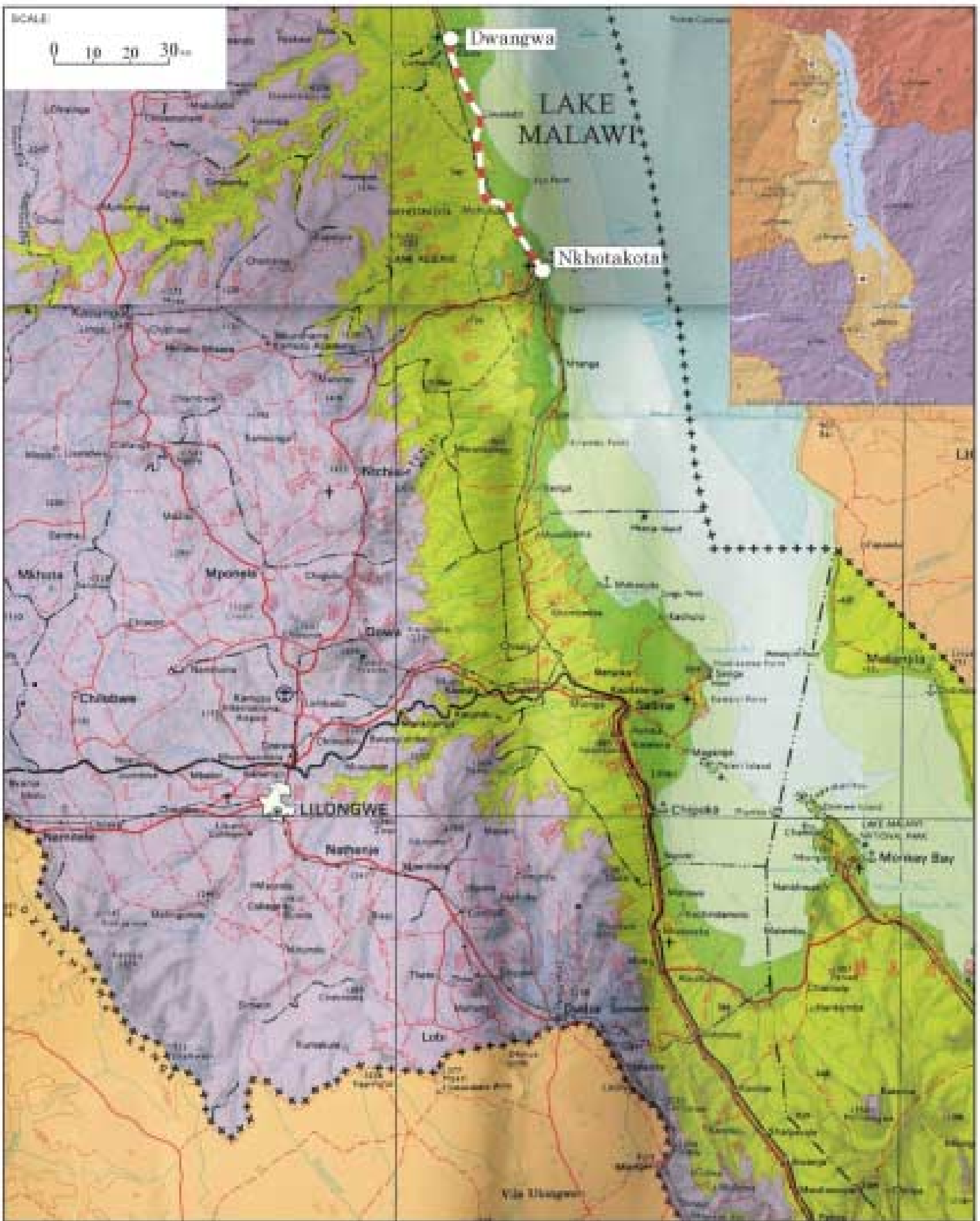
2.2. Pavement Construction

2.2.1. Background

The ROMARP study involves the investigation of 19 roads. Their approximate locations are shown on the map presented in Figure 2-1. This section of the report provides a brief summary of when each of the main project roads were constructed and rehabilitated, what constructions were adopted and what materials were used to form the pavement structure. The information presented is based on data derived from consultants reports, Ministry of Works (MOW) reports and observations made during the current study. The roads which had modified DCP testing, and other structural analyses performed upon them were numbers 1, 2.1, 2.2, 4, 11, 14.1 and 14.2 The details of other roads are briefly included here as standard DCP testing was undertaken every 2km on all roads.

Figure 2-1 - The Approximate Location of the Project Roads

ROUGHTON INTERNATIONAL in association with The University of Nottingham	FIELD TRIALS OF MODIFIED DCP EQUIPMENT
THE REPUBLIC OF MALAWI NATIONAL ROADS AUTHORITY	TITLE: LOCATION OF PROJECT ROADS MAIN ROADS (CENTRAL REGION)



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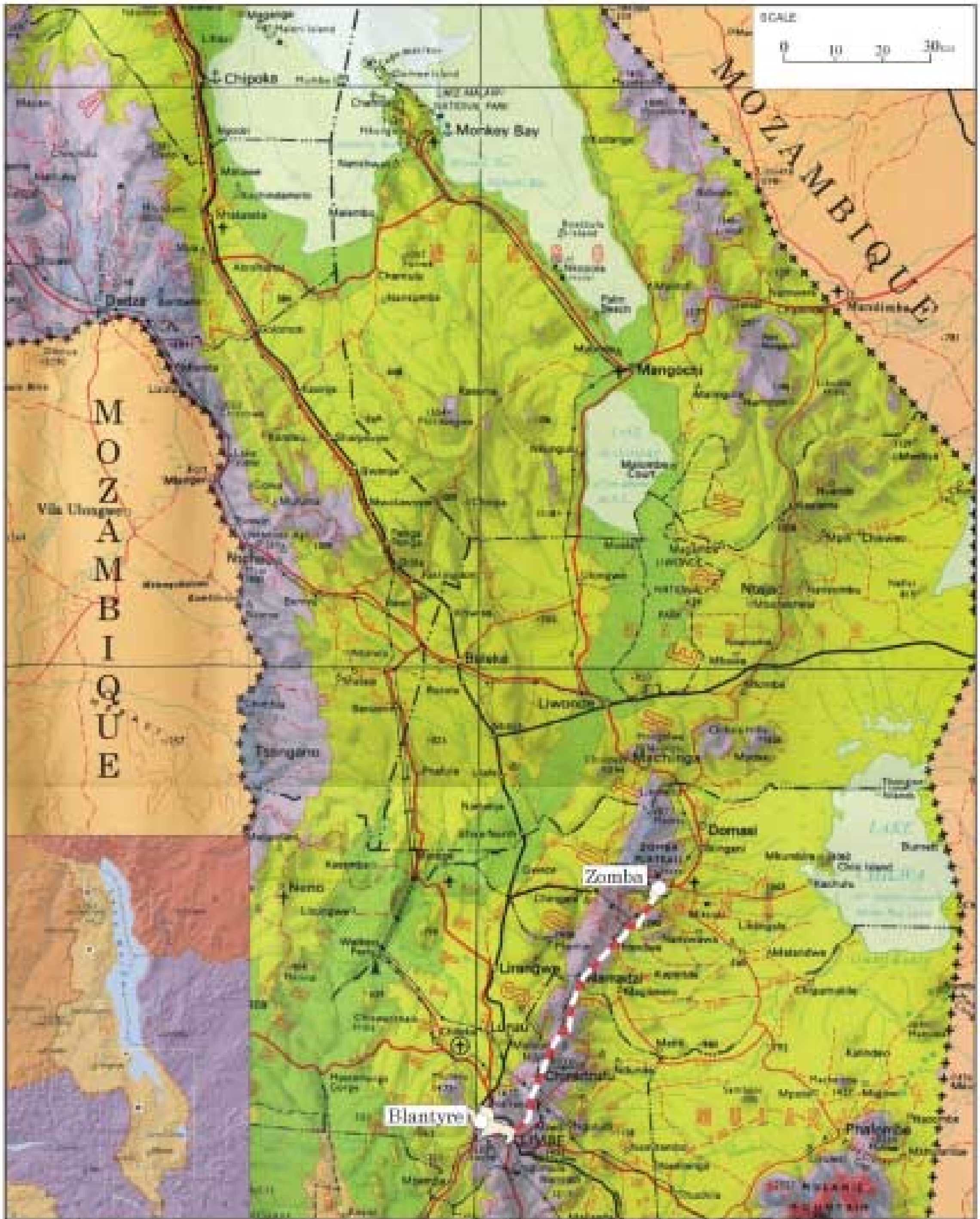
TITLE

LOCATION OF PROJECT ROADS
MAIN ROADS
(CENTRAL REGION)



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THE REPUBLIC OF MALAWI
NATIONAL ROADS AUTHORITY

TITLE

LOCATION OF PROJECT ROADS
MAIN ROADS
(CENTRAL REGION)

Karonga to Songwe Road (No. 1)

The Karonga to Songwe Road (45.9 km) was upgraded from gravel road to bitumen sealed construction with 6.7 m wide carriageway during the period 1988 to 1991. The contract was carried out by Held and Franke Bauaktiengesellschaft and supervised/ designed by Adonis Drettas Karlaftis (ADK). Pavement design drawings dated October 1985 show a 150 mm wet mix macadam (crushed stone) base with a 100 mm thick natural gravel subbase. These design drawings show gravel shoulders with base drains. However, when constructed the crushed stone base was extended beneath 1.8 m wide sealed shoulders. A chip seal surface dressing was applied to the carriageway.

The road has not been resealed since construction.

Mzuzu to Bwengu Road (No. 2.1)

The 59 km long Mzuzu to Bwengu road was upgraded and bitumen sealed in the early 1980's. Design drawings prepared by Scott Wilson Kirkpatrick (dated March 1980) for the Mzuzu to Ekwendeni Contract (24,25/80) were located and reviewed. These drawings show a 150 mm wet-mix macadam (crushed stone) base with a 100 mm thick natural gravel subbase. The road has a 6.7 m carriageway and the design incorporates natural gravel shoulders. Base drains beneath the 1.5 m shoulders are not shown on the drawings and field investigations showed no evidence of their presence. This road is being patched and resealed (single surface dressing) as part of the 1998 maintenance programme. There are no records of any previous reseal.

Bwengu to Chiweta Road (No. 2.2)

The Luzi River to Chiweta section of road is reported to have been originally constructed in 1975. No records have been located concerning the construction of the existing pavement. However, the existing Bwengu to Chiweta pavement was most likely constructed in the mid 1980's and has received no further treatment until the programmed patch and single coat reseal scheduled for 1998.

The existing carriageway is 6.1 m wide with 1.6 m sealed shoulders except on the descent of the Chiweta escarpment where there are some reductions in road width. The road has a crushed stone base (170 – 185 mm) and a natural gravel subbase (100 – 280 mm) The crushed stone base extends under the shoulders.

Jenda to Chikangawa Road (No. 3)

This 82 km long road section incorporates two construction contacts undertaken in the early to mid 1980's. Namely, Jenda to Luwawa Turnoff (Contract 24/80) and Luwawa Turnoff to Champhoyo Road (Contract 7/83). Both road sections were designed by Scott Wilson Kirkpatrick. The contract design drawings and soils and materials reports were located in the MOW and have been reviewed.

Pavement design drawings for the Luwawa Turnoff to Champhoyo Road dated 1983 show a double seal surface dressing with a 150 mm wet-mix macadam (crushed stone) base on a 100 mm thick natural gravel subbase. Base drains were located along some sections of road and there was evidence that they had been functioning. However, where deep kerbs had been installed base drainage would certainly be impeded. The typical cross section shows the carriageway to be 6 m wide with 1.5 m shoulders. However, the constructed road has a 7 m wide carriageway.

This road has never been resealed.

Mzuzu to Nkhata Bay Road (No. 4)

The Mzuzu to Nkhata Bay road was originally made into a bitumen surfaced road in the mid 1970's. It was substantially rehabilitated in 1983-1984 after the pavement evaluation investigation work done in 1982 and reported in Ministry of Works report DMR 38.

The original construction comprised a natural gravel base and subbase up to about km 20 with a cement stabilised quartz gravel base from km 20 to Nkhata Bay (km 45.7). During the 1983-1984 rehabilitation the road was patched and repaired and a new crushed stone base was constructed along some badly deformed lengths. Exact details of the existing pavement construction have been determined during the current study and are reported in Section 2 of this volume.

The existing carriageway is 5.1 to 6.3 m wide with unsealed gravel shoulders approximately 1 m wide. Parts of the first 10 km of road are located along a steep sided watershed ridge. Landslide activity downslope of the road has given rise to pavement subsidence at several locations in this area. A maintenance contract to repair, patch and reseal this road was in progress during 1998.

Bwengu to Rumphi Road (No. 5)

Records indicate that the 8.9 km length of Road No. 5 was constructed as a double surface bitumen sealed pavement in 1980 and given a single coat reseal in 1987. The pavement design comprises 150 mm of crushed stone base on a minimum 100 mm thick natural gravel subbase.

Kasungu to Dwandwa River Road (No .6)

Madisi to Kasungu Road (No. 7) and

Lumbadzi to Mponela (No. 8)

All these sections of the M1 north of Lilongwe were designed and constructed at the end of the 1970's and beginning of the 1980's. The pavement design (prepared by Scott Wilson Kirkpatrick) comprises 150 mm of "as dug" laterite gravel on a minimum of 100 mm of "as dug" gravel subbase. The carriageway is 6.7 m wide with unsealed natural gravel shoulders 1.5 – 1.6 m wide.

Some short sections (5 km) of reseal have been applied but the majority of the road lengths have received no surface treatment since original construction.

Bunda Turn-off to Chimbiya (No. 9)

This 53.8 km length of the M1 was originally surfaced in 1971. At which time some sections were constructed with a 1 inch (25 mm) premix (asphaltic concrete) surfacing and some were given a double surface dressing. One of the surface dressed sections from Kamchere to Kalumba turn-off received a 40 mm premix overlay in 1981, as did the existing premix section from Linthipe to Chimbiya. As a result, the only remaining section with a surface dressing is between the Diamphwe River and Linthipe, but this has received spot premix overlays.

The base course comprises a 125 to150 mm thick crushed stone macadam with a minimum 100 mm natural gravel subbase. The carriageway is 6.7 m wide and the design incorporates natural gravel shoulders 1.6 m wide. It is not known whether base drains were installed, but they were not observed during the current field investigations.

Dedza to Biriwiri (No. 10)

It is reported that this 64.5 km length of the M1 was originally constructed in the early 1970's and that a 1 inch (25 mm) premix surfacing was applied everywhere except along the 20.9 km section between Masasa and Kalitsilo. The road has been strengthened and repaired with premix overlays at various times since original construction. No surface dressed sections were seen to be remaining during the current field studies. Locally, existing depths of premix were observed to exceed 120 mm.

The pavement was designed to comprise 125 – 150 mm of crushed stone macadam base and not less than 125 to 150 of natural gravel subbase. The carriageway is 6.7 m wide and the design incorporates natural gravel shoulders 1.6 m wide. Base drains were not observed during the current field investigations.

Salima to Senga Bay Road (No. 11)

This 22km long road was bitumen surfaced in 1976. Records indicate that the pavement design comprised a single surface chip seal on a 150mm of natural gravel base with not less than 100 mm of natural gravel subbase. The carriageway is 5.6 m wide with 1.0 m unsealed natural gravel shoulders. The Salima to Senga Bay Road has never been resealed.

Benga to Nkhotakota Road (No. 12.1)

The lakeshore road from Benga to Nkhotakota town junction is 52.2 km long. This road was constructed to gravel standard between 1966 and 1968. During the period 1974 to 1976 it was upgraded by construction of a subbase and cement stabilised natural gravel base with a sand seal surface dressing. The road was further upgraded between 1981 to 1982 by patching and localised reconstruction followed by a application of a single chip seal and a slurry seal. Around Sani the reconstructed section consists of a crushed stone base. During the rehabilitation works experimental road sections were incorporated along the road to study the performance of various pavement constructions. This rehabilitation work was carried out by MOW Road Construction Unit No.1.

The road section from Benga to a point km 9.5 Northwards has a 150 mm thick crushed stone macadam overlay which extends across the shoulders (which have been sealed). It is believed that this was constructed in 1993 as part of the Resealing of Paved Roads Programme which included patching and application of a single coat reseal along the rest of the road section.

North of km 9.5 the carriageway is 5.5 m wide with 1.0 m wide unsealed gravel shoulders. Stabilised gravel typically extends about 300 mm beyond the edge of the sealed carriageway where a stabilised base exists.

Nkhotakota to Dwangwa Road (No. 12.2)

The 56.1 km long section of lakeshore road from Nkhotakota Town junction to Dwangwa Bridge was originally constructed to gravel standard between 1968 and 1970. Between 1973 to 1974 a stabilised natural gravel base was constructed and a sand seal applied.

Some sections of the road were overlaid or replaced with a crushed stone base during the period 1978 to 1981, when a single chip seal and slurry seal surfacing was constructed. In 1993 the road was patched and a single coat reseal applied

The existing carriageway is 5.6 m wide with 1.5 m wide unsealed natural gravel shoulders (shoulder erosion is however quite severe in places). It is not known whether base drains were installed where the crushed stone base was constructed, but no evidence for base drainage through the clayey shoulders was observed during the field studies. Indeed, pavement deterioration along the crushed stone base sections is almost certainly linked to inadequate base drainage.

Chingeni to Liwonde Road (No. 13.1)

The Chingeni to Liwonde road (34.4 km long) was upgraded to a bitumen surfaced road in 1971. Pavement designs have not been located, but test pitting indicates that the structure comprised a minimum 100 mm natural gravel subbase with a 120 –150 mm thick stabilised gravel base and a 1 inch (25mm) premix asphalt surfacing. Opinions differ as to whether the base was cement or lime stabilised. The HCl field test used during the current investigations cannot differentiate between lime and cement treated materials.

The 6.7 m wide carriageway has been extensively patched but has received no new surface treatment (overlay or reseal) since construction. However, the premix surfacing has been ripped and scarified into the stabilised base along the following sections, where the surface had become excessively rough:

km 10.3	to	15.8 (Liwaladzi Bridge)
km 28.2	to	28.6
km 29.8	to	34.3 (100 m before M’manga/ Mangochi Jn)

Liwonde (M’manga) to Zomba Road (No. 13.2)

This 54.6 km long road was upgraded to a bitumen surfaced road in about 1971. Construction records have not been found, but test pitting has indicated that the pavement design comprised a minimum 100 mm natural gravel subbase with a 130 – 160 mm thick stabilised natural gravel base and a 1inch (25 mm) premix surfacing.

The road has been very extensively patched (often to shallow depth – surface replacement) but has never been resealed.

A contract to patch and reseal this road was in progress during the 1998 field investigations, but it was observed that the weak weathered rock (mainly from Liwonde Town Pit) being used to repair the base and shoulders appeared to be of poor quality. The existing carriageway is 6.7 m wide with 1.6 m wide unsealed natural gravel shoulders.

Liwonde (M’manga) to Mangochi Road (No. 14.1)

The Liwonde to Mangochi Road was originally upgraded to a bitumen surfaced construction in 1974. Records indicate that a 25 mm premix surfacing was used from M’manga (km 0.0) to Chibwana (km 10), but elsewhere a double chip surface dressing was applied. It is unclear whether this 68 km long road was initially constructed with a stabilised natural gravel base along its entire length or whether some sections were originally constructed with a crushed stone base. What is known is that repair sections have been constructed with a crushed stone base.

Between M’manga junction and Nkungulu/Chimwala (approximately km 48) a major programme of pavement repair including application of a new surface dressing was concluded in 1986.

A slurry seal was applied to the road between Chibwana (km10) and Nkungulu/Chimwala (km 48) in 1996.

Records suggest that the section of road from Nkungulu (km 48) to Mangochi (km 68) has been patched and repaired but never given a full reseal.

The road section from M’manga junction was being extensively patched and repaired during the current investigations (1998). However, it was noted that the “as dug” weak decomposed gneiss being used as base material in the patch repairs appeared to be unsuitable for this use.

The existing carriageway width is typically 6.7 m with 1.5 m wide unsealed natural gravel shoulders.

<u>Mangochi to Monkey Bay Road (No. 14.2)</u>

This 61.4 km length of road was upgraded to bitumen standard in 1974. Records suggest that the original pavement design comprised a minimum100 mm of natural gravel subbase with 150 of base course and a double chip surface dressing. A stabilised natural gravel base was constructed from Mangochi (km 0.0) to approximately the Nkopola Lodge (km 22) and from Nkudzi Bay (km 43) to Monkey Bay (km 61). While a crushed stone base was laid from Nkopola Lodge (km 22) to Nkudzi Bay (km 43).

This road was extensively rehabiliated by MOW Road Construction Unit 3 between 1984 and 1985. At this time sections of failing pavement were reconstructed with a crushed stone base course and new bitumen surface dressing.

In1989 the road was patched and resealed up to Mang'oma/Mua Road Junction (km 50). Records indicate that the S128 road section from Mang'oma junction (km 50) to Monkey Bay (km 61) has never been resealed.

The carriageway width ranges from 6.3 to 7.3 with an average natural gravel shoulder width of 1.5 m. No evidence for the existence of base drains was observed along the road lengths with a crushed stone base. Lack of effective base drainage in these areas is believed to be a significant factor contributing to pavement distress.

<u>Zomba to Blantyre Road (No. 15)</u>

The 57 km long Zomba to Blantyre section of the M3 was originally made into a single lane bitumen surfaced road in 1950. The base for the road was a very coarse graded water-bound macadam.

In the late 1980's the road was upgraded and widened. This upgrading involved strip widening on both sides of the existing carriageway in order to avoid disturbing the strong single lane macadam construction. Widening was carried out with similar water-bound macadam, but inevitably the final construction was far from uniform in strength and surface profile.

In 1996 the road was patched and a slurry seal was applied along the whole road length.

2.2.2. Condition

<u>Karonga to Songwe (No. 1)</u>

Much of this road has been constructed on fill. In the first 10 km there are cracks in the shoulder suggesting that the fill has not been properly compacted at the edge. The base of the pavement continues through the shoulders but in many places the drainage through the crushed stone base has been blocked by the construction of concrete kerbs and concrete bus bays. As a consequence, water has been held in the crushed stone at the edge of the lane, increasing the rate of distress in the pavement. The ruts beside kerbs and bus bays are usually at least twice as deep as the ruts on the adjacent road where the base is able to drain.

Very fine cracking occurs in the last third of the road suggesting that the surfacing has become very brittle and fatigue failure has occurred. If this road is not sealed in the very near future it is likely that the pavement will deteriorate substantially during the next wet season.

Mzuzu to Chiweta (No. 2)

The road is generally in a distressed condition with rutting, ravelling, cracking and, in some places, pumping occurring. Most of the surfacing is very old and brittle, causing it to crack very easily. In some places the surfacing has stripped off the previous surfacing suggesting there has been a major problem with the reseal or that cracks in the hardened surfacing has allowed water into the pavement.

The pavement has generally been constructed with a crushed stone base confined between laterite shoulders that are much less permeable. It is understood that drains have been constructed through the laterite shoulders but the spacing has been too great or some of the drains have become blocked because some of the distress indicates water has entered the pavement and been held there. Deep ruts between km 9 and 14 are typical of this type of problem. It is recommended that the water in the pavement structure is checked with DCP standpipes whenever this road is rehabilitated.

Severe crocodile cracking occurs from the approach to the escarpment until the end of the road at Chiweta. Much of this distress is also due to inadequate drainage of the pavement layers. Down the escarpment a lined drain has been constructed against the pavement on the cut side but no weep holes were found in the concrete or stone masonry linings. It is obvious that a considerable amount of maintenance work has had to be carried out on the pavement on this section of the road to keep it in a serviceable condition although it was noted that slip debris had not been cleaned out of the drain.

Jenda to Chikangawa (No. 3)

The road from Jenda to Chikangawa appears to have been constructed with a permeable base and natural gravel shoulders. Water has accumulated in the pavement on the low side of superelevated sections, particularly in cuttings, concentrating the distress at these points. In the first 20 km erosion is common in the narrow shoulders. The road surface is old and brittle and should be resealed as a matter of urgency to prevent rapid deterioration.

Thirty four potholes were noted during the visual assessment, together with approximately 300 sq.m of patching. Approximately 8% of the road has cracks and ruts with the ruts varying in depth from 10 to 35 mm.

Mzuzu to Nkhata Bay (No. 4)

The road from Mzuzu to Nkhata Bay is in very poor condition with most forms of distress quite common. Some of this deterioration can be attributed to the age of the road but much of it could have been prevented by adequate maintenance of the drainage and regular applications of reseals. In many places the side ditches are completely filled and have ceased to work. After rain, water will pond along the road in a number of places. Short sections of the road are being reconstructed at the present time.

It is understood that the base of the majority of the road was constructed from stabilised natural gravel but the appearance of the potholes suggest the stabiliser may have been inadequately mixed through the base or the base has completely carbonated and lost the major part of its strength. There are several short sections of road where it appears that the stabilised base has been replaced with crushed stone. In many places the road has lost its shape, both longitudinally and transversely, and the ride quality is extremely poor.

Approximately 50% of the road is affected by cracking and, in some cases, this is accompanied by pumping. There are numerous potholes which should be repaired, although the amount of work may be beyond the capacity of the maintenance crew because they appear to have been forced to reduce the standard of their work in order to increase their output. More than 9000 sq.m have already been patched.

Bwengu to Rumphi (No. 5)

The major part of the spur road from Bwengu to Rumphi is very narrow and, as a consequence, has suffered from considerable damage to the edges. The pavement already has a number of small patches in the remainder of the carriageway but approximately 75 have yet to be repaired. Generally the shoulders are in very poor condition.

The surfacing, which is very old and brittle, is likely to deteriorate quickly and any increase in the traffic loading could cause rapid deterioration during wet periods.

Kasungu to Dwangwa River (No. 6)

Section 6 starts at the southern turn-off to Kasungu town. A total of approximately 12 km are severely cracked and in the remainder the cracking is less prevalent. The first 3.5 km, between the first and second turn-offs to Kasungu, has recently been resealed with a surface dressing but the longitudinal cracks have already reflected through this new surface. On the remainder of the section the surfacing has deteriorated through ageing. Ruts of up to 35 mm occur in most of the pavement and approximately 175 potholes should be repaired as soon as possible. Some of the un-trimmed potholes have been temporarily repaired by filling them with laterite. In several places shear failures have occurred at the edge of the pavement.

The laterite shoulder has not been properly maintained and the edge of the pavement has lost all support in places where the shoulder has been severely worn or eroded.

Madisi to Kasungu (No. 7)

This section of road is generally in a poor condition with cracking, rutting, shear failures, patching and potholes being evident in a number of places.

Most of the cracking, which affects about half the total length of the road, has advanced to the stage where it is now crocodile cracking. In some kilometres none of the road is free from cracking while in others only a small percentage is affected.

Shear failures have occurred in approximately 9 kilometres of the road although the failures are not continuous over that distance. Commonly the failures extend for up to 200 m, sometimes with several failed sections occurring in a kilometre, casting doubt about the drainage of the edge of the pavement, the quality of the material in the base or the thickness of the pavement layers. Where there are no shear failures the pavement generally has ruts of up to 25 mm in depth.

Approximately 350 potholes have not yet been repaired. Temporary repairs have sometimes been carried by filling the un-trimmed pothole with laterite.

A thin bituminous overlay has been placed on three short sections that total 1100 m in length. It is not clear if these overlays are expected to strengthen the pavement or to seal the cracks and improve the riding quality in the locality.

Concrete edge beams were noted on 200 m of road constructed on fill. At this location the edge of the pavement has failed and been patched.

Lumbadzi to Mponela (No. 8)

The effective starting point for this section was the end of the new surfacing at the main turn-off to Lilongwe International Airport.

Longitudinal cracking is prevalent. In some places this cracking has progressed to the point where there is now secondary crocodile cracking. Approximately 65% of the road is affected by cracking.

Ruts are not a major problem but at four locations, totalling approximately 200 m, the edge of the pavement has sheared. The road has many patches but approximately 160 potholes have to be repaired. In the first 22 km some of the chippings used in the surfacing are embedded in the top of the base and there is some problem with the surfacing bleeding even though the binder has aged to some extent.

The gravel shoulders are generally in poor condition.

Salima to Senga Bay (No. 11)

Almost all of this spur road from Salima to the lakeshore is badly cracked with very many potholes and patches. The road has reached a condition where it does not seem possible to return it to a sound condition, with reasonable riding quality, by normal maintenance methods. The crack patterns suggest it has an old stabilised base but more than half of it also has ruts. It is possible, therefore, that a natural gravel with some self-cementing properties has been used in the pavement.

The surfacing, which is very old and brittle, is in an extreme stage of fatigue failure. There are several thousand patches in the short section of road and several thousand potholes have not yet been repaired. Some sections are constructed on fill over low-lying ground and general settlement appears to be common feature of these.

Benga to Dwangwa (No. 12)

Most of the road between Benga and Dwangwa has been constructed with a stabilised base but, in some places, short sections have been replaced with a crushed stone base when the road has been repaired. The shoulders have been sealed on parts of the road. In some places the shoulder is constructed from stabilised gravel but in others it appears to be unstabilised, an appearance which may result from non-uniform distribution of the stabiliser and subsequent degredation with time.

The edge of the pavement has failed in shear at a number of places, particularly near the southern end of the road. In some of the one kilometre sections at least 300 m has failed in shear. Ruts have formed in most of the road, usually with a depth of 10 to 15 mm. Potholes and patches are common.

In the second half of the road there are places where the formation has settled. Some of this settlement, which distorts the surface and spoils the riding quality, has occurred in cuttings where one would normally expect the underlying material to have an adequate density. It is possible, therefore, that the insitu materials may have some collapse potential.

Chingeni to Liwonde and Zomba (No. 13)

The section from Chingeni to Liwonde has deteriorated substantially more than the second half. Approximately 9.5 km of the poorer half have already been ripped and broken down to form a gravel-surfaced road. Most of the remainder is severely cracked, usually in a block pattern that is common in pavements with cement-stabilised bases. Since the visual inspection was conducted, a considerable amount of cosmetic patching and resealing has been carried out between Liwonde and Zomba, temporarily reducing the number of patches and potholes visible in the surface.

An old, thin premix bituminous surfacing can be seen on some of the road. This surfacing may have been used in an attempt to cover the block cracks that have been visible in the first half of the road since the mid 1970's.

There is very little rutting in the section from Chingeni to Liwonde but, in the second half much more of the road is affected, particularly where secondary cracking is more obvious. General deformation occurs in the last four kilometres, within the Zomba city limits, where the road is substantially older than the remainder.

Liwonde to Monkey Bay (No. 14)

The road from Liwonde to Monkey Bay is in very poor condition and would normally be considered to be beyond treatment with normal maintenance methods. A lot of maintenance work has been carried out in the section up to Mangochi where most of the potholes have been filled. During the visual inspection, resurfacing work was being undertaken at the southern end.

Two different types of base have been used in the pavement between Liwonde and Mangochi. Most of it has been constructed with crushed stone but in several places a stabilised material has been used. The base of the northern part is mostly constructed from stabilised material. Earthworks on the road have been minimised by keeping the shoulders very narrow but the road appears to have suffered from inadequate support at the edge of the pavement. Ruts have formed in most of the pavement, even in some of the sections that have a stabilised base.

After km 55 there is a considerable amount of general deformation in the pavement, probably caused by insufficient compaction of the fill. In places the edge of the fill has settled much more than the centre, causing longitudinal cracks at the edge of the surfacing.

There are many patches in the road, particularly south of Mangochi. To the north of this town there are almost 1500 potholes and more than 1100 patches.

Zomba to Blantyre (No. 15)

The first surfaced road from Zomba to Blantyre was one lane wide with extended gravel shoulders for passing. This single-lane road has been widened on both sides and, in subsequent years, several attempts have been made to correct the uneven settlement of the different strips of the road. Almost all the road has substantial ruts but one cannot be certain if some of these ruts reflect the differential movement between the different strips or transverse deformation in the wheelpath.

Approximately 50% of the road has crocodile cracking. In several places there is some pumping associated with the cracking. As one would expect in a road carrying the high level of traffic observed, edge damage is quite common.

Most of the road has been well-maintained but there are some potholes between km 30 and km 48 and these should be repaired as soon as possible.

3. PAVEMENT TESTING

As part of Roughton International pavement investigation, tests were conducted on all project roads. On each project road a number of sample lengths were selected in order that the current condition and residual life could be assessed and rehabilitation treatment options be determined. The surveys undertaken were:

- Structural response tests
- In-situ strength tests
- Excavation of trial pits

Each of these tests provides information for the overall categorisation of the state of distress of the pavement but a brief overview could be summarised as

3.1.1. Deflection Bowls

Roughton International method of measuring traffic induced Deflection Bowl is based on a method developed by TRL (Smith et al, 1980) for peak deflection and involves the use of photographs to collect a record of vehicle position and of pavement deflection (using the Benkleman Beam) at the same instant. The method collects a full bowl, so an approach Mr and rebound Mr can be obtained. In the US and Australia, the test is purely performed as a rebound test.

3.1.2. Radius of Curvature (ROC)

Relationships have been developed that permit Mr to be calculated from this test, this method was presented by Grant et al (1987), and is used to test integrity of the pavement layers. It is conducted at the same time that a peak deflection test is performed, but by using a small piece of equipment and a dial gauge. A value in the region of 50m to 70 m is a “grey” area of concern, so with appropriate conservatism a value of less than 70m, is generally accepted as a value of a poor quality layer in the pavement layer.

3.1.3. DCP Testing

The DCP tests are analysed by an in house computer package, that uses the TRL equations to calculate a CBR value based upon the penetration rate of the DCP. Following on from this CBR calculation, a further TRL equation links CBR to Mr values. This equation was developed in English clay soils and so can be considered quite site specific, however, the form “$aCBR^b$” which the equation takes has been used by other research organisations. It would seem that the TRL equation is almost a "middle average" value, and for the purpose at present is considered sufficient. It will be recalled that the results in Report III of this study, confirmed the broad pattern of CBR:DCP relationships for the present study.

3.1.4. Modified DCP – Small Flat Tip

During the testing on the sample pavement lengths, tests were repeated with a modified tip. From the results obtained, it was seen that the standard cone and small flat foot produced in a number of cases, almost identical results, so no advantage could be seen in using the modified equipment in this situation. However, in the UK it had been found that the small flat tip produced a slightly better correlation with stiffness readings than a standard cone. However, it must be noted in the UK cases, differing results with standard cone and small flat tip were obtained.

3.1.5. Trial Pit Excavation

At the location where a bowl test was performed, a trial pit was excavated. This is used to identify the materials, the layer thickness and to obtain specimens for soil index properties testing in the laboratory. This information can then be used to assess the readings obtained from the DCP, Bowl Test, Peak Deflection and Radius of Curvature. At Trial Pit locations, three DCP tests were carried out, the standard test which was performed every 100m in the same location as the ROC measurement, plus two extra tests at either side of the pit, to establish a better idea of the DCP consistency.

3.2. Structural Response Tests

Detailed investigations were carried out to determine the structural response of each road link length. The testing programme included:

Measurement of peak deflection values.

- Measurement of the radius of curvature of the deflection bowl.
- Measurement of the full deflection bowl under the loaded wheel.
- Dynamic Cone Penetrometer Testing (DCP)

The radius of curvature and the peak deflection are measured during the same test, but logistics mean that the deflection bowl needs to be measured as a separate test. Essentially, these structural response test involve a benkleman beam being placed between the rear wheels on a correctly loaded truck. Once the recording gauges have been recorded, the truck is driven away at a slow speed for at least 15m. During this period, the maximum deflection is recorded from the dial gauge, as is the final reading. Simultaneously, another technician will have watched and recorded the maximum reading on the radius of curvature gauge. The bowl test is of a similar principle, except the use of a high speed camera is required to photograph the dial gauge reading at the same time as a tape being pulled by the truck passes it. This then gives readings of deflection at a specific horizontal distance, hence a bowl can be plotted.

All structural response tests were conducted using a truck that was loaded to achieve 15.6 kN on each of the four rear wheels. For analytical purposes the application area of each tyre was taken to be circular, with a radius of 120 mm, applying a pressure to the road surface of 0.344 MPa. The centre of the tyres is taken as 165 mm from the origin as shown in Figure 3-1 together with a photograph showing the deflection testing.

3.2.1. Measurement of the Peak Deflection

Deflection tests were carried out using the transient testing procedure developed by the Transport Research Laboratory (TRL) in the United Kingdom {Smith and Jones, 1980}. Tests were conducted at an interval of 100 m in both wheel paths.

At any single test point the maximum peak deflection is taken since this is the critical value.

The deflection truck was loaded with 6,350 kg, evenly distributed across the rear axle. This was achieved using concrete blocks placed to the rear of a tipper truck and shored in by means of timber. The beams were calibrated before and after testing.

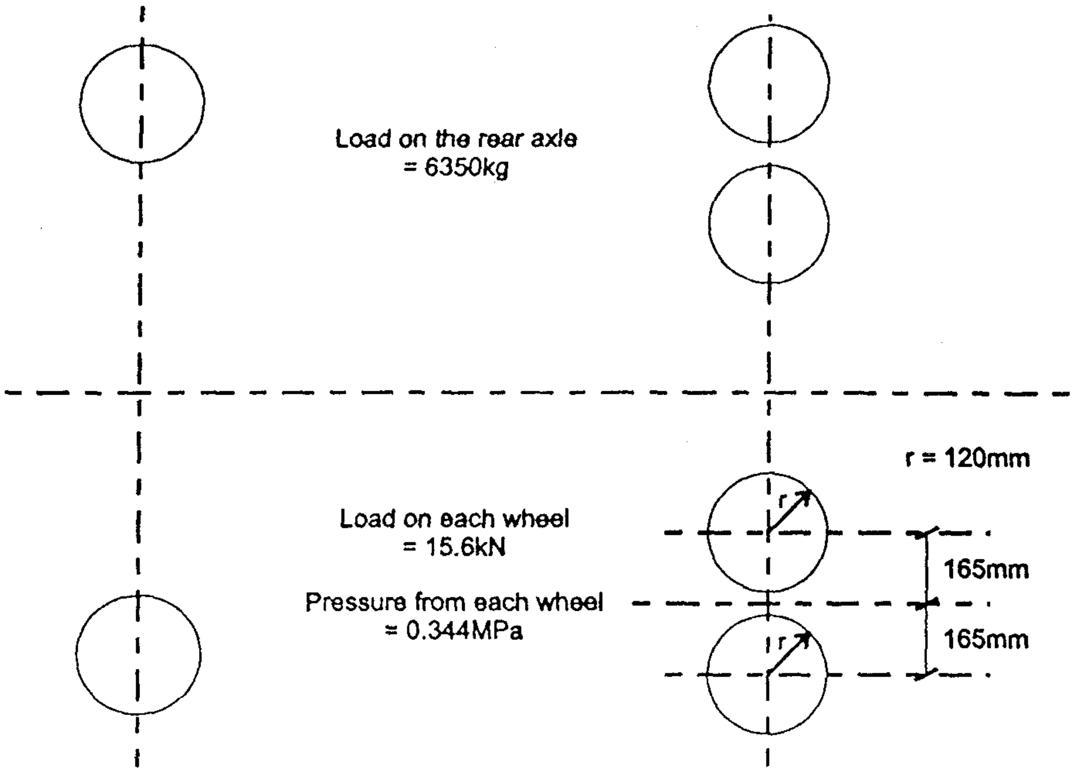
Numerous studies have shown that for practical purposes the relationship between deflection and load in this range is linear. Therefore each side of the truck was weighed and a truck correction factor should be applied to the measured deflection. Two pointers were constructed and were attached to the truck approximately 1.2 m in front of the axle exactly in the centre of the two tyres. The deflection at each point is computed using the following equation:

$$\delta_p = 2 \times \left[Maximum - \left(\frac{Initial + Final}{2} \right) \right] \qquad \text{Eqn. 1}$$

Where:	δ_p	Peak deflection at a particular point (mm);
	Initial	Initial reading from the dial gauge, (should be between 1 and 10);
	Maximum	Maximum reading from the dial gauge;
	Final	Final reading from the dial gauge, (may be negative if it returns beyond 0).

When the TRL first started manual deflection measurements they standardised the rear axle load of the truck to 6,350 kg (14,000 lb.) or 62.3 kN. They have maintained this standard ever since, even though the axle loads of vehicles have increased considerably, as there is a wealth of pavement performance criteria for UK conditions based on this loading. A further advantage of using a lighter load is that the wear and tear on the truck as well as the running costs will be lower. However, several states in the USA, Canada and South Africa later standardised on 8,165 kg (18,000 lb.) or 80 kN as being a more realistic load.

Figure 3-1 - Configuration of the Axle Loading as applied by the Deflection Truck



Whenever possible, deflection tests should be carried out when the pavement is likely to be in its weakest state. Since this project fell in the dry season the road materials were found to be dry and consequently strong. Some obviously failed areas that would be very weak if saturated were found to have satisfactory strength. Comparisons of the material strength from 4-day soaked Californian Bearing Ratio (CBR) strength tests conducted in the laboratory on material excavated from trial pits were compared with DCP tests conducted in the road at the trial pit locations. This comparison yielded that a seasonal mean factor of 1.3 as appropriate for these roads.

3.2.2. Measurement of the Radius of Curvature

Where possible, at each deflection point in the outer wheel-path, the radius of curvature was measured. This was conducted using a Dehlen curvature meter {Dehlen, 1962} to determine the minimum radius of curvature of the deflection bowl as shown in Figure 3-3. The tests were used to give information about the quality of the base as well as approximate values of the resilient, or elastic, modulus of the base and the subgrade. The radius of curvature meter can be seen in operation in Figure 3-2.

Figure 3-2- The Radius of Curvature Meter

The radius of curvature is given by the equation {TMH6, 1984}:

$$R_c = \frac{1400}{r_p - \frac{(r_i + r_f)}{2}} \qquad \text{Eqn.2}$$

Where	R_c	Radius of curvature (m);
	r_p	peak dial gauge reading (1/100 of mm);
	r_i	Initial dial gauge reading (1/100 of mm);
	r_f	final dial gauge reading (1/100 of mm).

The radius of curvature is primarily influenced by the quality of the material in the surfacing and base. If the radius of curvature is less than 70 m it is likely that the tensile strain in the bottom of a thin bituminous surfacing will cause premature fatigue failure. This value will be used to indicate whether the base is substandard.

The radius of curvature and the corresponding peak deflection value will be used to estimate the elastic modulus, or resilient modulus, of the subgrade and the base from the following relationships. Grant (*Committee of Asphalt Pavements of Southern Africa, 1978*), developed these relationships from a simple linear elastic model:

$$R_m = 0.00074(\delta_d \times R_c)^{2.12} \qquad \text{Eqn.3}$$

$$E_{sg} = \frac{52.44}{\delta_d \times R_m^{\;0.25}} \qquad \text{Eqn.4}$$

$$E_b = E_{sg} \times R_m \qquad \text{Eqn.5}$$

Where	R_m	Modular ratio
	E_{sg}	Elastic modulus of the Subgrade (MPa)
	E_b	Elastic modulus of the Base (MPa)

This gives an estimation of the strength of the upper layers and the pavement foundation layers which, together with the layer thickness, is used to model the pavement response and to determine the residual life.

3.2.3. Measurement of Deflection Bowls

The Roughton Deflection Bowl is based on a method developed by TRL (Smith et al) for peak deflection and involves the use of photographs, so a deflection can be measured, as well as a horizontal distance. The bowl also uses a full bowl method, so an approach Mr and rebound Mr can be obtained. In the US and Australia, the test is purely performed as a rebound test only.

One full deflection bowl was measured using a photographic technique developed by the Consultant (Roughton International) on every Sample Length. A standard axle load (6,350 kg) is used to apply the rolling wheel load and points in the bowl are measured at intervals of approximately 150 mm during a normal transient test.

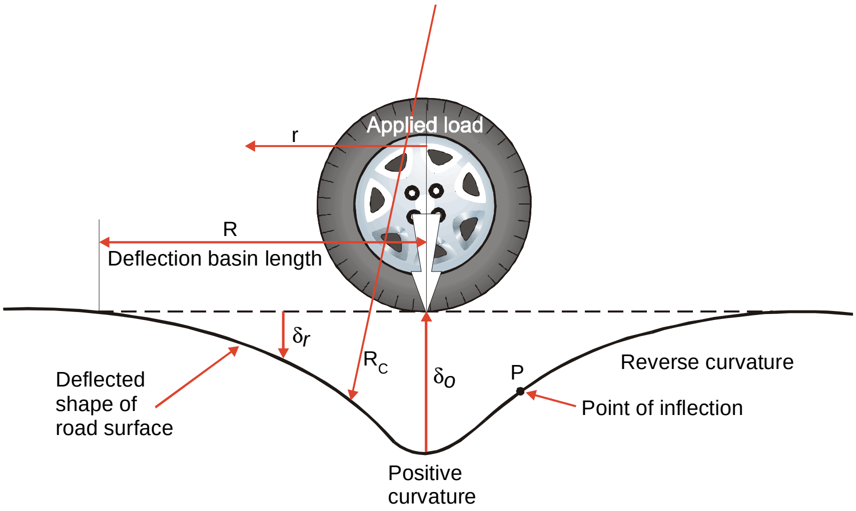
The thickness of the pavement layers is determined from the results of the trial pit survey and DCP testing. The deflection bowls are analysed using sophisticated non-linear computer based models to determine the resilient, or elastic, parameters of each of the pavement layers.

The full deflection bowl under a wheel-load applied on a pavement structure gives further information about the likely behaviour of the pavement. A number of different parameters may be used to characterise the deflection bowl, as follows:

- The Surface Curvature Index (SCI) characterises the area of positive curvature in the immediate vicinity of the load and it reflects the structural capacity of the base and surfacing. It usually extends past the point of inflection, which often occurs less than 200 mm from the peak deflection.
- The Base Damage Index (BDI) describes the first portion of the zone of reverse curvature and gives an indication of the structural capacity of the base and sub-base layer.
- The Base Curvature Index (BCI) describes the second zone of reverse curvature and provides a very good guide to the structural capacity of the lower layers such as the selected layer and subgrade.
- The Slope Deflection (SD) provides information about the behaviour and performance of the pavement structure. It gives an indication of the extent of the deflection bowl.

A typical pavement surface deflection bowl as measured by the Roughton International method is shown in Figure 3-3. The various parameters and their relevance to the prediction of the strength of the layers that make up the pavement structure are also shown.

Figure 3-3 - Typical Deflection Bowl as Measured by the Roughton International Method

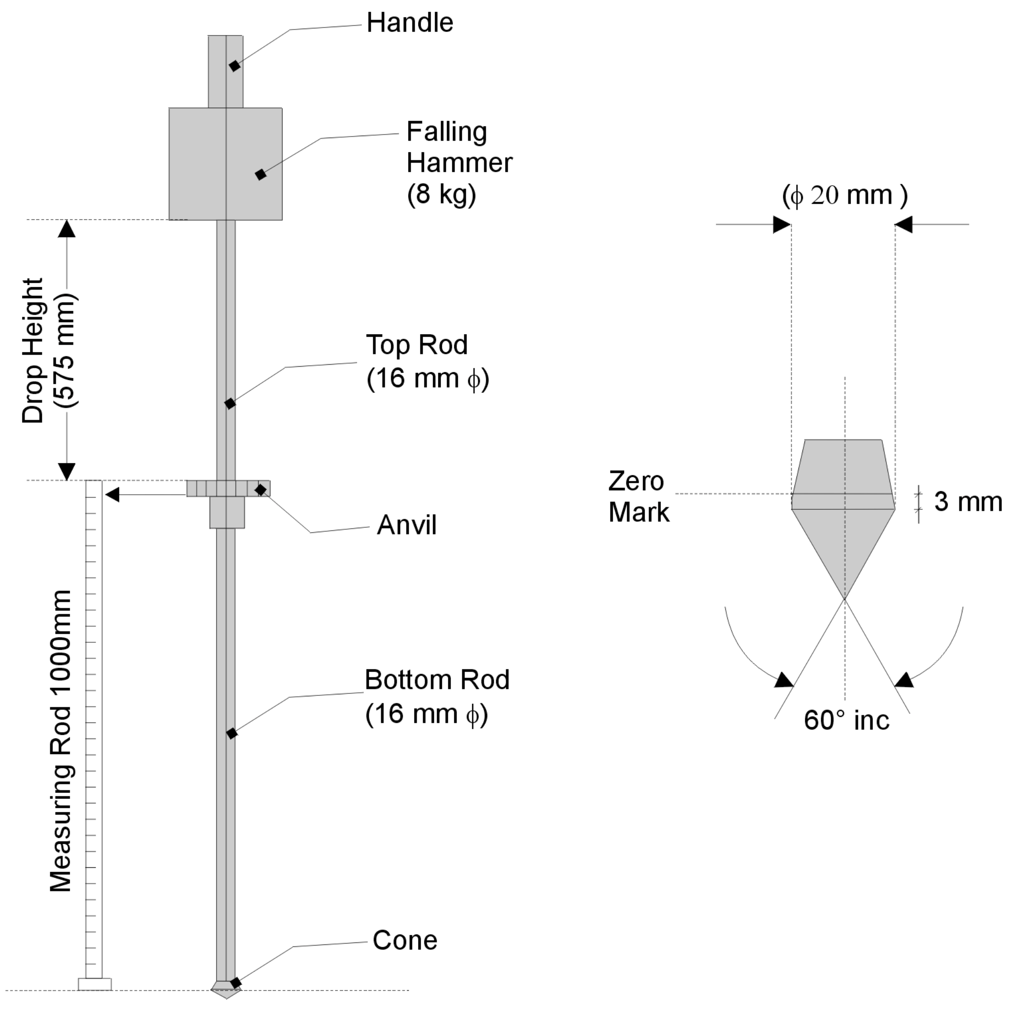


	Parameter	**Formula**
1.	Maximum Deflection (µm)	δ_o
2.	Deflection at a distance (r) from the maximum deflection	δ_r
3.	Surface Curvature Index (µm)	$SCI = \delta_{0mm} - \delta_{305\,mm}$
4.	Base Damage Index (µm)	$BDI = \delta_{305\,mm} - \delta_{610\,mm}$
5.	Base Curvature Index (µm)	$BCI = \delta_{610\,mm} - \delta_{915\,mm}$
6.	Slope of Deflection	$SD = \tan^{-1}\left(\frac{\delta_{0mm} - \delta_{610\,mm}}{r}\right)$
7.	Radius of Curvature (m), measured with the Dehlen curvature meter.	$R_C = \dfrac{1400}{D_0 - \dfrac{D_{1ni} + D_{Fin}}{2}}$

3.3. In-situ Strength Tests (DCP)

In-situ strength profiles, through the pavement and into the subgrade, were obtained using a Dynamic Cone Penetrometer (DCP) apparatus at a frequency of 1 test per kilometre along the length of all roads. Where it is found that the test is stopped due to refusal a second test will be conducted through the shoulder. This will provide important information as to the likely bearing capacity of the subgrade. A standard DCP apparatus is shown in Figure 3-4.

Figure 3-4 - Standard DCP Apparatus



Analysis of the field data was conducted using a computer program developed by Roughton International. The effective thickness of each layer in the pavement was determined from the strength profiles. The computer program uses the relationships of DCP penetration depth per blow to California Bearing Ratio strength as described in Overseas Road Note 31.

The relationship chosen is as follows:

$$Log_{10}(CBR) = 2.48 - 1.027 \times Log_{10}(mm / blow) \qquad \text{Eqn.6}$$

Where CBR - California Bearing Ratio

In order to confirm this relationship, and make any adjustments where necessary, a DCP test will be conducted in the subgrade soil adjacent to each of the test-pits as described above. From this it was possible to compare the CBR values obtained from the DCP under the pavement and off the road with CBR values obtained in the laboratory from samples taken and make any necessary adjustments in the analysis of the DCP data.

The detailed results of the DCP testing for the Routine and the Sample Lengths surveys are contained in Appendix I. An assessment of the thickness of each layer in the carriageway was made from the penetration versus depth curves. The material strength in terms of CBR corresponding to each layer is also calculated using the relationship between penetration rate and CBR as discussed above. For this analysis the pavement is considered to comprise three fundamental layers namely; base, subbase and subgrade.

The average base layer thickness of each sample length is calculated by taking the average of the thickness measured during each individual test for the identified layers Base and subbase. Similarly, this is conducted for the subgrade but as two independent layers, with the top layer having definitive thickness, and may be considered as the selected subgrade, whereas the lower layer is taken as the in-situ subgrade and has infinite depth.

The strength of the defined layers is calculated in exactly the same way except that instead of the average of the CBR values for each individual test the CBR strength is taken to be the average of the 10^{th} percentile of the individual strengths for each layer. Ie. Where it is obvious that a result is erroneous it is omitted. After this point, all results for the same layer are taken as percentile, not an average.

The DCP tests are analysed by an in house computer package, that uses the TRL equations to calculate a CBR value based upon the penetration rate of the DCP. Following on from this CBR calculation, a further TRL equation links CBR to Mr values. This equation was developed in English clay soils and so can be considered quite site specific, however, the form $aCBR^b$ which the equation takes has been used by other research organisations. It would seem that the TRL equation is almost a "middle average" value, and for the purpose at present is considered sufficient. An example of DCP logging is shown Figure 3-5.

Figure 3-5 - An example of DCP log sheet and graphical representation

Road Maintenance and Rehabilitation Project
Dynamic Cone Penetrometer Test

Roughton International
in association with **Jatula Partners**

Road Name: Mzuzu to Nkhata Bay

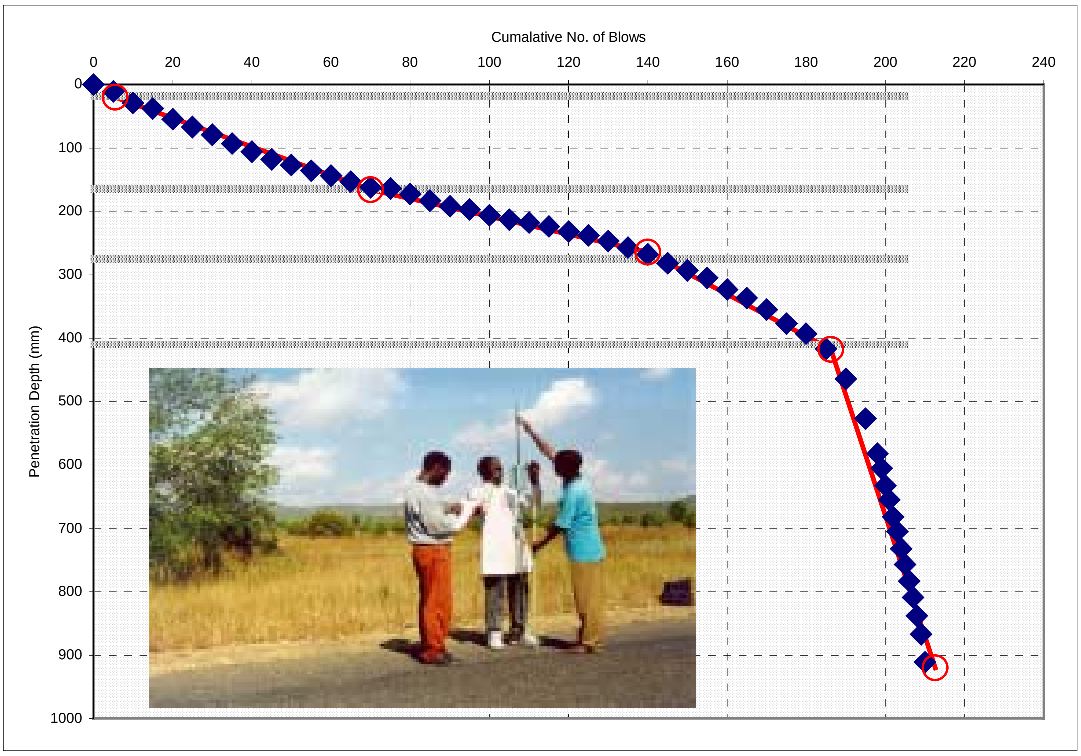
Road Code: 4 Operator: FOSTINO

Section No.: 1 Chainage: 0.500 km Date: 24/7/98

Depth below Surface at test start: 0 mm Side: LHS

Layer Description at test start: Surface Dressing - Cracked, Old and Brittle

Description of Area: Small Cutting



Strength CBR Relationship $Log_{10}\ (CBR) = 2.48 \quad -1.057 \quad Log_{10}\ (mm/\ blow)$

Layer Characteristics as Determined for the Trial Pits and Construction Details

Layer	Start (mm)	End (mm)	Thickness (mm)	Blows (No.)	Strength CBR (%)
Layer 1	0	20	20	6	77
Layer 2	20	166	146	70	127
Layer 3	166	264	98	140	212
Layer 4	264	418	154	186	85
Layer 5	418	920	502	213	13

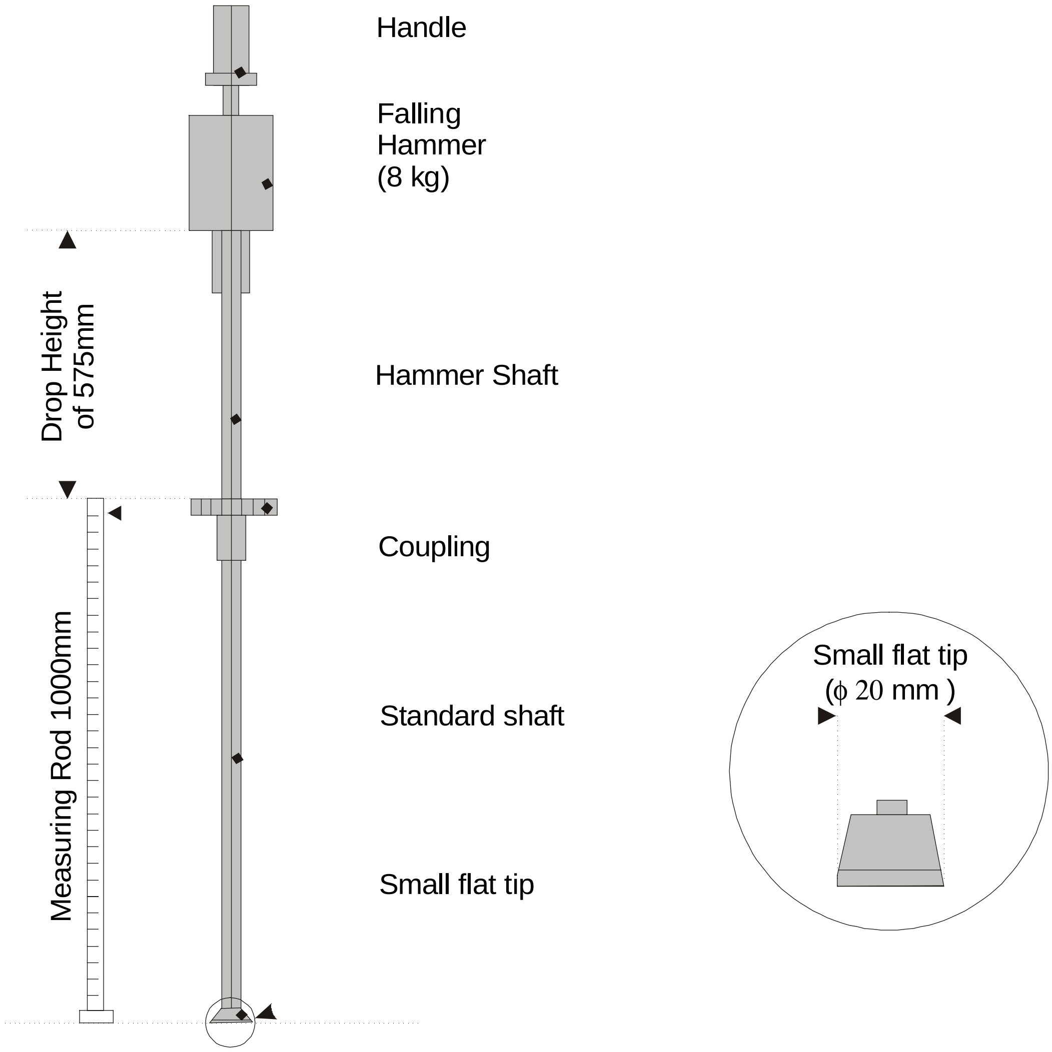
Pavement Layer Characteristics as Determined for the Trial Pits and Construction Details

Layer	Material Code	Depth (mm)	Blows (No.)	Strength CBR (%)
Surface		18		
Base	GS	165	75	148
Subbase	GN	275	140	173
Selected Subgrade	GN	410	180	83
Subgrade	GN	911	210	15

3.3.1. Modified DCP - Small Flat Tip

During the testing on the sample lengths, tests were repeated with a modified tip. From the results obtained, it can be seen that the standard cone and small flat foot produce in a number of cases almost identical results, so no advantage could be seen in using this pieces of equipment in this situation. However, in the UK it had been found that the small flat tip produced a slightly better correlation with stiffness readings than a standard cone. However, it must be noted in these cases, differing results with standard cone and small flat tip were obtained. An example of a DCP with a modified small tip is shown in Figure 3-6.

Figure 3-6 - Modified DCP with a Small Flat Foot



Trial Pit Excavation

At the location where a bowl test was performed, a trial pit was excavated. This pit was used to identify the materials, the layer thickness and soil index properties under laboratory conditions. This information can then be used to assess the readings obtained from the DCP, Bowl Test, Peak Deflection and Radius of Curvature. At Trial Pit locations, three DCP test were carried out, the standard test which was performed every 100 m in the same location as the ROC measurement, plus two extra test at either side of the pit, to establish a better idea of the DCP consistency.

Trial pit excavation was carefully conducted and the materials from each layer stored separately to avoid contamination. The profile of the pit was carefully logged and each layer depth was measured and described. Representative samples of the material from each layer were photographed and tested in the laboratory. The complete trial pit profiles are contained in Appendix I together with the test results, an example is shown in Figure 3-7. A summary of these results is shown in Table 4-1.

Figure 3-7 - Trial Pit Example

Road Maintenance and Rehabilitation Project
Test Pit and Material Logging Investigation

Roughton International
in association with **Jatula Partners**

Road Name: Mzuzu - Nkhata Bay Road Code: 4 S.Length: 1 Date: ######
Chainage: 8.60 RHS Location Number: L04/P12 Operator: JDR
Point Number 12 GPS Co-ordinates: S 11, 29.958 E33, 3.808

General Description of Area
The road surface is rutted, deformed, potholed and patched. The road is founded at natural ground level through dry bush.

Layer	From (mm)	To (mm)	Material Description	Field Tests			Laboratory Results						Estimated CBR (ORN31) %	MOWS Complience	ORN31 Complience
				m (%)	% of MDD	CBR-DCP (%)	PI (%)	PSD MOWS (75µm)	PSD ORN31 (75µm)	OMC (%)	MDD (kg/m^3)	CBR (Soak) 98%			
Surface	0	20	The surface is double surface dressing with 14mm chip size. The surface was very hard and dry.												
Base	20	150	The base was found not to react with HCl. The material was very hard, dry, reddy orange lateritic quartz gravel.	6.4	87	95	31	✗	✗	9	2055	22		✗	✗
Subbase	150	250	The subbase was found not to react with HCl. The material was a firm damp, poorly graded orangey brown silty sandy gravel.	-	-	69	21	✗	✗	-	-			✗	✗
Subgrade	250	410+	The subgrade was found not to react with HCl. The material was a firm, damp, poorly graded, orangey grey, clayey sand.	-	-	15	28	✗	✗	-	-		11		
Note:															

3.3.2. Method of Sampling

Samples, of mass approximate 40 kg samples were taken from each different layer in the pavement, these will be sealed in plastic bags so that their moisture content can be determined in the laboratory.

Immediately after the base and subbase were removed the vertical profile of the hole was cleaned to expose the different material layers, the profile was then logged with respect to material type, condition and thickness. If necessary the layers were tested to determine whether they were stabilised with cement or lime and the extent of the remaining stabilisation.

When a weak solution of hydrochloric acid is sprayed onto the material the solution will effervesce, bubble, if the material contains any cement or lime, however this will also occur if the material is naturally calcareous. Calcareous materials include limestone, coral materials, calcretes and some Sandstones.

If cement or lime-stabilised materials are exposed to the air the hydration products react with the carbon dioxide in the atmosphere, this usually reduces the strength of the stabilised material. Associated with this loss of strength is a reversion of the Plasticity Index (PI) of the stabilised material to that of the parent material from which it was produced. These reactions are linked with a decrease in the pH from more than 12 to about 8.3. and were detected using phenolphthalein.

The samples taken from the test-pits described above were rapidly returned to a laboratory in order to establish the present condition and strength of the materials in each layer. Common tests conducted on samples were:

- Moisture content
- Particle size grading
- Atterberg limits and linear shrinkage
- Compaction characteristics
- Soaked Californian Bearing Ratio (CBR)

3.4. Results Processing

After the tests had been performed, the results were tabulated and graphical representations presented of laboratory classification tests, CBR testing, DCP testing and of the correlation's between resilient Moduli Mr produced from the different methods. The TRL equation, from Radius of Curvature, and the Deflection Bowl. This work is then compared to the DCP:stiffness relationship that was developed during the trials at Bardon in the UK, as part of the Highways Agency testing programme on subgrade and capping stiffness in relation to rut formation. It was at this trial that testing was initially undertaken by this project to develop a relationship between a standard DCP and a modified DCP tip. This data and equation have now been used to compare the data from Malawi with other methods.

3.5. Resilient Modulus or Elastic stiffness:

The term used to describe the resilient stress strain ratio in this report is resilient modulus (M_r). The word ‘elastic’ is inappropriate due to the non-linear hysteretic nature of resilient behaviour in soils and aggregates and because of some time-dependency indicating a viscous component. In evaluating it numerically it is defined as the ratio of the applied transient stress pulse to the strain recovered upon the unloading part of the pulse. Often an equivalency with Young’s Modulus (E) is adopted for convenience even though this is not defensible on the grounds of differing definitions.

In roads the load distribution of a layer is directly related to the resilient modulus of a layer and its thickness.

Boussinesq (1885) published an equation for calculating stresses and displacement in an elastic half-space under point loading. This was followed by an analytical solution for a three-layer pavement structure (Burmister, 1943). With the advent of computers, the numerical modelling of pavements (which takes into account various parameters and models) was adopted. In all these methods, the stress-strain relationship of pavement materials and formation soil are expressed in terms of the basic elastic parameters, resilient modulus and Poisson's ratio (Mr and ν respectively). Damage by trafficking of the pavement materials will result in the reduction of resilient modulus, the quasi-elastic response of the pavement is found to be a fundamental indicator of the remaining life of the pavement. This effect, in addition to the direct relationship between M_r and the load distributing ability, has led to the recognition that M_r is a key parameter in the design and performance assessment of roads.

The resilient modulus of soils is often estimated using the CBR, Heukelom & Foster (1960) derived the following relationship:

$$Mr = 11 * CBR \qquad \text{Eqn. 7}$$

Shell (1978) use a similar equation in their design code, namely:

$$Mr = 10 * CBR \qquad \text{Eqn. 8}$$

TRRL (1984) derived another equation based on comprehensive analysis of wave propagation data and cyclic triaxial testing:

$$Mr = 17.6(CBR)^{0.64} \qquad \text{Eqn. 9}$$

However, Brown et al (1987), while agreeing that the shape of the Mr - CBR relationship is better modelled by the last equation, showed that the actual relationship was still very sensitive to soil type, speed of loading and transient stress pulse magnitude. The last equation can only be considered as giving a crude mean value. These relationships are discussed further in Report III of this study.

From these relationships and those that described above, the resilient moduli can be estimated for a CBR, or an index based upon the mm/blow of the DCP test.

4. RESULTS OF THE FIELD AND LABORATORY TESTS

On completion of the fieldwork all of the results were analysed and assessed. These include the visual inspections of all roads and the results of the structural response tests, which provide information about the integrity of the entire pavement structure. Samples of materials were taken and tested in the MOW's laboratory in Lilongwe to provide important information about the quality of the individual layers of the pavements.

4.1. Peak Deflection and Radius of Curvature Results

The results of the peak deflection survey for each of the Sample Lengths is summarised in Table 4-4. The measured peak deflection values for each wheel-path at 100 m intervals are contained in Appendix II.

The results of the radius of curvature measurements are also presented in and again details of the testing can be found in Appendix II.

4.2. Deflection Bowl Results

The results of the deflection bowl measurements are shown in Appendix I. Where possible the deflection bowls were conducted near to the trial pits and the pavement structure used in the analysis of the layer strength is based on the trial pit information. The resilient modulus from the deflection bowl analysis is summarised in Appendix II.

4.3. In-situ Strength Tests (DCP)

The results from the DCP testing, including routine and sample lengths are presented in Table 4-2 and Table 4-4 in a summarised form. The full set of DCP results can be seen in Appendix I. For the comparison purpose with the work undertaken at the Bardon trial we can see from Figure 5-1 and Appendix I that in Malawi very little difference was in results were obtained, whether using the standard DCP cone, or the modified version. The Figure 5-1 shows a comparison of a standard DCP test with the small flat tip in almost identical locations. The curves are surprisingly similar in shape, given that such a relationship was not evident in the trials at Bardon, UK.

Table 4-1 – Material Characteristics from the Trial Pit Survey

Road Maintenance and Rehabilitation Project **Roughton International**

Trial Pit and Material Logging Investigation - Summary *in association with* **Jatula Partners**

Road Name	Chainage (km)	Layer Code	Thickness (mm) and Layer Type SF		BC		SB		SSG		SG
1 Karonga - Songwe	4.30	L01/P06	20	DSD	180	CR	130	GN	-	-	340
1 Karonga - Songwe	23.58	L01/P23	20	DSD	155	CR	85	GN	180	GN	160
1 Karonga - Songwe	31.77	L01/P49	20	DSD	300	CR	-	-	-	-	420
2.1 Mzuzu - Bwengu	6.35	L02.1/P00	25	DSD	175	CR	100	GN	-	-	170
2.1 Mzuzu - Bwengu	13.09	L02.1/P25	30	DSD	160	CR	160	GN	-	-	200
2.1 Mzuzu - Bwengu	37.26	L02.1/P59	25	DSD	150	CR	200	GN	-	-	200
2.1 Mzuzu - Bwengu	60.34	L02.1/P82	25	DSD	185	CR	100	GN	-	-	170
2.2 Bwengu - Chiweta	6.35	L02.2/P16	25	DSD	185	CR	100	GN	-	-	170
2.2 Bwengu - Chiweta	13.09	L02.2/P33	20	DSD	180	CR	280	GN	-	-	170
2.2 Bwengu - Chiweta	37.26	L02.2/P39	25	DSD	170	CR	105	GN	-	-	350
4 Mzuzu - Nkhata Bay	8.99	L04/P12	20	DSD	130	GN	100	GN	-	-	160
4 Mzuzu - Nkhata Bay	22.18	L04/P16	10	DSD	90	GN	120	GN	-	-	130
4 Mzuzu - Nkhata Bay	43.06	L04/P42	10	DSD	160	GN	110	GN	130	GN	450
11 Salima - Senga Bay	5.99	L11/P01	10	DSD	145	GN	115	GN	-	-	95
11 Salima - Senga Bay	18.08	L11/05	20	DSD	160	GN	60	GN	-	-	-
11 Salima - Senga Bay	*		20		175		200		-		350
11 Salima - Senga Bay	18.08	L11/15	20	DSD	230	GN	200	GN	-	-	-
12 Benga - Nkhotakota	6.49	L12.1/P71	25	AS	120	CR	155	GN	-	-	125
12 Benga - Nkhotakota	22.13	L12.1/P44	30	AS	110	CR	140	GN	-	-	110
12 Nkhotakota - Dwangwa	*		20		150		175		-		400
12 Nkhotakota - Dwangwa	40.56	L12.2/P05	80	AS	110	GS	320	GN	-	-	100
13 Chingeni - Liwonde	7.09	L13.1/P07	30	AS	120	GS	170	GN	-	-	170
13 Chingeni - Liwonde	20.28	L13.1/P19	20	DSD	120	GS	155	GN	-	-	165
13 Chingeni - Liwonde	26.87	L13.1/P30	15	DSD	150	GS	110	GN	-	-	325
13 Liwonde - Zomba	43.86	L13.2/P49	20	DSD	145	GS	135	GN	-	-	300
13 Liwonde - Zomba	66.93	L13.2/P55	40	AS	160	GS	100	GN	-	-	200
13 Liwonde - Zomba	88.41	L13.2/P85	20	DSD	130	CR	100	GN	-	-	150
14 Liwonde - Mangochi	5.95	L14.1/P00	13	DSD	97	CR	150	GN	-	-	90
14 Liwonde - Mangochi	13.69	L14.1/P24	60	AS	80	CR	60	GN	-	-	90
14 Liwonde - Mangochi	44.46	L14.1/P32	15	DSD	145	CR	220	GN	130	GN	100
14 Mangochi - Monkey Bay	*		25		125		150				300
14 Mangochi - Monkey Bay	86.71	L14.2/P15	25	DSD	185	GN	510	GN	-	-	-
14 Mangochi - Monkey Bay	98.30	L14.2/P27	25	DSD	105	GN	55	GN	10	GN	320
14 Mangochi - Monkey Bay	111.99	L14.2/P32	20	DSD	180	CR	115	GN	-	-	110
14 Mangochi - Monkey Bay	128.30	L14.2/P57	20	DSD	175	GN	75	GN	-	-	205

AS - Asphaltic Surface
DSD - Double Surface Dressing
CR - Crushed Rock
CM - Gap Graded Crushed Rock (MacAdam)
GN - Natural Gravel
GC - Self Cementing Natural Gravel
GS - Stabilised Natural Gravel

* - Depths obtained from DCP results on the Sample Lenths

Table 4-2 – Layer Thickness from the DCP Results

Location of the Routine Testing		Pavement Layer Characteristics (Measured from Trial Pits)							
		SF	BS		SB		SSG		SG
Road Code	Road Name	Thick (mm)	Thick (mm)	Str CBR	Thick (mm)	Str CBR	Thick (mm)	Str CBR	Str CBR
1	Karonga to Songwe	20.000	235.625	185.961	420.000	100.434	670.000	28.256	20.965
2.1	Mzuzu to Bwengu	25.000	200.000	218.278	347.500	52.485	525.000	29.556	25.800
2.2	Bwengu to Chiweta	25.000	175.000	274.169	375.000	50.992	575.000	34.988	27.447
3	Jenda to Chikangawa	29.000	200.000	191.625	305.000	54.635	422.500	34.906	30.221
4	Mzuzu to Nkhata Bay	18.000	165.000	121.553	275.000	55.320	410.000	36.897	17.547
5	Bwengu to Rumphi	25.000	185.000	196.785	350.000	67.551	425.000	39.786	35.548
6	Kasungu to Dwangwa	20.000	175.000	183.067	325.000	75.729	460.000	45.686	52.670
7	Madisi to Kasungu	25.000	205.000	122.626	325.000	65.455	525.000	41.943	35.596
8	Lumbadzi to Mponela	20.000	205.000	96.233	345.000	55.250	500.000	32.797	25.236
9	Bunda Turn Off to Chimbiya	20.000	210.000	192.737	345.000	37.121	500.000	23.884	21.544
10	Dedza to Biriwiri	20.000	150.000	269.176	250.000	99.515	360.000	31.762	17.994
11	Salima to Senga Bay	20.000	210.000	109.834	345.000	59.992	500.000	44.971	24.104
12.1	Benga to Nkhotakota	20.000	210.000	157.419	345.000	76.012	500.000	59.406	21.391
12.2	Nkhotakota to Dwangwa	25.000	145.000	181.642	300.000	71.033	425.000	37.868	24.303
13.1	Chingeni to Liwonde	25.000	150.000	165.858	295.000	80.773	520.000	42.984	25.257
13.2	Liwonde to Zomba	25.000	175.000	213.490	295.000	80.384	500.000	47.054	22.706
14.1	Liwonde to Mangochi	17.500	145.000	238.055	300.000	68.028	410.000	43.947	32.603
14.2	Mangochi to Monkey Bay	20.000	210.000	146.354	345.000	50.876	500.000	38.666	25.848
15	Zomba to Blantyre	35.000	175.000	64.817	280.000	30.410	450.000	18.977	15.612

Table 4-3 – Material CBR Strength from the DCP Results

Location of the Routine Testing		Layer Characteristics									
		Layer 1		Layer 2		Layer 3		Layer 4		Layer 5	
Road Code	Road Name	Thk (mm)	Str CBR	Thk (mm)	Str CBR	Thk (mm)	Str CBR	Thk (mm)	Str CBR	Thk (mm)	Str CBR
1	Karonga to Songwe	20.000	32.114	190.444	177.899	155.250	149.182	198.571	37.600	460.125	21.607
2.1	Mzuzu to Bwengu	20.000	56.668	132.438	240.143	174.688	100.904	245.000	53.642	384.125	89.438
2.2	Bwengu to Chiweta	20.000	32.114	143.714	182.608	272.571	47.136	279.571	36.018	324.429	30.395
3	Jenda to Chikangawa	20.000	32.114	162.014	162.528	208.000	56.439	227.819	43.837	275.019	31.239
4	Mzuzu to Nkhata Bay	20.000	42.703	114.900	140.167	144.900	84.508	221.500	34.409	480.650	20.768
5	Bwengu to Rumphi	20.000	46.634	172.000	186.145	164.000	57.432	332.333	43.650	343.333	26.757
6	Kasungu to Dwangwa	20.000	118.728	167.800	178.022	175.600	72.556	210.900	43.930	317.900	55.984
7	Madisi to Kasungu	20.000	57.687	173.519	161.295	167.200	65.908	265.000	45.261	272.880	33.395
8	Lumbadzi to Mponela	20.000	63.283	180.056	125.007	168.500	60.877	217.357	32.175	315.000	26.530
9	Bunda Turn Off to Chimbiya	20.000	32.114	122.333	231.319	192.333	136.874	237.667	28.222	464.333	26.366
10	Dedza to Biriwiri	20.000	32.114	124.400	219.134	157.182	139.008	355.900	19.732	330.700	19.137
11	Salima to Senga Bay	20.000	58.346	192.182	107.763	212.300	81.175	234.200	37.299	365.800	22.009
12.1	Benga to Nkhotakota	20.000	32.000	134.857	141.096	217.000	82.666	218.500	73.374	429.500	17.806
12.2	Nkhotakota to Dwangwa	20.000	261.471	148.000	146.572	149.700	62.377	366.900	27.391	342.500	20.240
13.1	Chingeni to Liwonde	20.000	44.994	157.364	132.336	185.364	76.978	242.857	38.865	384.857	17.839
13.2	Liwonde to Zomba	20.000	37.898	190.500	183.378	199.300	90.513	248.000	47.242	441.167	20.576
14.1	Liwonde to Mangochi	20.000	34.442	133.750	174.527	218.500	82.810	314.909	48.365	237.318	17.881
14.2	Mangochi to Monkey Bay	19.711	114.099	152.667	151.717	195.444	76.611	236.447	43.770	430.465	21.415
15	Zomba to Blantyre	20.000	40.446	95.375	182.478	196.313	30.037	230.813	23.353	445.813	12.985

Table 4-4 – Layer Thickness and CBR Strengths from DCP Results

Location of the Selected Sample Lengths						Pavement Layer Characteristics - As Determined by Trial Pit Inspection							
			Point			SF Thick	BS Thick	Str	SB Thick	Str	SSG Thick	Str	SG Str
Road Name	No.	Length	From	To	Side	(mm)	(mm)	CBR	(mm)	CBR	(mm)	CBR	CBR
1 Karonga - Songwe	S1	2.0	0 -	20	L	20.000	200.000	127.657	300.000	67.606	670.000	20.423	21.844
	S2	1.0	21 -	31	R	20.000	175.000	137.941	280.000	69.164	530.000	20.625	12.423
	S3	2.0	32 -	52	L	20.000	320.000	131.917	732.222	26.477	797.500	27.712	34.600
2.1 Mzuzu - Bwengu	S1	1.5	0 -	15	L	25.000	200.000	197.677	300.000	37.510	470.000	39.688	20.667
	S2	2.0	16 -	36	L	30.000	190.000	158.480	390.000	17.910	550.000	17.363	13.830
	S3	2.0	46 -	66	R	25.000	175.000	207.193	375.000	36.427	575.000	20.158	15.478
	S4	2.0	67 -	87	R	25.000	210.000	126.256	310.000	29.319	480.000	24.699	27.824
2.2 Bwengu - Chiweta	S5	2.0	0 -	20	L	20.000	210.000	165.956	345.000	50.960	500.000	40.903	35.379
	S6	1.5	21 -	36	L	20.000	210.000	149.168	345.000	28.856	500.000	16.761	20.868
	S7	1.0	37 -	47	L	25.000	195.000	209.292	300.000	74.847	630.000	49.113	23.465
3 Jenda - Chikangawa	S1	1.0	0 -	10	R	40.000	200.000	165.882	300.000	86.736	430.000	28.365	28.683
	S2	2.0	19 -	39	R	25.000	180.000	169.454	310.000	47.381	450.000	26.783	21.405
	S3	2.0	32 -	52	L	35.000	230.000	165.859	330.000	45.630	430.000	40.822	24.474
	S4	2.0	53 -	73	L	40.000	200.000	170.214	300.000	45.631	430.000	31.059	27.715
4 Mzuzu - Nkhata Bay	S1	1.5	0 -	15	R	20.000	150.000	95.288	250.000	68.530	410.000	25.694	15.233
	S2	1.5	16 -	31	R	10.000	100.000	246.452	150.000	102.829	200.000	67.043	18.337
	S3	1.5	32 -	47	L	10.000	170.000	189.706	280.000	29.528	410.000	24.173	15.956
5 Bwengu - Rumphi	S1	1.0	0 -	10	L	25.000	185.000	170.847	350.000	63.085	425.000	26.575	34.063
6 Kasungu - Dwangwa	S1	1.0	0 -	10	L	20.000	210.000	86.583	345.000	36.498	500.000	16.479	12.449
	S2	1.0	11 -	21	R	20.000	210.000	114.210	345.000	70.059	500.000	60.072	105.260
7 Madisi - Kasungu	S1	1.5	0 -	15	R	20.000	210.000	125.640	345.000	67.392	500.000	36.768	25.358
	S2	1.5	16 -	31	R	20.000	210.000	105.310	345.000	64.877	500.000	32.512	31.031
	S3	2.0	33 -	53	L	20.000	210.000	104.017	345.000	39.590	500.000	28.529	21.316
8 Lumbadzi - Mponela	S1	2.0	0 -	20	L	20.000	210.833	88.721	344.583	42.151	500.000	26.251	26.077
	S2	1.0	21 -	31	L	20.000	220.000	75.383	340.000	47.983	500.000	27.708	23.023
9 Bunda Turn Off - Chimbiya	S1	2.0	32 -	52		18.667	142.000	267.884	296.000	73.497	386.667	22.353	13.159
	S2	1.0	21 -	31		10.000	155.000	315.200	270.000	56.709	365.000	38.213	24.129
	S3	2.0	0 -	20		73.077	188.462	473.522	345.000	125.374	425.769	28.345	33.482
10 Dedza - Biriwiri	S1	2.0	42 -	62		20.000	180.000	194.739	290.000	62.187	375.000	59.768	27.342
	S2	2.0	21 -	41		20.000	135.000	287.245	220.000	201.484	345.000	42.535	22.920
	S3	2.0	0 -	20		10.000	110.000	328.540	230.000	197.721	350.000	78.895	39.322
11 Salima - Senga Bay	S1	1.0	0 -	10		10.000	155.000	146.674	270.000	103.527	365.000	45.860	18.885
	S2	1.0	11 -	21		10.000	155.000	118.522	270.000	92.610	365.000	84.256	153.460
12.1 Benga - Nkhotakota	S1	2.0	63 -	83		10.000	155.000	283.476	270.000	128.746	365.000		
	S2	2.5	42 -	67		10.000	155.000	215.784	270.000	68.567	365.000	50.190	41.372
12.2 Nkhotakota - Dwangwa	S3	2.0	21 -	41		25.385	172.308	292.411	310.000	57.615	440.769	44.127	24.646
	S4	2.0	0 -	20		24.615	208.462	263.794	357.692	100.500	519.231	32.383	23.194
13.1 Chingeni - Liwonde	S1	1.0	0 -	10		30.000	150.000	239.904	320.000	45.200	490.000	34.133	21.092
	S2	1.0	11 -	21		19.500	142.500	164.231	295.500	71.736	474.000	46.306	22.371
	S3	1.0	22 -	32		16.111	165.000	107.128	291.667	118.493	600.000	85.550	40.958
13.2 Liwonde - Zomba	S4	2.0	33 -	53		19.375	163.125	123.912	302.500	86.651	586.250	51.313	38.608
	S5	2.0	54	74		30.000	150.000	159.590	320.000	77.671	490.000	28.531	26.150
	S6	1.0	75	85		30.000	150.000	404.498	320.000	71.619	490.000	37.879	27.970
14.1 Liwonde - Mangochi	S1	2.0	0 -	20									
	S2	1.0	21 -	31									
	S3	1.0	32 -	42		15.000	160.000	188.450	380.000	67.666	560.000	22.558	15.296
	S4	2.0	43 -	63		15.000	160.000	210.958	380.000	102.983	373.333	60.775	44.081
14.2 Mangochi - Monkey Bay	S5	2.0	0	20									
	S6	1.0	22	32									
	S7	2.0	33	53		20.000	200.000	126.303	300.000	61.842	410.000	55.569	37.087
	S8	1.0	53	63		20.000	200.000	192.756	300.000	84.886	410.000	47.528	30.742
15 Zomba - Blantyre	S1	1.0	0 -	10		40.000	200.000	151.261	280.000	42.467	480.000	29.380	26.148
	S2	1.0	11 -	21		65.000	225.000	287.732	302.500	64.896	476.250	34.131	76.677
	S3	1.0	22 -	32									
	S4	1.0	33 -	43									
	S5	2.0	44 -	64		90.000	250.000	110.954	325.000	77.911	450.000	61.104	24.731

5. ANALYSIS OF MODIFIED DCP TESTING

This section of the report presents the data and assumptions used in the calculation of the graphs presented in the . It will attempt to draw conclusions from the data obtained and to relate that to the data obtained in the UK field trials and in the laboratory. Firstly a comparison between the small flat tipped DCP and the standard DCP cone will be made before studying the relation between DCP, Radius of curvature meter and the Roughton Deflection bowl methods of Resilient Moduli calculation, and compares this with the DCP values. A relationship correlation in this area would help reduce the cost and time involved in pavement analysis, thereby enabling a rapid assessment of pavement conditions (Gravel or Surfaced) and thus time and overheads in rehabilitation requirements.

5.1. Standard DCP Testing

The DCP results were analysed using the TRL equation (Section 3.3), as previous work undertaken as part of this study (Report III) of the project had shown that there was little overall difference in which equation was used for correlating DCP readings with in situ CBR result (see Main Report). Due to the fact that a correlation linking CBR to Resilient Moduli (Mr) had also been developed by TRL a consistency would be maintained.

5.1.1. Routine Testing

The routine DCP are shown in Table 4-2 and the average for that length can be seen. The averages have been calculated by eliminating obviously incorrect, or when the test has not penetrated more than 400 mm into the pavement structure.

The results obtained from this testing are acceptable and compare well to the expected results. As usual in some areas the DCP was unable to penetrate due to the nature of the compacted pavement base revealed little except that in places the DCP could not penetrate the pavement. When compared with the laboratory result there was a general “overread” factor of approximately 6.

5.1.2. Sample Lengths

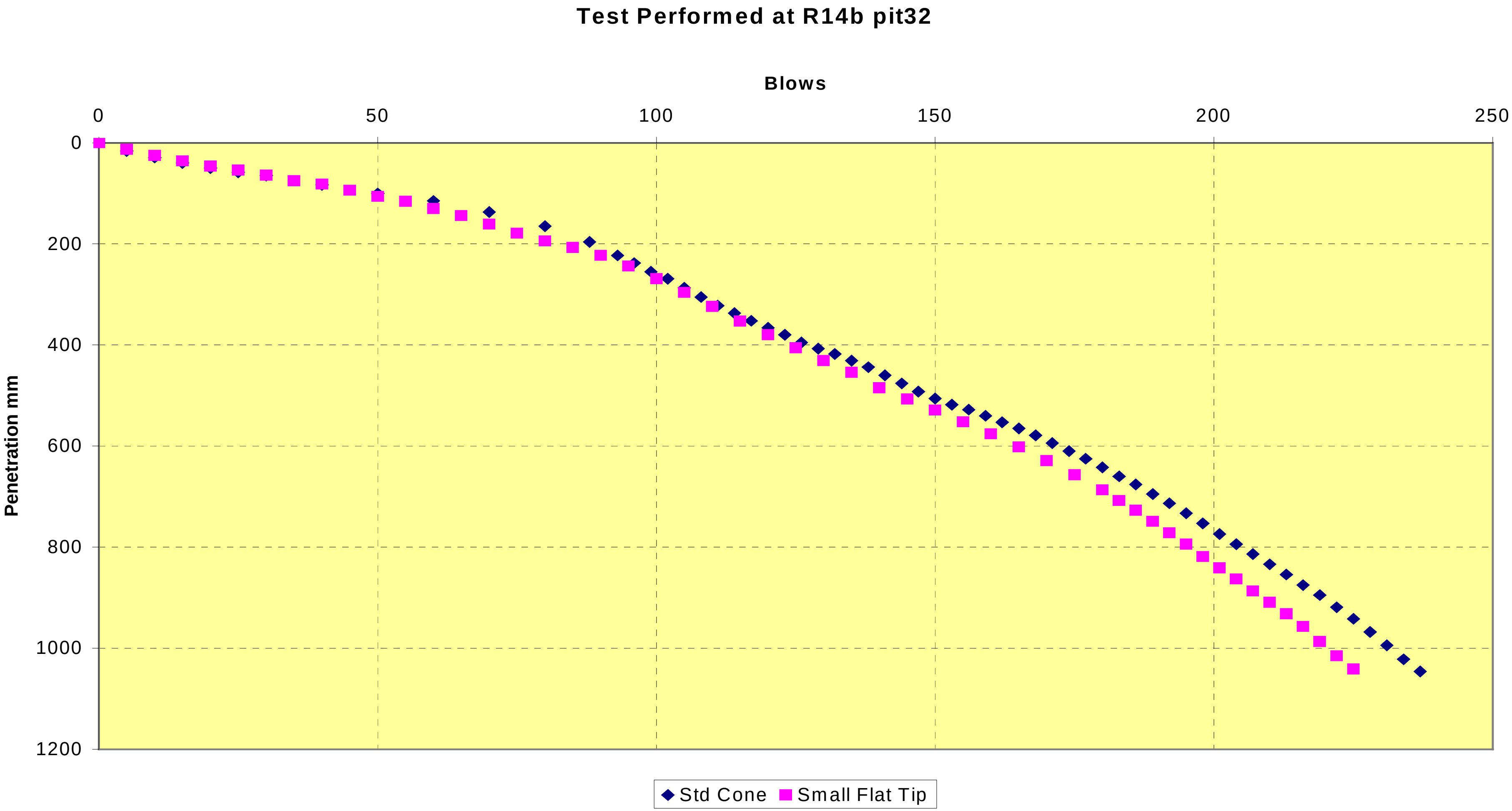
The results from the DCP testing on the sample lengths are shown in Table 4-4 and the average for that length can be seen in bold type. The averages have been calculated by eliminating obviously incorrect results, or when the test has not penetrated more than 400mm into the pavement structure.

5.1.3. DCP Results in General

From the DCP testing conducted in the sample lengths, and during the routine testing the spread of results was in the range expected considering the type of pavement construction and the climate. On the routine testing, the results compare well, ie over the length of road under consideration the correlation between each individual test is fairly high and consistent over the section under consideration.

The acceptable results for this type of testing indicate a consistency with the laboratory based results.

Figure 5-1 - Comparison of a Standard DCP Cone with a Small Flat Tip



5.2. Resilient Moduli Calculations

From the consultant's experience in Southern African countries, and the subsequent laboratory analysis, it was found in general that the pavement included in the project were in a very dry condition, producing artificially high DCP readings. From work in the wet and dry seasons, in various countries, a conditioning index has been developed that is applied to results based upon laboratory testing, in situ testing and a visual assessment of the pavement. to lower the field strengths of the DCP CBR's to a realistic soaked CBR that could be used for design. A comparison of the predicted deflection based on the structural number from the dynamic cone penetrometer tests against the design deflection showed a factor of 6 may be applicable. This can also be seen in the laboratory results when comparing in-situ DCP CBR results with the 98% soaked CBR from the laboratory. This is not unexpected since the consultant has found the factor to be as high as 10 in certain countries in Southern and Central Africa. However, since the structural number is only used to compare the strength of one road against another this correction is not required for design, but therefore we must take heed of dry season conditions when analysing the results for research purposes.

Based on the relationships between the DCP and CBR as described above it is possible to estimate the strength and thickness of each layer in the pavement as well as the subgrade strength. Figure 5-3 shows a summary and comparison of the averaged available test data from Malawi.

The work undertaken so far, has shown that the DCP consistently overeads the stiffness compared to ROC by a factor of 6, whilst the deflection bowl method shows a closer match with an underead factor of 0.5. The results and plots are shown in Figure 5-3 and more comprehensively for all the individual roads in Appendix II, where the DCP plots and the DCP summary tables can be seen also. The associated laborarory testing is presented in Appendix I. When these DCP CBR values are compared with the Laboratory CBR’s it can be seen that the DCP values compare more favourable with the unsoaked testing. However, as the Mr calculations are taken from the DCP it is inevitable that an over read value will be obtained. The modified tip may have further uses when performed in a borrow pit, or loose compaction stage. With a well compacted, laterically bound material, the results were almost identical.

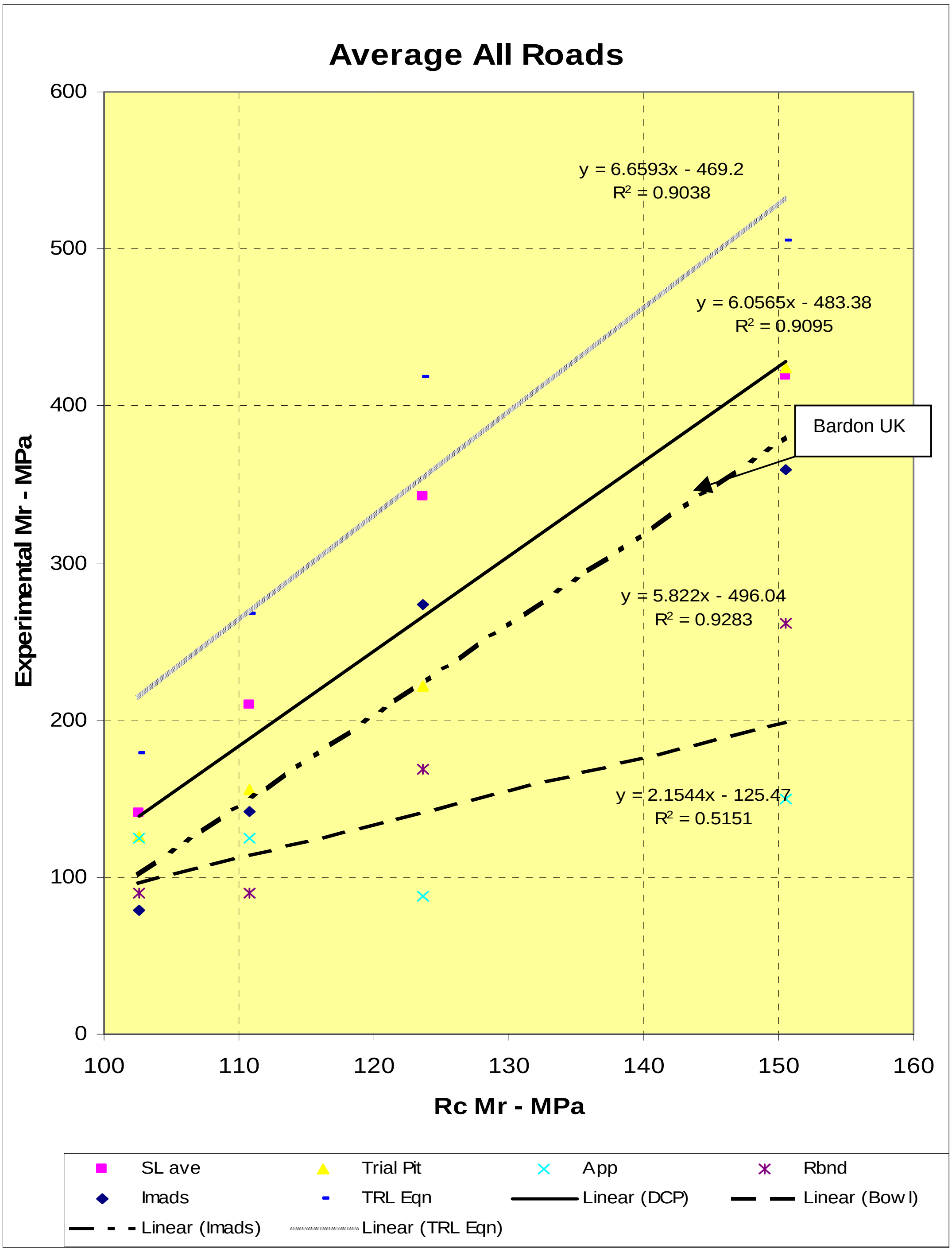
Figure 5-2 - Deflection Bowl Summary

Road Maintenance and Rehabilitation Project Roughton International
Deflection Bowl Summary *in association with* Jatula Partners

Road Details	Chain	Thickness (mm)			LHS	Resilient Modulus (MPa)						RHS
	(km)	BC	SB	SG1	BC	SB	SG1	SG2	BC	SB	SG1	SG2
1 Karonga - Songwe	3.3	200	130	1000	163	65	130	1029	109	496	82	242
1 Karonga - Songwe	23.1	175	265	1000	30	36	33	5000	51	41	22	5000
1 Karonga - Songwe	30.8	320	0	1000	255	67	82	1986	112	365	74	98
2.1 Mzuzu - Bwengu	5.6	200	100	1000	151	73	154	965	78	313	146	600
2.1 Mzuzu - Bwengu	12.1	190	160	1000	75	36	283	768	87	52	97	5000
2.1 Mzuzu - Bwengu	36.3	175	200	1000	122	76	95	2194	282	45	107	908
2.1 Mzuzu - Bwengu	59.3	210	100	1000	38	23	54	3400	48	43	35	5000
2.2 Bwengu - Chiweta	79.1	210	100	1000	199	122	252	883	207	98	284	723
2.2 Bwengu - Chiweta	102.2	200	280	1000	33	41	77	3998	46	45	43	5000
2.2 Bwengu - Chiweta	114.3	195	105	1000	75	37	156	946	134	20	394	691
3 Jenda - Chikangawa	11.0	200	100	1000	50	215	153	1052	169	90	88	464
3 Jenda - Chikangawa	25.3	180	130	1000	157	33	115	1070	115	132	56	2418
3 Jenda - Chikangawa	61.5	230	100	1000	118	29	67	2957	79	605	35	532
3 Jenda - Chikangawa	69.2	195	85	1000	138	24	190	831	110	47	121	842
4 Mzuzu - Nkhata Bay	8.2	150	100	1000	38	49	41	5000	173	137	24	305
4 Mzuzu - Nkhata Bay	21.4	100	120	1000	148	299	91	1993	425	372	90	227
4 Mzuzu - Nkhata Bay	42.3	170	240	1000	28	27	75	2064	46	25	58	1663
5 Bwengu - Rumphi	3.3	185	165	1000	180	36	5000	317	49	1016	110	742
6 Kasungu - Dwangwa	6.6	200	150	1000	86	38	115	3052	68	259	44	3403
6 Kasungu - Dwangwa	15.4	140	160	1000	202	115	150	5000	290	199	129	165
7 Test Failure												
7 Madisi - Kasungu	31.9	270	130	1000	158	20	264	614	139	204	61	185
7 Madisi - Kasungu	31.9	190	100	1000	49	376	153	1883	81	175	118	1608
8 Lumbadzi - Mponela	23.1	210	135	1000	61	201	105	1732	139	63	196	75
8 Lumbadzi - Mponela	30.8	220	120	1000	79	63	216	1182	299	20	225	699
9 Bunda Turn Off - Chimbiya	7.7	140	160	1000	36	23	385	977	40	176	44	669
9 Bunda Turn Off - Chimbiya	28.6	175	110	1000	59	40	84	1493	127	60	53	177
9 Bunda Turn Off - Chimbiya	47.3	205	170	1000	207	230	150	5000	252	237	95	747
10 Dedza - Biriwiri	9.9	180	110	1000	60	123	105	5000	76	225	122	79
10 Dedza - Biriwiri	27.5	135	85	1000	138	20	56	5000	253	20	45	5000
10 Dedza - Biriwiri	52.7	110	120	1000	184	77	111	5000	372	171	72	1554
11 Salima - Senga Bay	5.5	155	115	1000	321	85	208	5000	372	142	208	135
11 Salima - Senga Bay	17.6	195	200	1000	43	128	143	5000	150	44	140	4968
12 Benga - Nkhotakota	20.9	140	140	1000	81	126	70	5000	134	254	26	349
12 Benga - Nkhotakota	20.9	140	140	1000	300	23	57	5000	76	81	46	139
12 Nkhotakota - Dwangwa	33.0	170	175	1000	415	50	74	5000	376	171	39	432
12 Nkhotakota - Dwangwa	39.6	190	320	1000	117	68	95	5000	75	298	43	126
13 Chingeni - Liwonde	6.6	150	170	1000	67	86	72	5000	501	20	118	23
13 Chingeni - Liwonde	19.8	140	155	1000	21	50	162	5000	54	83	73	71
13 Chingeni - Liwonde	26.4	165	110	1000	125	75	132	5000	63	946	104	195
13 Liwonde - Zomba	42.9	165	135	1000	37	52	104	5000	92	36	89	595
13 Liwonde - Zomba	65.9	200	100	1000	138	24	171	5000	482	20	66	5000
13 Liwonde - Zomba	87.9	150	100	1000	27	741	176	5000	571	284	96	1507
14 Liwonde - Mangochi	4.9	110	150	1000	1497	20	35	5000	1876	20	153	15
14 Liwonde - Mangochi	13.2	140	60	1000	47	84	44	5000	82	153	20	243
14 Liwonde - Mangochi	44.0	160	350	1000	45	21	52	5000	38	40	41	5000
14 Liwonde - Mangochi	58.2	150	150	1000	94	32	87	5000	32	290	54	83
14 Mangochi - Monkey Bay	85.7	210	510	1000	71	38	140	5000	226	38	24	748
14 Mangochi - Monkey Bay	97.8	130	65	1000	793	37	176	5000	2509	20	145	5000
14 Mangochi - Monkey Bay	111.0	200	115	1000	126	31	170	5000	145	253	53	240
14 Mangochi - Monkey Bay	7.7	195	75	1000	275	27	348	5000	268	276	86	5000
15 Zomba - Blantyre	11.0	200	80	1000	273	73	118	5000	434	48	117	988
15 Zomba - Blantyre	16.5	190	200	1000	48	83	136	5000	128	45	143	5000
15 Zomba - Blantyre	24.2	190	200	1000	156	53	96	5000	806	28	52	392
15 Zomba - Blantyre	51.6	190	200	1000	248	58	128	5000	187	180	48	5000
15 Zomba - Blantyre	56.0	145	180	1000	319	71	114	5000	260	166	63	5000

Figure 5-3 - Comparisons of the various Resilient Moduli calculated

	Road No: Average All Roads											
	Resilient Modulus (Mpa)					Soil Properties				Dry In Situ Density	Soaked CBR %	
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI		%Comp	
		SL ave	Trial Pit	App	Rbnd						98	95
Base	151	419	425	150	261	-	-	0	-	-	-	-
Subbase	124	342	221	87	169	-	-	0	-	-	-	-
SSG	111	210	155	125	90	-	-	-	-	-	-	-
SG	103	141	126	125	90							



6. DISCUSSIONS AND CONCLUSION

Correlation between DCP and resilient modulus for subgrade soils showed that DCP results relate reasonably to resilient modulus. The scatter in the results is partly due to the natural variability in the field conditions, especially as the DCP tests were not carried out exactly at the points of the resilient modulus measurements. Additionally the subgrade soil contained cobbles which increased the variability in the test results. However, it is interesting to note that R^2 for the DCP-stiffness relationships were higher than that between the two resilient modulus measurement methods used (GDP & TFT), in the case of the subgrade material.

Thus, there appears to be an inherent difficulty in measuring subgrade soil resilient modulus, independent of the difficulties of using a DCP to do so, and the DCP seems to be no worse than the competing (and far more sophisticated) equipment, such as the GDP and TFT, at least as far as the Bardon situation is concerned.

The DCP value for each tested point used above was the average of the DCP readings (mm/blow) for that point. The values are given in Appendix I. This method worked well with the subgrade because it was one layer with fairly uniform properties. When aggregates were placed the situation was changed in three ways. Firstly, a 2-layer system is introduced with the possibility of interference effects between the two layers. Secondly, unbound aggregates generally give unrealistically low DCP values because of lack of confinement. Thirdly, DCP results reflect shear strength more than resilient modulus. For these reasons, the correlations between resilient modulus and DCP values were not good with very low R^2 values. Therefore, improvements are suggested for further work to undertake on the next field trials, where adjustments need to made to create equivalent DCP values (where a DCP value is a single value in mm/blow which represents the entire test in the layer) as follows:

- The first improvement was to find the rate of penetration in mm/blow for each 100 mm of the penetration depth and then take the average of these readings as the equivalent DCP.
- The second improvement was to find a weighted average rather than the simple average to take into account the effect of stress distribution so that shallower depths have more influence on the resilient modulus than deeper ones.
- Regarding the top layer correction, the weighted average may need to be corrected further due to a loosening effect of initial impacts of the DCP.
- The consistency (or lack of) agreement when comparing the Small Flat Tip DCP with Standard DCP Cones needs to be investigated further, as too much scatter in the results is evident.

The testing undertaken as part of the Bardon trial and the subsequent analysis showed that the small flat tip related to resilient modulus measurements using GDP and TFT better than the other tips. The use of a modified tip improved the correlation between DCP readings (mm/blow) and stiffness. The resilient modulus to flat tip relationship having the highest correlation, and displaying most consistency. The Equations developed and shown in Appendix II, demonstrate taking a mm/blow reading, using the relationship from the Bardon Trial:

$$\text{Mod DCP} = 0.6889\,(\text{DCP}) + 5.882 \qquad \text{Eqn. 10}$$

To obtain a mm/blow reading equivalent to using the small flat tip. Then we are able to use the following relationship to produce an interpretation of the Stiffness (Resilient Modulus):

$$\text{Mr} = 83.179\,(\text{Mod DCP})^{-0.5823} \qquad \text{Eqn. 11}$$

The relationship between the small flat tip and resilient modulus from the GDP and TFT is worthy of further investigation. The relationship has so far only been investigated using the Bardon trial and a small amount of work in Malawi and therefore further investigations would be necessary using overseas soils. It was not possible to undertake many resilient modulus trials as part of this project, due to the limited availability of the GDP and TFT. Therefore in Malawi the resilient modulus was measured using deflection bowl measurements to compare with the DCP results obtained from the small flat tip.

7. REFERENCES

7.1. Ministry of Works Materials Laboratory Branch Reports

The following Construction Material Investigation Reports were studied:

REPORT	Report No.	Year	Study Road No.
Benga – Nkhotakota Lime Stabilisation	2A		12.1
Benga – Nkhotakota Gravel Survey	19	1982	12.1
Salima – Balaka Road (M17)	31	1983	11
Salima Airport	40	1986	11
Blantyre – Lirangwe – Machimbeya – Balaka Road S85	47	1985	15
Blantyre – Lirangwe – Machimbeya – Balaka	48	1985	15
S69 Zomba – Kachulu Road and S73 Namadidi Loop Road	68		15
Jenda – Edingeni – Kamteteka Road S49	81	1987	3
Mponela – Mtchisi Construction Materials	92	1988	8
Balaka – Ulongwe S55 Gravel Survey	108	1989	13
Lilongwe – Salima Road Geotechnical Investigation	113	1988	8
Areas 13, 14 and 32 Construction Materials	126	1989	8
Kasungu Airport – Pavement Evaluation & Materials	144	1990	6 & 7
Benga – Nkhotakota – Dwangwa Construction Materials	146	1990	12
Dzaleka – Lumbadzi Gravel and Soil Survey	188	1992	8
Ntcheu – Mwanza Road Preliminary Soil and Construction Materials Investigations	236	1996	10

The following Pavement Evaluation Reports were studied:

REPORT	DMR NO.	YEAR	ROAD NO.
Blantyre – Chileka Road (M2)	20	1982	45
Mangochi – Monkey Bay Road	26A	1982	14.2
Kacheche – Chiweta Road	33	1983	2
Lilongwe – Kasungu and Jenda Pavement Evaluation Vol. I, II and III	76	1987	3,6,7 & 8
Mangochi – Monkey Bay Road	102	1988	14
Nkhotakota – Benga Pavement Evaluation	103	1989	12
Nkhotakota – Dwangwa Pavement Evaluation	104	1989	12
Mzuzu – Nkhata – Bay Road M12 Pavement Evaluation	110	1989	4
South Rukuru – Chiweta Pavement Evaluation	111	1989	2.2
Mzuzu – Mbowe Spur Pavement Evaluation	164	1991	2 & 4
Mzuzu – Nkhata – Bay Pavement Evaluation (M1)	169	1991	4
Independence Drive, Blantyre	325	1986	

The following Consultants Reports were used for this study:

REFERENCE	REPORT TITLE
CSIR Division of Roads, 1990	A Study of Road Pavement Failures and Rehabilitation Strategies M1 Lilongwe – Kasungu, Kacheche – Kargonga
Gibb Orointec JV, 1997	Economic Feasibility Study for the karonga- Chilumba-Chiweta Road Final Report
jose a. torroja, oficina technica s.a., 1997	Detailed Design and Environmental Analysis for the Karonga – Chilumba – Chiweta Road
Scott Wilson & Kirkpatrick	Economic Study review and detailed Engineering Design Kasungu – Nkotakota Road Stage 1 Volume 1 Draft final Report
Scott Wilson & Kirkpatrick, 1997	Detailed Engineering Design of the Karonga – Chitipa- Nyala Border Post Road, Report on Soils and Construction Materials
Scott Wilson & Kirkpatrick, 1983	Construction of the Luwawa Turn-off Champhoyo Road Comntract No 7/83 Volume III Report on Soils and Construction Materials
Scott Wilson & Kirkpatrick, 1983	Rehabilitation of Road M17 between Salima and Balaka Section M5 to M18 Contact No 44/86 Volume III Report on Soils and Construction Materials.
SMEC International, 1998	Road Maintenance and Rehabilitation Programme Final Report Part D Other reviews and Outputs

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In association with
THE UNIVERSITY OF BIRMINGHAM
and
THE UNIVERSITY OF NOTTINGHAM

Report IV- Appendix I
Field Trials of Modified DCP Apparatus

DFID Department for International Development

February 2000

Appropriate and Efficient Maintenance of Low Cost Rural Roads

Report IV- Appendix I
Field Trials of Modified DCP Apparatus

February 2000

The University of Nottingham
School of Civil Engineering
University Park
Nottingham
NG7 2RD
United Kingdom
www.nottingham.ac.uk/p&g

Roughton International.
321 Millbrook Road West
Southampton
SO15 OHW
United Kingdom
www.roughton.com

University of Birmingham
School of Civil Engineering
Edgbaston
Birmingham
B15 2TT
United Kingdom
www.bham.ac.uk/CivEng/

DFID Department for International Development

Department for International Development
94 Victoria Street
London
SW1E 5JL
www.dfid.gov.uk

Department for International Development
Knowledge and Research (KaR) Programme

Project Title:	Appropriate and Efficient Maintenance of Low Cost Rural Roads
***DFID Project Reference*:**	R6852
Subsector:	*Transport*
***Theme*:**	T2
Element A:	Review of Procedures, Standards and Methods
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Appendix I - Laboratory and Field Results

DCP Survey Results

This section contains:

- Sample Length, one test performed at every peak deflection test point.
- Routine Lengths, one test every 2km on all roads

Trial Pit Logs

This provides a summary of the trial pits, the depths of each layer, a visual description and any associated test results from the laboratory.

Laboratory Results

This provides a comprehensive summary of the testing undertaken on the roads.

Road Maintenance and Rehabilitation Project

Dynamic Cone Penetrometer Test **Summary**

Road Name: Karonga to Songwe Road Code: 1

Test Location and Pavement Assessment		Layer Characteristics										Pavement Layer Characteristics							
Chainage	Condition	Layer 1		Layer 2		Layer 3		Layer 4		Layer 5		SF	BS		SB		SSG		SG
		Thk	Str	Thk	Str	Thk	Str	Thk	Str	Thk	Str	Thick	Thick	Str	Thick	Str	Thick	Str	Str
(km)		(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	(mm)	CBR	(mm)	CBR	(mm)	CBR	CBR
0.200 LHS	SURFACE DRESSING	20	32	7	1204	124	118	74	163	21	813	20	200	171	330	157	670		
2.200 RHS	SURFACE DRESSING	20	32	13	626	87	218	60	306	22	422	20	200	311	330		670		
4.200 LHS	SURFACE DRESSING	20	32	16	502	68	204	74	194	15	897	20	200	275	330		670		
6.200 RHS	SURFACE DRESSING	20	32	7	600	17	423	45	202	18	610	20	200	171	330		670		
8.200 LHS	SURFACE DRESSING	20	459	209	138	95	108	263	16	435	23	20	200	197	330	87	670	21	24
10.200 RHS	SURFACE DRESSING	20	32	113	264	142	185	188	37	479	23	20	200	258	330	98	670	26	27
12.200 LHS	SURFACE DRESSING	20	32	7	1204	59	216	56	204	24	863	20	200	293	330		670		
14.200 RHS	SURFACE DRESSING	20	32	11	1126	77	259	68	278	6	2243	20	175	333	400	49	600		
16.200 LHS	SURFACE DRESSING	20	334	200	96	136	149	44	360	622	19	20	175	130	400	176	600	29	16
18.200 RHS	SURFACE DRESSING	31	185	191	165	158	115	136	48	506	15	20	175	190	400	115	600	39	15
20.200 LHS	SURFACE DRESSING	20	32	13	626	112	149	21	550	9	1067	20	175	292	400		600		
22.200 RHS	SURFACE DRESSING	20	32	13	626	67	182	42	214	6	1376	20	175	241	400		600		
24.200 LHS	SURFACE DRESSING	20	32	220	227	75	321	185	45	522	16	20	175	200	400	204	600	32	15
26.200 RHS	SURFACE DRESSING	20	32	22	359	138	124	63	247	9	1261	20	320	171	500		740		
28.200 LHS	SURFACE DRESSING	20	32	13	304	50	137	57	102	11	897	20	320	85	500		740		
30.200 RHS	SURFACE DRESSING	20	32	24	327	83	184	48	245	18	524	20	320	145	500		740		
32.200 LHS	SURFACE DRESSING	20	32	146	156	161	173	357	45	338	55	20	320	161	500	62	740	39	57
34.200 RHS	SURFACE DRESSING	20	32	146	188	108	256	115	78	633	31	20	320	197	500	45	740	37	26
36.200 LHS	SURFACE DRESSING	20	115	246	178	238	45	302	32	216	18	20	320	155	500	53	740	35	20
38.200 RHS	SURFACE DRESSING	20	302	126	152	103	156	308	36	76	100	20	320	145	500	33	740	44	
40.200 LHS	SURFACE DRESSING	20	151	243	190	290	14	201	7	268	28	20	320	161	500	25	740	7	25
ROAD 1		**21.38**	**32**	**190.4**	**178**	**155.3**	**149**	**198.6**	**38**	**460.1**	**22**	**20**	**236**	**186**	**420**	**100**	**670**	**28**	**21**

Road Maintenance and Rehabilitation Project

Dynamic Cone Penetrometer Test **Summary**

Road Name: Mzuzu to Ekwendeni Road Code: 2.11

Test Location and Pavement Assessment		Layer Characteristics										Pavement Layer Characteristics							
Chainage	Condition	Layer 1		Layer 2		Layer 3		Layer 4		Layer 5		SF	BS		SB		SSG		SG
		Thk	Str	Thk	Str	Thk	Str	Thk	Str	Thk	Str	Thick	Thick	Str	Thick	Str	Thick	Str	Str
(km)		(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	(mm)	CBR	(mm)	CBR	(mm)	CBR	CBR
10.100 LHS	SURFACE DRESSING	20	176	29	569	111	168	344	50	518	19	20	210	210	345	51	500	44	22
12.100 LHS	SURFACE DRESSING	20	390	162	331	251	54	251	37	338	25	20	210	319	345	72	500	35	32
14.100 LHS	SURFACE DRESSING	20	410	76	253	124	84	349	31	453	30	20	210	186	345	40	500	33	30
16.100 LHS	SURFACE DRESSING	20	449	155	161	169	34	193	9	485	13	20	210	178	345	30	500	13	13
18.100 LHS	SURFACE DRESSING	20	32	24	218	16	284	2	1760	12	228	20	210	89	345		500		
20.100 LHS	SURFACE DRESSING	3	239	33	496	77	91	71	250	12	1673	20	210	319	345		500		
22.100 LHS	SURFACE DRESSING	3	239	22	737	31	543	49	328	6	2636	20	210	327	345		500		
ROAD2.11		**20**	**32**	**104.3**	**241**	**163.8**	**85**	**284.3**	**32**	**448.5**	**21**	**20**	**210**	**223**	**345**	**48**	**500**	**31**	**24**

Road Maintenance and Rehabilitation Project

Dynamic Cone Penetrometer Test **Summary**

Road Name: Ekwendeni to Bewngu Road Code: 2.12

Test Location and Pavement Assessment		Layer Characteristics										Pavement Layer Characteristics							
Chainage	Condition	Layer 1		Layer 2		Layer 3		Layer 4		Layer 5		SF	BS		SB		SSG		SG
		Thk	Str	Thk	Str	Thk	Str	Thk	Str	Thk	Str	Thick	Thick	Str	Thick	Str	Thick	Str	Str
(km)		(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	(mm)	CBR	(mm)	CBR	(mm)	CBR	CBR
0.500 RHS	SURFACE DRESSING	3		30	557	20	392	24	408	15	1074	30	190	302	350		550		
2.500 LHS	SURFACE DRESSING	3		21	429	16	445	20	506	-4		30	190	252	350		550		
4.500 RHS	SURFACE DRESSING	20	32	-5		45	305	20	993	16	1001	30	190	382	350		550		
6.500 RHS	SURFACE DRESSSING	20	473	233	131	235	40	196	37	354	36	30	190	203	350	70	550	35	37
8.500 RHS	SURFACE DRESSING	3	36	33	517	20	449	21	515	6	3250	30	190	332	350		550		
10.500 RHS	SURFACE DRESSING	-3		21	414	26	617	24	207	-3		30	190	332	350		550		
12.500 RHS	SURFACE DRESSSING	20	32	7	1204	26	451	33	309	3	9109	30	190	332	350		550		
14.500 RHS	SURFACE DRESSING	20	32	0		30	322	33	582	3	5298	30	190	332	350		550		
16.500 RHS	SURFACE DRESSING	20	32	116	306	154	65	121	43	562	23	30	190	252	350	51	550	29	24
18.500 LHS	SURFACE DRESSING	20	32	-2		6	999	-6		-3		30	190	145	350		550		
20.500 RHS	SURFACE DRESSING	6		21	670	53	321	24	656	6	1267	30	190	332	350		550		
22.500 LHS	SURFACE DRESSING	20	294	168	146	359	42	266	42	209	32	30	190	184	350	51	550	39	38
24.500 RHS	SURFACE DRESSING	20	32	100	402	133	62	294	14	259	43	30	190	272	350	41	550	15	40
26.500 RHS	SURFACE DRESSING	0		20	397	33	183	27	466	3	5410	30	190	252	350		550		
28.500 RHS	SUURFACE DRESSING	0		12	510	12	112	3	2362	-3		30	190	136	350		550		
30.500 RHS	SURFACE DRESSING	28	265	126	284	294	41	250	17	324	15	30	190	272	350	42	550	32	15
32.500 RHS	SURFACE DRESSING	3	65	19	448	34	289	20	468	0		30	190	272	350		550		
34.500 RHS	SURFACE DRESSING	8	492	224	80	249	23	143	23	423	11	30	190	117	350	35	550	24	12
36.500 RHS	SURFACE DRESSING	-11		213	184	148	43	263	14	409	21	30	190	242	350	46	550	14	22
38.500 LHS	SURFACE DRESSING	20	32	-3		33	244	37	281	0		30	190	252	350		550		
39.200 RHS	SURFACE DRESSSING	-3		191	133	47	292	210	49	565	28	30	190	164	350	117	550	35	30
ROAD2.12		**17.17**	**81**	**160.6**	**240**	**185.6**	**117**	**205.8**	**75**	**319.8**	**157**	**30**	**190**	**213**	**350**	**57**	**550**	**28**	**27**

Road Maintenance and Rehabilitation Project

Dynamic Cone Penetrometer Test **Summary**

Road Name: Bwengu to Mountain Section Road Code: 2.21

Test Location and Pavement Assessment		Layer Characteristics										Pavement Layer Characteristics							
Chainage	Condition	Layer 1		Layer 2		Layer 3		Layer 4		Layer 5		SF	BS		SB		SSG		SG
		Thk	Str	Thk	Str	Thk	Str	Thk	Str	Thk	Str	Thick	Thick	Str	Thick	Str	Thick	Str	Str
(km)		(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	(mm)	CBR	(mm)	CBR	(mm)	CBR	CBR
0.200 LHS	SURFACE DRESSING	37	242	155	365	256	43	244	36	346	14	25	175	388	375	70	575	38	22
2.200 RHS	SURFACE DRESSING	-3		225	118	507	15	119	6	174	19	25	175	145	375	38	575	15	14
4.200 LHS	SURFACE DRESSING	3	239	59	210	71	515	74	230	13	1545	25	175	399	375	115	575		
6.200 RHS	SURFACE DRESSING	0		60	189	11	1276	24	319	3	4016	25	175	291	375		575		
8.200 LHS	SURFACE DRESSING	20	424	200	186	253	51	333	36	216	75	25	175	249	375	77	575	41	56
10.200 RHS	SURFACE DRESSING	20		13	697	44	250	39	348	0		25	175	355	375		575		
12.200 LHS	SURFACE DRESSING	20		13	710	29	460	24	710	21	1023	25	175	388	375		575		
14.200 RHS	SURFACE DRESSING	37	201	139	414	224	52	348	13	274	20	25	175	420	375	55	575	25	18
16.200 LHS	SURFACE DRESSING	9	166	157	157	240	7	394	15	222	41	25	175	166	375	11	575	18	27
18.200 RHS	SURFACE DRESSING	9	352	87	210	182	119	294	41	450	15	25	175	218	375	70	575	39	17
20.200 LHS	SURFACE DRESSING	20	32			12	795	6	1737	4	2657	25	175	239	375		575		
22.200 RHS	SURFACE DRESSING	20	32	13	626	50	239	95	168	22	643	25	175	334	375		575		
24.200 RHS	SURFACE DRESSING	20	32	0		40	199	17	560	15	867	25	175	249	375		575		
26.200 RHS	SURFACE DRESSING	20	32	144	279	182	48	214	74	494	41	25	175	260	375	58	575	76	42
28.200 LHS	SURFACE DRESSING	20	32	146	344	245	50	300	27	311	63	25	175	323	375	55	575	34	53
30.200 RHS	SURFACE DRESSING	20	32	10	826	12	273	38	399	24	815	25	175	302	375		575		
32.200 LHS	SURFACE DRESSING	20	145	218	207	299	39	303	53	47	160	25	175	249	375	77	575	34	80
34.200 LHS	SURFACE DRESSING	20	213	84	262	126	179	223	87	20	1046	25	175	249	375	107	575	137	
36.200 LHS	SURFACE DRESSING	20	32	11	747	53	153	39	247	17	809	25	175	260	375		575		
38.200 RHS	SURFACE DRESSING	20	324	131	254	193	82	244	43	159	163	25	175	270	375	77	575	48	218
40.200 LHS	SURFACE DRESSING	20	32	45	323	68	359	55	259	22	719	25	175	345	375	77	575		
42.200 LHS	SURFACE DRESSING	20	32	13	426	23	244	27	358	12	1058	25	175	218	375		575		
44.200 LHS	SURFACE DRESSING	20	32			28	174	20	224	8	2109	25	175	186	375		575		
46.200 RHS	SURFACE DRESSING	20	32			8	653	4	1256	12	1041	25	175	166	375		575		
48.200 LHS	SURFACE DRESSING	20	32	4	2175	16	431	22	276			25	175	207	375		575		
50.200 LHS	SURFACE DRESSING	20	32	10	826	17	697	15	501	0		25	175	239	375		575		
ROAD2.21		**20**	**32**	**143.7**	**183**	**272.6**	**47**	**279.6**	**36**	**324.4**	**30**	**25**	**175**	**274**	**375**	**51**	**575**	**35**	**27**

Road Maintenance and Rehabilitation Project

Dynamic Cone Penetrometer Test **Summary**

Road Name: Mountain Section to Chiweta Road Code: 2.22

Test Location and Pavement Assessment		Layer Characteristics										Pavement Layer Characteristics							
Chainage	Condition	Layer 1		Layer 2		Layer 3		Layer 4		Layer 5		SF	BS		SB		SSG		SG
		Thk	Str	Thk	Str	Thk	Str	Thk	Str	Thk	Str	Thick	Thick	Str	Thick	Str	Thick	Str	Str
(km)		(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	(mm)	CBR	(mm)	CBR	(mm)	CBR	CBR
0.500 LHS	SURFACE DRESSING	20	32	0		16	320	44	281	12	1365	25	210	208	310		480		
2.500 LHS	SURFACE DRESSING	20	32	13	928	53	242	36	303	3	5622	25	210	268	310		480		
4.500 LHS	SURFACE DRESSING	20	32			9	169	6	562	3	4593	25	210	133	310		480		
6.500 RHS	SURRFACE DRESSING	20	32			12	483			6	1754	25	210	141	310		480		
8.500 LHS	SURFACE DRESSING	20	32			8	994			12	650	25	210	133	310		480		
10.500 LHS	SURFACE DRESSING	20	32	76	246	124	204	237	120	16	749	25	210	216	310	161	480	172	
ROAD2.22		**20**	**32**	**44.5**	**587**	**37**	**402**	**80.75**	**316**	**8.667**	**2456**	**25**	**210**	**183**	**52**	**161**	**80**	**172**	

Road Maintenance and Rehabilitation Project

Dynamic Cone Penetrometer Test **Summary**

Road Name: Jenda to Chikangawa Road Code: 3

Test Location and Pavement Assessment		Layer Characteristics										Pavement Layer Characteristics							
Chainage	Condition	Layer 1		Layer 2		Layer 3		Layer 4		Layer 5		SF	BS		SB		SSG		SG
		Thk	Str	Thk	Str	Thk	Str	Thk	Str	Thk	Str	Thick	Thick	Str	Thick	Str	Thick	Str	Str
(km)		(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	(mm)	CBR	(mm)	CBR	(mm)	CBR	CBR
0.000 RHS	SURAFCE DRESSING	20	32	168	378	168	183	191	38	167	84	28	190	367	305	219	425	107	63
2.000 RHS	SURFACE DRESSING	20	32	14	579	40	461	37	820	34	1060	28	190	557	305		425		
4.000 RHS	SURFACE DRESSING	20	137	250	137	246	42	231	9	145	42	28	190	162	305	99	425	45	25
6.000 LHS	SURFACE DRESSING	20	32	152	159	184	52	164	26	340	30	28	190	153	305	60	425	41	28
8.000 LHS	SURFACE DRESSING	31	215	219	142	213	72	221	23	280	49	28	190	181	305	112	425	70	39
10.000 LHS	SURFACE DRESSING	20	32	11	747	225	101	402	30	235	69	28	190	143	305	81	425	31	49
12.000 RHS	SURFACE DRESSING	20	508	162	211	325	42	182	26	223	25	28	190	269	305	48	425	45	30
14.000 LHS	SURFACE DRESSING	40	306	142	231	207	54	161	25	310	40	28	190	269	305	73	425	34	34
16.000 RHS	SURFACE DRESSING	20	32	16	502	32	193	18	511	18	912	28	190	239	305		425		
18.000 LHS	SURFACE DRESSING	20	32	0		27	322	42	264	21	1046	28	190	298	305		425		
20.000 LHS	SURFACE DRESSING	20	344	202	116	276	34	311	27	86	86	28	190	153	305	73	425	29	39
22.000 LHS	SURFACE DRESSING	20	32	4	1016	3	1643					28	190	96	305		425		
24.000 RHS	SURFACE DRESSING	20	32	4	2175	18	311	35	196			28	190	210	305		425		
26.000 LHS	SURFACE DRESSING	20	423	172	206	111	49	164	16	466	15	28	190	259	305	60	425	22	16
28.000 RHS	SURFACE DRESSING	20	392	271	68	183	22	186	33	250	26	28	190	124	305	48	425	20	31
30.000 LHS	SURFACE DRESSSING	20	337	134	181	229	61	269	52	241	69	28	190	210	305	60	425	53	61
32.000 RHS	SURFACE DRESSING	20	428	165	110	195	85	233	71	287	31	28	190	162	305	99	425	70	47
34.000 LHS	SURFACE DRESSING	20	32			28	210	19	344	9	1616	28	190	191	305		425		
36.000 RHS	SURFACE DRESSING	20	32			5	688	9	897	5	3081	28	190	201	305		425		
38.000 LHS	SURFACE DRESSING	20	539	110	241	167	55	299	19	309	22	28	190	249	305	48	425	26	20
40.000 RHS	SURFACE DRESSING	20	32			24	248	11	419	0		28	190	153	305		425		
42.000 LHS	SURFACE DRESSING	20	156	96	231	184	11	210	20	382	29	28	190	160	305	9	425	20	27
44.000 RHS	SURFACE DRESSING	20	347	158	99	296	34	249	21	164	18	28	190	134	305	43	425	34	20
46.000 LHS	SURFACE DRESSING	20	232	122	160	214	70	148	34	367	70	28	190	172	305	73	425	45	61
48.000 RHS	SURFACE DRESSING	20	157	146	195	190	37	373	25	6	824	28	190	201	305	35	425	34	37
50.000 LHS	SURFACE DRESSING	20	308	190	137	235	74	146	39	313	42	28	190	181	305	86	425	82	41
52.000 RHS	SURFACE DRESSING	20	145	260	97	196	25	327	22	93	36	28	190	115	305	86	425	24	26
54.000 LHS	SURFACE DRESSING	11	60	155	192	212	41	311	15	221	30	28	190	191	305	35	425	31	24
56.000 RHS	SURFACE DRESSING	20	145	84	122	112	95	264	43	427	29	28	190	124	305	60	425	34	34
ROAD3 part1		**20**	**32**	**172**	**149**	**200**	**51**	**233**	**30**	**265**	**37**	**28**	**190**	**177**	**305**	**63**	**425**	**38**	**33**

Road Maintenance and Rehabilitation Project

Dynamic Cone Penetrometer Test **Summary**

Road Name: Jenda to Chikangawa Road Code: 3

Test Location and Pavement Assessment		Layer Characteristics										Pavement Layer Characteristics							
Chainage	Condition	Layer 1		Layer 2		Layer 3		Layer 4		Layer 5		SF	BS		SB		SSG		SG
		Thk	Str	Thk	Str	Thk	Str	Thk	Str	Thk	Str	Thick	Thick	Str	Thick	Str	Thick	Str	Str
(km)		(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	(mm)	CBR	(mm)	CBR	(mm)	CBR	CBR
58.000 LHS	SURFACE DRESSING	20	281	170	119	264	26	80	46	373	19	30	210	137	305	43	420	25	26
60.000 RHS	SURFACE DRESSING	6	502	160	143	190	28	328	15	208	25	30	210	145	305	31	420	25	19
62.000 LHS	SURFACE DRESSING	20	32	156	267	180	55	328	25	200	26	30	210	240	305	58	420	40	27
64.000 RHS	SURFACE DRESSING	20	307	100	178	60	213	308	50	405	22	30	210	214	305	43	420	60	25
66.000 LHS	SURFACE DRESSING	20	32	160	219	176	48	299	17	235	41	30	210	205	305	43	420	23	33
68.000 RHS	SURFACE DRESSING	20	121	160	156	358	47	27	235	347	32	30	210	162	305	49	420	43	47
70.000 LHS	SURFACE DRESSING	20	32	20	688	34	325	21	397	9	1082	30	210	232	305		420		
72.000 RHS	SURFACE DRESSING	20	176	128	440	226	34	142	13	297	32	30	210	338	305	46	420	20	26
74.000 LHS	SURFACE DRESSING	20	32	7	1204	41	386	68	259	6	3292	30	210	329	305		420		
76.000 RHS	SURFACE DRESSING	47	147	161	150	284	13	188	16	224	15	30	210	162	305	31	420	13	16
78.000 LHS	SURFACE DRESSING	20	32	13	626	20	384	30	368	15	854	30	210	214	305		420		
80.000 RHS	SURFACE DRESSING	20	723	104	268	293	55	213	26	260	28	30	210	249	305	74	420	35	31
82.000 LHS	SURFACE DRESSING	20	32	13	626	11	299	56	310	25	674	30	210	249	305		420		
84.000 RHS	SURFACE DRESSING	20	32	13	626	50	275	62	223	3	3992	30	210	258	305		420		
ROAD3 part2		**20**	**32**	**152.4**	**176**	**216**	**61**	**222.6**	**58**	**284.6**	**26**	**30**	**210**	**206**	**305**	**46**	**420**	**32**	**28**

Road Maintenance and Rehabilitation Project

Dynamic Cone Penetrometer Test **Summary**

Road Name: Mzuzu to Nkhata Bay Road Code: 4

Test Location and Pavement Assessment		Layer Characteristics										Pavement Layer Characteristics								
Chainage	Condition	Layer 1		Layer 2		Layer 3		Layer 4		Layer 5		SF	BS		SB		SSG		SG
		Thk	Str	Thk	Str	Thk	Str	Thk	Str	Thk	Str	Thick	Thick	Str	Thick	Str	Thick	Str	Str
(km)		(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	(mm)	CBR	(mm)	CBR	(mm)	CBR	CBR
0.500 LHS	SURFACE DRESSING	20	77	146	127	78	224	176	95	500	13	18	165	148	275	173	410	83	15
2.500 RHS	SURFACE DRESSING	20	297	170	48	136	28	194	7	390	7	18	165	86	275	29	410	15	8
4.500 LHS	SURFACE DRESSING	20	65	102	156	158	44	236	14	418	6	18	165	127	275	39	410	23	7
6.500 RHS	SURFACE DRESSING	20	76	7	2204	151	87	139	19	578	8	18	165	180	275	37	410	9	9
8.500 LHS	SURFACE DRESSING	20	68	208	63	45	107	163	34	504	8	18	165	66	275	76	410	42	9
10.500 RHS	SURAFCE DRESSING	3	239	117	77	236	13	328	10	338	8	18	165	66	275	12	410	15	9
12.500 LHS	SURFACE DRESSING	20	59	27	170	122	27	181	60	672	9	18	165	56	275	68	410	30	10
14.500 RHS	SURFACE DRESSING	20	88	105	112	65	139	175	47	657	19	18	165	127	275	63	410	36	20
16.500 LHS	SURFACE DRESSING	20	77	105	170	340	43	219	14	338	14	18	165	138	275	45	410	42	17
18.500 RHS	SURFACE DRESSING	20	150	66	156	54	381	225	44	695	14	18	165	233	275	50	410	32	14
20.500 LHS	SURFACE DRESSING	20	67	87	75	83	38	207	21	625	7	18	165	66	275	24	410	21	8
22.500 RHS	SURFACE DRESSING	3	595	142	108	95	71	255	22	527	11	18	165	117	275	63	410	25	12
24.500 RHS	SURFACE DRESSING	20	109	209	179	127	26	132	6	454	29	18	165	190	275	104	410	23	26
26.500 LHS	SURFACE DRESSING	20	32	10	826	17	583	21	429	-6		18	165	254	275		410		
28.500 LHS	SURFACE DRESSING	20	85	90	75	299	54	119	31	494	7	18	165	66	275	50	410	68	11
30.500 RHS	SURFACE DRESSING	20	62	66	146	145	54	217	30	596	16	18	165	97	275	50	410	30	17
32.500 LHS	SURFACE DRESSING	20	32	86	299	250	62	328	48	338	56	18	165	190	275	76	410	40	55
34.500 RHS	SURFACE DRESSING	20	64	106	99	230	38	380	20	207	54	18	165	86	275	39	410	30	34
36.500 LHS	SURFACE DRESSING	20	32	11	354	9	536	55	127	5	2369	18	165	180	275		410		
38.500 RHS	SURFACE DRESSING	8	246	101	135	154	40	322	9	73	89	18	165	127	275	26	410	13	32
40.500 LHS	SURFACE DRESSING	3	650	133	109	84	30	222	17	580	9	18	165	117	275	24	410	15	9
42.500 RHS	SURFACE DRESSING	20	32	0		0		0		0		18	165	148	275		410		
44.500 RHS	SURFACE DRESSING	37	68	219	97	100	105	107	113	559	20	18	165	107	275	63	410	151	24
46.500 RHS	SURFACE DRESSING	20	32	13	401	97	166	244	45	648	19	18	165	159	275	50	410	30	19
47.500 LHS	SURFACE DRESSING	20	32	-2		0		12	399	-10		18	165	127	275		410		
ROAD 4		**20**	**43**	**114.9**	**140**	**144.9**	**85**	**221.5**	**34**	**480.7**	**21**	**18**	**165**	**122**	**275**	**55**	**410**	**37**	**18**

Road Maintenance and Rehabilitation Project

Dynamic Cone Penetrometer Test **Summary**

Road Name: Road Code: 5

Test Location and Pavement Assessment		Layer Characteristics										Pavement Layer Characteristics							
Chainage	Condition	Layer 1		Layer 2		Layer 3		Layer 4		Layer 5		SF	BS		SB		SSG		SG
		Thk	Str	Thk	Str	Thk	Str	Thk	Str	Thk	Str	Thick	Thick	Str	Thick	Str	Thick	Str	Str
(km)		(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	(mm)	CBR	(mm)	CBR	(mm)	CBR	CBR
0.500 LHS	SURFACE DRESSING	20	145	190	194	146	48	413	47	253	27	25	185	223	350	68	425	36	41
1.250 RHS	SURFACE DRESSING	20	32	146	199	190	81	256	47	423	7	25	185	193	350	76	425	55	20
3.250 LHS	SURFACE DRESSING	20	32	13	793	44	241	23	531	10	1463	25	185	292	350		425		
5.250 RHS	SURFACE DRESSING	20	32	4	1892	-6		0		6	1400	25	185	184	350		425		
7.250 LHS	0	20	76	180	166	156	42	328	37	354	46	25	185	174	350	59	425	28	45
9.250 RHS	SURFACE DRESSING	20	32	30	437	21	665	12	1098	0		25	185	332	350		425		
ROAD 5		**20**	**47**	**172**	**186**	**164**	**57**	**332.3**	**44**	**343.3**	**27**	**25**	**185**	**197**	**350**	**68**	**425**	**40**	**36**

Road Maintenance and Rehabilitation Project

Dynamic Cone Penetrometer Test **Summary**

Road Name: Kasungu to Dwangwa Road Code: 6

Test Location and Pavement Assessment		Layer Characteristics										Pavement Layer Characteristics								
Chainage	Condition	Layer 1		Layer 2		Layer 3		Layer 4		Layer 5		SF	BS		SB		SSG		SG
		Thk	Str	Thk	Str	Thk	Str	Thk	Str	Thk	Str	Thick	Thick	Str	Thick	Str	Thick	Str	Str
(km)		(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	(mm)	CBR	(mm)	CBR	(mm)	CBR	CBR
0.500 RHS	SURFACE DRESSING	20	32	48	157	104	113	92	60	643	12	20	175	130	325	36	460	15	12
2.500 LHS	SURFACE DRESSING	20	220	291	63	187	11	222	18	200	20	20	175	91	325	55	460	9	19
4.500 RHS	SURFACE DRESSING	20	154	215	59	198	79	251	57	209	144	20	175	82	325	57	460	88	96
6.500 LHS	SURFACE DRESSING	20	161	191	122	145	33	130	16	424	25	20	175	140	325	55	460	17	24
8.500 RHS	SURFACE DRESSING	20	85	110	217	66	77	320	21	388	21	20	175	190	325	23	460	19	23
10.500 LHS	SURFACE DRESSING	20	98	78	101	190	61	326	22	293	40	20	175	91	325	51	460	21	35
12.500 RHS	SURFACE DRESSING	20	184	260	276	202	96	65	11	222	132	20	175	323	325	186	460	106	108
14.500 LHS	SURFACE DRESSING	20	137	146	265	384	82	173	121	182	39	20	175	261	325	95	460	72	82
16.500 RHS	SURFACE DRESSING	20	32	193	221	143	54	253	73	293	68	20	175	230	325	85	460	72	70
18.300 LHS	SURFACE DRESSING	20	85	146	299	137	118	277	40	325	60	20	175	292	325	115	460	36	58
ROAD 6		**20**	**119**	**167.8**	**178**	**175.6**	**73**	**210.9**	**44**	**317.9**	**56**	**20**	**175**	**183**	**325**	**76**	**460**	**46**	**53**

Road Maintenance and Rehabilitation Project

Dynamic Cone Penetrometer Test **Summary**

Road Name: Madisi to Kasungu Road Code: 7

Test Location and Pavement Assessment			Layer Characteristics										Pavement Layer Characteristics							
Chainage		Condition	Layer 1		Layer 2		Layer 3		Layer 4		Layer 5		SF	BS		SB		SSG		SG
			Thk	Str	Thk	Str	Thk	Str	Thk	Str	Thk	Str	Thick	Thick	Str	Thick	Str	Thick	Str	Str
(km)			(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	(mm)	CBR	(mm)	CBR	(mm)	CBR	CBR
0.000	LHS	SURFACE DRESSING	20	170	240	115	203	54	235	91	198	105	25	205	128	325	82	525	77	91
2.000	LHS	SURFACE DRESSING	20	73	30	229	83	95	137	60	640	22	25	205	111	325	41	525	26	21
4.000	RHS	SURFACE DRESSING	20	67	420	57	85	26	115	62	264	17	25	205	70	325	50	525	45	29
6.000	RHS	SURFACE DRESSING	20	122	280	113	197	61	187	151	228	58	25	205	128	325	107	525	70	98
8.000	LHS	SURFACE DRESSING	20	88	146	105	190	60	181	38	376	14	25	205	111	325	45	525	41	18
10.000	RHS	SURFACE DRESSING	20	107	146	64	230	103	288	61	236	75	25	205	86	325	107	525	70	72
12.000	LHS	SURFACE DRESSING	20	119	193	105	143	47	498	17	50	43	25	205	111	325	58	525	28	19
14.000	RHS	SURFACE DRESSING	20	201	282	94	229	42	302	28	74	65	25	205	120	325	70	525	48	36
16.000	LHS	SURFACE DRESSING	20	85	146	99	190	45	453	10	80	16	25	205	95	325	45	525	22	9
18.000	RHS	SURFACE DRESSING	20	91	94	65	170	86	328	71	308	48	25	205	75	325	85	525	76	56
20.000	LHS	SURFACE DRESSING	20	70	214	74	154	26	296	13	238	6	25	205	78	325	45	525	17	9
22.000	RHS	SURFACE DRESSING	20	59	143	53	148	54	282	16	307	8	25	205	62	325	45	525	18	9
24.000	LHS	SURFACE DRESSING	20	32	131	183	152	75	257	49	89	297	25	205	154	325	70	525	55	235
26.000	RHS	SURFACE DRESSING	20	32	33	905	182	138	225	60	464	21	25	205	284	325	70	525	48	22
28.000	LHS	SURFACE DRESSING	20	71	240	97	96	65	328	30	223	15	25	205	103	325	82	525	38	22
30.000	RHS	SURFACE DRESSING	20	32	53	416	190	64	288	13	339	27	25	205	171	325	36	525	13	26
32.000	LHS	SURFACE DRESSING	20	74	210	67	195	39	180	34	302	30	25	205	78	325	34	525	39	33
34.000	RHS	SURFACE DRESSING	20	253	229	95	64	165	168	35	401	25	25	205	120	325	120	525	38	28
36.000	LHS	SURFACE DRESSING	20	32	131	93	205	31	364	82	178	41	25	205	78	325	34	525	76	60
38.000	RHS	SUTFACE DRESSING	20	32	91	317	245	104	200	73	344	67	25	205	223	325	95	525	62	74
40.000	LHS	SURFACE DRESSING	20	73	146	63	362	19	190	43	189	11	25	205	62	325	24	525	15	28
42.000	RHS	SURFACE DRESSING	20	67	208	101	128	48	178	30	364	27	25	205	103	325	70	525	32	29
44.000	LHS	SURFACE DRESSING	20	32	88	175	176	304	241	145	35	576	25	205	267	325	236	525	137	691
46.000	RHS	SURFACE DRESSING	20	73	128	106	122	49	414	23	205	29	25	205	95	325	34	525	28	26
48.000	LHS	SURFACE DRESSING	20	85	146	334	112	98	414	49	210	36	25	205	302	325	82	525	48	41
50.000	LHS	SURFACE DRESSING	20	134	249	134	111	81	208	38	308	15	25	205	154	325	107	525	48	20
52.000	LHS	SURFACE DRESSING	20	124	268	97	146	48	166	4	296	15	25	205	120	325	70	525	26	15
ROAD 7			**20**	**58**	**174**	**161**	**167**	**66**	**265**	**45**	**273**	**33**	**25**	**205**	**123**	**325**	**65**	**525**	**42**	**36**

Road Maintenance and Rehabilitation Project

Dynamic Cone Penetrometer Test **Summary**

Road Name: Lumbadzi to Mponela Road Code: 8

Test Location and Pavement Assessment		Layer Characteristics										Pavement Layer Characteristics							
Chainage	Condition	Layer 1		Layer 2		Layer 3		Layer 4		Layer 5		SF	BS		SB		SSG		SG
		Thk	Str	Thk	Str	Thk	Str	Thk	Str	Thk	Str	Thick	Thick	Str	Thick	Str	Thick	Str	Str
(km)		(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	(mm)	CBR	(mm)	CBR	(mm)	CBR	CBR
0.100 LHS	SURFACE DRESSING	20	32	0		4	5109	6	2475	3	7886	20	205	319	345		500		
2.100 RHS	SURFACE DRESSING	20	176	134	219	161	65	96	102	504	55	20	205	191	345	70	500	82	60
4.100 LHS	SURFACE DRESSING	20	76	146	94	101	65	115	40	528	15	20	205	92	345	49	500	29	15
6.100 RHS	SURFACE DRESSING	20	67	128	125	104	57	139	33	522	13	20	205	108	345	47	500	17	13
8.100 LHS	SURFACE DRESSING	20	80	208	151	178	34	249	17	57	94	20	205	149	345	70	500	15	46
10.100 RHS	SURFACE DRESSING	20	76	87	87	148	76	291	22	352	23	20	205	92	345	39	500	18	24
12.100 LHS	SURFACE DRESSING	20	55	226	70	30	67	184	34	460	11	20	205	76	345	49	500	31	10
14.100 RHS	SURFACE DRESSING	20	85	87	96	187	85	237	25	104	95	20	205	100	345	59	500	31	85
16.100 LHS	SURFACE DRESSING	20	32	286	148	354	45	106	96	152	34	20	205	166	345	91	500	53	55
18.100 RHS	SURFACE DRESSING	20	115	75	170	80	125	509	39	232	16	20	205	141	345	28	500	46	29
20.100 LHS	SURFACE DRESSING	20	76	315	60	300	29	80	16	195	17	20	205	68	345	53	500	37	20
22.100 RHS	SURFACE DRESSING	20	110	13	416	243	89	326	43	305	35	20	205	124	345	70	500	38	37
24.100 LHS	SURFACE DRESSING	20	77	244	47	316	15	173	19	151	30	20	205	54	345	26	500	15	24
26.100 RHS	SURFACE DRESSING	20	73	152	75	196	63	204	30	338	19	20	205	76	345	70	500	31	23
28.100 LHS	SURFACE DRESSING	6	302	184	65	133	80	160	42	433	21	20	205	84	345	59	500	46	23
30.100 RHS	SURAFCE DRESSING	20	67	276	78	86	33	172	12	350	17	20	205	84	345	66	500	13	17
32.100 LHS	SURFACE DRESSING	20	97	285	166	204	60	175	29	89	96	20	205	174	345	145	500	55	53
34.100 RHS	SURFACE DRESSING	20	95	249	115	196	64	215	34	220	41	20	205	124	345	91	500	53	36
35.600 LHS	SURFACE DRESSING	20	156	146	67	248	54	226	70	267	19	20	205	76	345	57	500	70	35
ROAD 8		**20**	**63**	**180.1**	**125**	**168.5**	**61**	**217.4**	**32**	**315**	**27**	**20**	**205**	**96**	**345**	**55**	**500**	**33**	**25**

Road Maintenance and Rehabilitation Project

Dynamic Cone Penetrometer Test **Summary**

Road Name: Bunda Turn off to Chimbiya Road Code: 9

Test Location and Pavement Assessment		Layer Characteristics										Pavement Layer Characteristics							
Chainage	Condition	Layer 1		Layer 2		Layer 3		Layer 4		Layer 5		SF	BS		SB		SSG		SG
		Thk	Str	Thk	Str	Thk	Str	Thk	Str	Thk	Str	Thick	Thick	Str	Thick	Str	Thick	Str	Str
(km)		(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	(mm)	CBR	(mm)	CBR	(mm)	CBR	CBR
0.000 RHS	SURFACE DRESSING	20	32	146	49	190	15	328	5	338	4	20	210	1	345		500		0
2.000 RHS	SURFACE DRESSING	20	32	104	307	98	244	121	43	679	18	20	210	277	345	51	500	29	18
4.000 LHS	SURFACE DRESSING	20	115	116	138	220	30	328	18	348	17	20	210	105	345	30	500	17	19
6.000 RHS	SURFACE DRESSING	20	127	27	523	89	104	181	30	705	16	20	210	145	345	19	500	20	17
8.000 LHS	SURFACE DRESSING	20	106	105	227	75	72	73	25	756	18	20	210	161	345	30	500	15	19
10.000 RHS	SURFACE DRESSING	20	725	182	93	266	14	83	50	489	14	20	210	153	345	19	500	18	19
12.000 LHS	SURFACE DRESSING	20	32	-5		-3		6	1090	0		20	210	121	345		500		
14.000 RHS	SURFACE DRESSING	20	98	7	1800	20	503	13	811	20	618	20	210	235	345		500		
16.000 LHS	SURFACE DRESSING	20	32	-5		3	2469	9	1036	13	759	20	210	169	345		500		
18.000 RHS	SURAFCE DRESSING	20	32	7	1204	6	1784	20	400	9	1208	20	210	186	345		500		
20.000 LHS	SURFACE DRESSING	20	85	116	265	144	47	224	13	536	21	20	210	186	345	30	500	13	22
22.000 RHS	SURFACE DRESSING	9	75	-6		9	691	0		-3		20	210	113	345		500		
24.000 LHS	SURAFCE DRESSING	20	127	20	470	28	337	12	787	15	516	20	210	194	345		500		
26.000 RHS	SURFACE DRESSING	20	32	-2		26	232	16	392	11	1070	20	210	161	345		500		
28.000 LHS	SURAFCE DRESSING	20	32	-8		3	2350	3	2089	2	4433	20	210	129	345		500		
30.000 RHS	SURFACE DRESSING	20	80	97	417	81	52	374	37	225	26	20	210	244	345	32	500	35	30
32.000 LHS	SURFACE DRESSING	20	110	78	330	258	41	403	39	19	531	20	210	169	345	32	500	53	71
34.000 RHS	SURFACE DRESSING	20	32	-3		19	388	12	990	0		20	210	202	345		500		
36.000 LHS	SURFACE DRESSING	20	402	89	196	123	118	224	43	574	26	20	210	194	345	51	500	44	25
38.000 RHS	SURFACE DRESSING	20	145	128	280	20	521	341	26	524	18	20	210	260	345	30	500	17	20
40.000 LHS	SURFACE DRESSING	20	32	0		22	260	5	1060	9	1242	20	210	129	345		500		
42.000 RHS	SURFACE DRESSING	20	595	187	168	269	73	161	29	392	55	20	210	227	345	72	500	53	51
44.000 LHS	SURFACE DRESSING	20	58	-5		15	666	0		14	817	20	210	210	345		500		
46.000 RHS	SURFACE DRESSING	20	32	11	2342	179	340	359	39	111	108	20	210	446	345	40	500	40	90
48.000 LHS	SURFACE DRESSING	20	32	0		22	519	8	2007	12	1115	20	210	252	345		500		
50.000 LHS	SURFACE DRESSING	20	109	20	437	43	389	62	330	28	520	20	210	327	345		500		
52.000 LHS	SURFACE DRESSING	11	193	98	340	378	33	148	40	412	22	20	210	202	345	28	500	31	27
54.000 RHS	SURFACE DRESSING	20	32	0		0		2	5323	-5		20	210	161	345		500		
56.000 LHS	SURAFCE DRESSING	20	32	0		2	3425	-2		2	3425	20	210	121	345		500		
58.000 RHS	SURFACE DRESSING	20	32	0		7	868	0		-7		20	210	129	345		500		
ROAD 9.1		**20**	**32**	**122.3**	**231**	**192.3**	**137**	**237.7**	**28**	**464.3**	**26**	**20**	**210**	**193**	**345**	**37**	**500**	**24**	**22**

Road Maintenance and Rehabilitation Project

Dynamic Cone Penetrometer Test **Summary**

Road Name: Dedza to Biriwiri Road Code: 10

Test Location and Pavement Assessment		Layer Characteristics										Pavement Layer Characteristics							
Chainage	Condition	Layer 1		Layer 2		Layer 3		Layer 4		Layer 5		SF	BS		SB		SSG		SG
		Thk	Str	Thk	Str	Thk	Str	Thk	Str	Thk	Str	Thick	Thick	Str	Thick	Str	Thick	Str	Str
(km)		(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	(mm)	CBR	(mm)	CBR	(mm)	CBR	CBR
0.100 LHS	SURFACE DRESSING	20	184	170	90	62	199	308	40	490	17	20	150	110	250	145	360	63	24
2.100 RHS	SURFACE DRESSING	20	207	146	79	157	64	264	17	463	12	20	150	110	250	70	360	37	15
4.100 LHS	SURFACE DRESSING	20	32	51	402	21	807	6	762	6	2054	20	150	413	250		360		
6.100 RHS	SURFACE DRESSING	20	299	146	144	110	63	258	23	169	25	20	150	193	250	70	360	24	36
8.100 LHS	SURFACE DRESSING	20	32	22	583	18	504	11	692	12	598	20	150	277	250		360		
10.100 RHS	SURFACE DRESSING	20	223	113	246	99	82	411	26	379	35	20	150	265	250	55	360	37	32
12.100 LHS	SURFACE DRESSING	20	110	120	188	216	48	328	16	338	13	20	150	193	250	41	360	50	15
14.100 RHS	SURFACE DRESSING	20	526	120	160	216	31	400	23	266	10	20	150	229	250	26	360	34	17
16.100 LHS	SURFACE DRESSING	20	170	146	201	50	487	468	22	338	17	20	150	241	250	270	360	24	17
18.100 RHS	SURFACE DRESSING	20	32	8	1045	12	900	87	211	46	542	20	150	376	250	130	360		
20.100 LHS	SURFACE DRESSING	20	32	16	502	8	419	18	505	6	1290	20	150	229	250		360		
22.100 RHS	SURFACE DRESSING	20	32	30	554	27	534	15	888	6	695	20	150	364	250		360		
24.100 LHS	SURFACE DRESSING	20	145	122	314	105	238	216	28	559	8	20	150	339	250	207	360	37	13
26.100 RHS	SURFACE DRESSING	20	257	149	220	187	41	406	12	260	15	20	150	241	250	100	360	24	16
28.100 LHS	SURFACE DRESSING	20	32	57	461	213	142	394	5	338	12	20	150	290	250	130	360	50	11
30.100 RHS	SURFACE DRESSING	20	32	16	502	12	273	16	439	9	1423	20	150	241	250		360		
32.100 LHS	SURFACE DRESSING	20	750	109	232	184	20	325	38	384	17	20	150	302	250	26	360	37	26
34.100 RHS	SURFACE DRESSING	20	657	146	281	374	7	384	12	98	46	20	150	351	250	85	360	7	15
36.100 LHS	SURFACE DRESSING	20	579	162	144	266	26	227	14	347	17	20	150	241	250	55	360	19	18
38.100 RHS	SURFACE DRESSING	20	910	184	284	504	27	268	43	46	233	20	150	464	250	100	360	24	50
40.100 LHS	SURFACE DRESSING	20	32	16	502	44	146	42	169	23	881	20	150	327	250		360		
42.100 RHS	SURFACE DRESSING	20	32	22	359	11	299	39	327	18	844	20	150	302	250		360		
44.100 LHS	SURFACE DRESSING	20	32	10	826	10	331	10	572	18	549	20	150	205	250		360		
46.100 RHS	SURFACE DRESSING	20	32	30	259	18	178	6	329	12	153	20	150	193	250		360		
48.100 LHS	SURFACE DRESSING	20	32	33	234	24	131	21	383	24	770	20	150	290	250		360		
50.100 RHS	SURFACE DRESSING	20	32	16	502	14	700	42	298	28	775	20	150	413	250		360		
52.100 LHS	SURFACE DRESSING	20	32	14	579	26	422	10	615	25	651	20	150	314	250		360		
54.100 RHS	SURFACE DRESSING	20	32	28	278	12	273	4	1170	6	1417	20	150	193	250		360		
56.100 LHS	SURFACE DRESSING	20	32	16	502	8	838	6	1233	39	364	20	150	277	250		360		
58.100 RHS	SURFACE DRESSING	20	32	20	397	10	331	10	602	11	643	20	150	181	250		360		
60.100 LHS	SURFACE DRESSING	20	32	40	191	8	419	6	1158	12	762	20	150	205	250		360		
62.100 RHS	SURFACE DRESSING	20	32	11	747	29	354	42	575	43	541	20	150	539	250		360		
64.100 LHS	SURFACE DRESSING	20	32	22	359	8	419	12	158	9	207	20	150	207	250		360		
ROAD 10		**20**	**32**	**124.4**	**219**	**157.2**	**139**	**355.9**	**20**	**330.7**	**19**	**20**	**150**	**269**	**250**	**100**	**360**	**32**	**18**

Road Maintenance and Rehabilitation Project

Dynamic Cone Penetrometer Test **Summary**

Road Name: Salima to Senga Bay Road Code: 11

Test Location and Pavement Assessment		Layer Characteristics										Pavement Layer Characteristics							
Chainage	Condition	Layer 1		Layer 2		Layer 3		Layer 4		Layer 5		SF	BS		SB		SSG		SG
		Thk	Str	Thk	Str	Thk	Str	Thk	Str	Thk	Str	Thick	Thick	Str	Thick	Str	Thick	Str	Str
(km)		(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	(mm)	CBR	(mm)	CBR	(mm)	CBR	CBR
0.000 LHS	SURFACE DRESSING	20	1033	134	273	56	277	108	86	624	23	20	210	378	345	72	500	31	21
2.000 LHS	SURFACE DRESSING	20	73	146	69	190	33	328	16	338	6	20	210	66	345	30	500	17	11
4.000 RHS	SURFACE DRESSING	20	130	146	113	466	19	71	51	337	24	20	210	97	345	30	500	13	28
6.000 LHS	SURFACE DRESSING	20	76	105	89	246	29	240	10	436	33	20	210	74	345	19	500	13	30
8.000 RHS	SURFACE DRESSING	20	67	110	82	285	16	269	11	356	11	20	210	58	345	19	500	15	11
10.000 LHS	SURFACE DRESSING	20	106	385	85	195	62	172	34	268	25	20	210	97	345	72	500	82	35
12.000 RHS	SURFACE DRESSING	20	103	252	134	133	113	126	48	513	12	20	210	145	345	128	500	72	13
14.000 LHS	SURFACE DRESSING	20	106	146	93	217	71	337	67	302	17	20	210	97	345	72	500	72	37
16.000 RHS	SURFACE DRESSING	20	55	214	41	202	112	228	29	383	28	20	210	43	345	106	500	72	29
18.000 LHS	SURFACE DRESSING	20	67	330	40	133	80	463	21	101	41	20	210	43	345	51	500	63	26
20.000 RHS	SURFACE DRESSING	20	32	146	165	190	180	304	55	69	504	20	210	169	345	174	500	72	193
22.000 LHS	SURFACE DRESSING	20	32	-5		59	207	59	203	3	3443	20	210	219	345		500		
ROAD 11		**20**	**58**	**192.2**	**108**	**212.3**	**81**	**234.2**	**37**	**365.8**	**22**	**20**	**210**	**110**	**345**	**60**	**500**	**45**	**24**

Road Maintenance and Rehabilitation Project

Dynamic Cone Penetrometer Test **Summary**

Road Name: Benga to Nkhotakota Road Code: 12.1

Test Location and Pavement Assessment		Layer Characteristics										Pavement Layer Characteristics							
Chainage	Condition	Layer 1		Layer 2		Layer 3		Layer 4		Layer 5		SF	BS		SB		SSG		SG
		Thk	Str	Thk	Str	Thk	Str	Thk	Str	Thk	Str	Thick	Thick	Str	Thick	Str	Thick	Str	Str
(km)		(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	(mm)	CBR	(mm)	CBR	(mm)	CBR	CBR
0.200 LHS	SURFACE DRESSING	20	67	-2		71	95	91	164	4	2095	20	210	178	345		500		
2.200 RHS	SURFACE DRESSING	20	32	16	439	62	86	56	303	12	1072	20	210	219	345		500		
4.200 LHS	SURFACE DRESSING	20	32	10	826	83	95	53	185	3	3516	20	210	186	345		500		
6.200 RHS	SURFACE DRESSING	20	32	4	956	36	205	-4		4	2086	20	210	129	345		500		
8.200 LHS	SURFACE DRESSING	20	62	90	148	181	62	91	27	656	6	20	210	105	345	51	500	13	5
10.200 RHS	SURFACE DRESSING	20	32	-5		5	755	0		0		20	210	81	345		500		
12.200 LHS	SURFACE DRESSING	20	32	-2		24	330	32	239	-3		20	210	178	345		500		
14.400 RHS	SURFACE DRESSING	6	115	0		21	371	44	234	6	1966	20	210	178	345		500		
16.200 LHS	SURFACE DRESSING	3	239	12	337	18	400	41	187	0		20	210	137	345		500		
18.200 RHS	SURFACE DRESSING	20	94	146	176	190	67	195	23	493	5	20	210	161	345	62	500	27	8
20.200 LHS	SURFACE DRESSING	12	55	-3		47	195	48	150	0		20	210	178	345		500		
22.200 RHS	SURFACE DRESSING	20	76	57	115	27	413	62	165	0		20	210	194	345		500		
24.200 LHS	SURFACE DRESSING	20	32	5	2505	204	124	291	51	512	14	20	210	178	345	72	500	44	17
26.200 RHS	SURFACE DRESSING	0		180	131	404	15	220	37	231	12	20	210	129	345	25	500	10	23
28.200 LHS	SURFACE DRESSING	20	32	10	386	3	1667	0		-3		20	210	97	345		500		
30.200 RHS	SURFACE DRESSING	20	32	-5		27	212	2	2630	-8		20	210	105	345		500		
32.200 LHS	SURFACE DRESSING	20	32	-9		20	299	-3		6	1095	20	210	105	345		500		
34.200 RHS	SURFACE DRESSING	20	32	2	2148	6	784	-3		6	807	20	210	97	345		500		
36.200 LHS	SURFACE DRESSING	0		36	150	44	128	18	267	-6		20	210	129	345		500		
38.200 RHS	SURFACE DRESSING	20	95	198	179	138	50	328	30	338	16	20	210	186	345	51	500	44	20
40.200 LHS	SURFACE DRESSING	20	32	-8		41	169	39	199	8	986	20	210	137	345		500		
42.200 RHS	SURFACE DRESSING	20	32	0		-8		3	1078	5	965	20	210	81	345		500		
44.200 LHS	SURAFCE DRESSING	20	32	-2		18	249	0		4	1187	20	210	97	345		500		
46.200 RHS	SURFACE DRESSING	20	104	146	168	190	149	92	236	574	27	20	210	178	345	162	500	140	25
48.200 LHS	SURFACE DRESSING	20	73	24	290	54	204	53	221	-3		20	210	210	345		500		
50.200 RHS	SURFACE DRESSING	6	355	226	99	176	91	185	63	429	32	20	210	113	345	83	500	91	35
52.200 LHS	SURFACE DRESSING	20	32	2	3189	244	106	182	236	588	86	20	210	129	345	174	500	190	85
54.200 RHS	SURFACE DRESSING	20	68	20	472	162	113	378	9	453	7	20	210	145	345	19	500	8	7
56.200 LHS	SURFACE DRESSING	20	32	16	237	26	224	33	44	3	3468	20	210	105	345		500		
58.200 RHS	SURFACE DRESSING	20	124	277	144	207	38	151	78	392	51	20	210	161	345	95	500	44	57
60.200 RHS	SURFACE DRESSING	6	115	12	447	18	327	24	260	2	5286	20	210	137	345		500		
62.200 RHS	SURFACE DRESSING	6	275	47	141	54	223	26	544	21	608	20	210	244	345		500		
ROAD 12.1		**20**	**32**	**135**	**141**	**217**	**83**	**218.5**	**73**	**429.5**	**18**	**20**	**210**	**157**	**345**	**76**	**500**	**59**	**21**

Road Maintenance and Rehabilitation Project

Dynamic Cone Penetrometer Test **Summary**

Road Name: Nkhotakota to Dwangwa Road Code: 12.2

Test Location and Pavement Assessment		Layer Characteristics										Pavement Layer Characteristics							
Chainage	Condition	Layer 1		Layer 2		Layer 3		Layer 4		Layer 5		SF	BS		SB		SSG		SG
		Thk	Str	Thk	Str	Thk	Str	Thk	Str	Thk	Str	Thick	Thick	Str	Thick	Str	Thick	Str	Str
(km)		(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	(mm)	CBR	(mm)	CBR	(mm)	CBR	CBR
0.200 LHS	SURFACE DRESSING	20	32	-5		3	1690	0		2	3353	25	145	158	300		425		
2.200 RHS	SURFACE DRESSING	20	32	-8		24	252	-6		10	477	25	145	171	300		425		
4.200 LHS	SURFACE DRESSING	20	32	10	826	50	120	33	323	-3		25	145	275	300		425		
6.200 RHS	SURFACE DRESSING	20	32	-2		0		6	684	3	1296	25	145	132	300		425		
8.200 LHS	SURFACE DRESSING	20	420	113	81	120	140	431	62	351	23	25	145	171	300	101	425	55	43
10.200 RHS	SURFACE DRESSING	20	32	7	1268	121	94	45	168	-6		25	145	315	300		425		
12.200 LHS	SURAFCE DRESSING	20	32	-2		18	251	17	357	3	2876	25	145	184	300		425		
14.200 RHS	SURFACE DRESSING	20	32	-14		18	338	0		3	1667	25	145	158	300		425		
16.200 LHS	SURFACE DRESSING	20	32	0		27	369	33	361	0		25	145	329	300		425		
18.200 RHS	SURFACE DRESSING	20	32	0		13	580	20	310	-3		25	145	236	300		425		
20.200 LHS	SURFACE DRESSING	20	32	-5		0		9	721	-6		25	145	236	300		425		
22.200 RHS	SURFACE DRESSING	20	32	10	549	38	147	0		3	3541	25	145	236	300		425		
24.200 LHS	SURFACE DRESSING	20	410	146	213	194	56	484	26	188	9	25	145	289	300	72	425	46	22
26.200 RHS	SURFACE DRESSING	20	112	48	339	169	50	199	22	244	72	25	145	184	300	35	425	25	76
28.200 LHS	SURFACE DRESSING	20	32	-8		12	798	6	1330	-3		25	145	249	300		425		
30.200 RHS	SURFACE DRESSING	20	188	93	165	103	28	252	27	554	27	25	145	158	300	33	425	25	27
32.200 LHS	SURFACE DRESSING	20	131	146	231	83	35	351	12	422	21	25	145	262	300	44	425	17	20
34.200 RHS	SURFACE DRESSING	20	103	30	208	48	162	6	1365	8	1655	25	145	302	300		425		
36.200 LHS	SURFACE DRESSING	20	218	80	219	85	66	271	10	566	9	25	145	197	300	31	425	10	9
38.200 RHS	SURFACE DRESSING	20	437	156	96	191	102	317	53	338	31	25	145	158	300	111	425	79	40
40.200 LHS	SURFACE DRESSING	20	64	20	229	28	203	3	2350	3	2255	25	145	197	300		425		
42.200 RHS	SURFACE DRESSING	20	246	173	74	121	46	510	17	198	4	25	145	120	300	44	425	28	14
44.200 LHS	SURFACE DRESING	20	257	152	60	377	40	358	19	125	40	25	145	95	300	53	425	44	26
46.200 RHS	SURFACE DRESSING	20	32	16	502	56	221	33	469	5	1986	25	145	382	300		425		
48.200 LHS	SURFACE DRESSING	20	59	24	302	18	178	36	169	18	702	25	145	249	300		425		
50.200 RHS	SURFACE DRESSING	20	181	172	189	136	54	367	12	345	28	25	145	210	300	101	425	21	22
52.200 LHS	SURFACE DRESSING	-6		23	342	28	291	42	172	3	2828	25	145	262	300		425		
54.200 RHS	SURFACE DRESSING	20	125	249	139	87	57	328	35	338	12	25	145	158	300	121	425	55	22
ROAD 12.2		**20**	**261**	**148**	**147**	**149.7**	**62**	**366.9**	**27**	**342.5**	**20**	**25**	**145**	**182**	**300**	**71**	**425**	**38**	**24**

Road Maintenance and Rehabilitation Project

Dynamic Cone Penetrometer Test **Summary**

Road Name: Chingeni to Liwonde Road Code: 13.1

Test Location and Pavement Assessment		Layer Characteristics										Pavement Layer Characteristics							
Chainage	Condition	Layer 1		Layer 2		Layer 3		Layer 4		Layer 5		SF	BS		SB		SSG		SG
		Thk	Str	Thk	Str	Thk	Str	Thk	Str	Thk	Str	Thick	Thick	Str	Thick	Str	Thick	Str	Str
(km)		(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	(mm)	CBR	(mm)	CBR	(mm)	CBR	CBR
0.100 LHS	SURFACE DRESSING	20	32	-8		8	753	-8		3	2255	25	150	201	295		520		
2.100 RHS	SURFACE DRESSING	20	270	184	148	152	139	164	72	324	181	25	150	201	295	150	520	95	182
4.100 LHS	SURFACE DRESSING	20	112	96	140	240	70	210	35	456	11	25	150	139	295	77	520	42	14
6.100 RHS	SURFACE DRESSING	36	211	222	73	267	38	175	26	322	25	25	150	127	295	67	520	30	28
8.100 LHS	SURFACE DRESSING	20	32	0		13	449	7	1204	0		25	150	213	295		520		
10.100 RHS	SURFACE DRESSING	20	795	147	134	318	35	235	51	302	26	25	150	251	295	57	520	36	37
12.100 LHS	GRAVEL	20	67	191	76	145	38	293	35	373	21	25	150	91	295	47	520	40	25
14.100 RHS	GRAVEL	20	88	105	252	91	79	155	23	649	14	25	150	239	295	47	520	21	14
16.100 LHS	GRAVEL	20	32	104	160	176	107	355	54	367	15	25	150	164	295	108	520	51	26
18.100 RHS	SURFACE DRESSING	20	32	73	233	107	158	149	160	3	6046	25	150	201	295	172	520	101	
20.100 LHS	SURFACE DRESSING	20	121	332	137	168	84	277	49	225	12	25	150	151	295	161	520	81	35
22.100 RHS	SURFACE DRESSING	20	176	107	100	136	139	421	50	338	38	25	150	139	295	119	520	49	44
24.100 LHS	SURFACE DRESSING	20	71	252	75	102	188	352	32	296	38	25	150	91	295	98	520	79	36
26.100 RHS	SURFACE DRESSING	20	32	16	302	24	260	20	473	0		25	150	251	295		520		
28.100 LHS	SURFACE DRESSING	20	431	236	127	180	119	250	100	336	38	25	150	201	295	108	520	121	59
30.100 RHS	SURFACE DRESSING	20	145	45	142	179	69	374	69	37	650	25	150	103	295	77	520	75	229
32.100 LHS	GRAVEL	20	88	30	350	23	506	25	517	11	1658	25	150	431	295		520		
34.100 RHS	GRAVEL	20	97	146	114	139	69	146	100	571	45	25	150	139	295	67	520	81	45
ROAD 13.1		**20**	**45**	**157.4**	**132**	**185.4**	**77**	**242.9**	**39**	**384.9**	**18**	**25**	**150**	**166**	**295**	**81**	**520**	**43**	**25**

Road Maintenance and Rehabilitation Project

Dynamic Cone Penetrometer Test **Summary**

Road Name: Liwonde to Zomba Road Code: 13.2

Test Location and Pavement Assessment		Layer Characteristics										Pavement Layer Characteristics							
Chainage	Condition	Layer 1		Layer 2		Layer 3		Layer 4		Layer 5		SF	BS		SB		SSG		SG
		Thk	Str	Thk	Str	Thk	Str	Thk	Str	Thk	Str	Thick	Thick	Str	Thick	Str	Thick	Str	Str
(km)		(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	(mm)	CBR	(mm)	CBR	(mm)	CBR	CBR
0.100 RHS	SURFACE DRESSING	20	1474	120	232	231	61	409	20	252	21	25	175	377	295	70	500	41	19
2.100 LHS	SURFACE DRESSING	20	302	144	155	142	129	222	61	494	21	25	175	197	295	107	500	75	25
4.100 RHS	SURFACE DRESSING	20	32	0		4	2550	3	2984	-3		25	175	218	295		500		
6.100 LHS	SURFACE DRESSING	20	67	146	77	128	26	160	64	593	27	25	175	75	295	34	500	59	29
8.100 RHS	SURFACE DRESSING	20	32	-2		2	3298	7	1081	3	2529	25	175	166	295		500		
10.100 LHS	SURFACE DRESSING	20	176	267	139	300	59	213	24	232	74	25	175	145	295	158	500	61	51
12.100 RHS	SURFACE DRESSING	20	207	295	91	213	133	350	65	144	43	25	175	135	295	70	500	134	62
14.100 LHS	SURFACE DRESSING	20	32	-8		12	289	0		-4		25	175	105	295		500		
16.100 RHS	SURFACE DRESSING	3	239	97	249	138	144	139	75	-3		25	175	228	295	132	500	61	
18.100 LHS	SURFACE DRESSING	20	104	338	110	173	12	347	123	162	42	25	175	135	295	107	500	33	95
20.100 RHS	SURFACE DRESSING	20	32	146	264	118	202	285	92	453	44	25	175	270	295	184	500	97	50
22.100 LHS	SURFACE DRESSING	20	32	0		36	155	18	275	0		25	175	155	295		500		
24.100 RHS	SURFACE DRESSING	20	145	190	182	300	38	68	72	466	22	25	175	218	295	70	500	34	30
26.100 LHS	SURFACE DRESSING	20	103	26	588	74	192	72	279	18	887	25	175	313	295	158	500		
28.100 RHS	SURFACE DRESSING	20	112	110	166	146	75	231	50	515	10	25	175	155	295	70	500	54	11
30.100 LHS	SURFACE DRESSING	20	32	-5		12	526	23	330	0		25	175	166	295		500		
32.100 RHS	SURFACE DRESSING	20	32	42	295	56	79	14	534	2	6541	25	175	239	295		500		
34.100 LHS	SURFACE DRESSING	20	32	8	695	32	176	102	83	-2		25	175	197	295		500		
36.100 RHS	SURFACE DRESSING	20	32	11	1123	31	138	25	298	-7		25	175	218	295		500		
38.100 LHS	SURFACE DRESSING	20	32	-6		6	1359	16	380	6	1365	25	175	176	295		500		
40.100 RHS	SURFACE DRESSING	31	81	31	533	235	160	398	17	327	22	25	175	260	295	132	500	19	22
42.100 LHS	SURFACE DRESSING	20	32	20	397	40	316	74	115	3	4114	25	175	270	295		500		
44.100 RHS	SURFACE DRESSING	20	32	13	491	29	203	86	123	3	4151	25	175	228	295		500		
46.100 LHS	SURFACE DRESSING	20	115	317	120	232	30	64	172	389	32	25	175	145	295	95	500	54	50
48.100 RHS	SURFACE DRESSING	20	32	-8		21	215	-6		3	2780	25	175	135	295		500		
50.100 RHS	SURFACE DRESSING	20	32	7	1067	17	533	16	513	11	992	25	175	228	295		500		
52.100 LHS	SURFACE DRESSING	20	780	274	190	255	99	140	84	333	58	25	175	302	295	171	500	97	72
54.100 RHS	SURFACE DRESSING	20	32	-14		11	357	-3		-6		25	175	115	295		500		
56.100 LHS	SURFACE DRESSING	20	32	-3		-3		3	2291	5	1536	25	175	145	295		500		
ROAD 13.2		**20**	**38**	**190.5**	**183**	**199.3**	**91**	**248**	**47**	**441.2**	**21**	**25**	**175**	**213**	**295**	**80**	**500**	**47**	**23**

Road Maintenance and Rehabilitation Project

Dynamic Cone Penetrometer Test **Summary**

Road Name: Liwonde to Mangochi Road Code: 14.1 Routine

Test Location and Pavement Assessment		Layer Characteristics										Pavement Layer Characteristics							
Chainage	Condition	Layer 1		Layer 2		Layer 3		Layer 4		Layer 5		SF	BS		SB		SSG		SG
		Thk	Str	Thk	Str	Thk	Str	Thk	Str	Thk	Str	Thick	Thick	Str	Thick	Str	Thick	Str	Str
(km)		(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	(mm)	CBR	(mm)	CBR	(mm)	CBR	CBR
0.000 RHS	SURFACE DRESSING	20	107	134	64	110	59	184	40	574	14	15	145	75	300	53	410	37	18
2.000 RHS	SURFACE DRESSING	20	210	193	24	164	22	243	20	402	17	15	145	53	300	17	410	26	18
4.000 LHS	SURFACE DRESSING	20	101	88	301	50	417	37	700	12	1842	15	145	327	300	333	410		
6.000 RHS	SURFACE DRESSING	20	32	10	826	10	1005	22	419	-2		15	145	314	300		410		
8.000 LHS	SURFACE DRESSING	20	32	-2		0		9	1109	3	2840	15	145	217	300		410		
10.000 RHS	SURFACE DRESSING	20	32	-2		50	445	32	520	10	1376	15	145	464	300		410		
12.000 LHS	SURFACE DRESSING	20	85	40	393	23	503	33	327	4	3863	15	145	413	300		410		
14.000 RHS	SURFACE DRESSING	20	32	-5		0		0		0		15	145	169	300		410		
16.000 LHS	SURFACE DRESSING	20	131	69	434	267	27	328	28	354	17	15	145	253	300	31	410	21	24
18.000 RHS	SURFACE DRESSING	20	145	146	430	350	87	247	33	259	10	15	145	451	300	130	410	76	31
20.000 LHS	SURFACE DRESSING	20	107	146	270	190	53	475	39	201	11	15	145	277	300	72	410	63	28
22.000 RHS	SURFACE DRESSING	20	85	22	306	88	253	57	195	6	3401	15	145	265	300	160	410		
24.000 RHS	SURFACE DRESSING	20	115	180	243	156	132	497	29	169	7	15	145	265	300	160	410	76	23
26.000 RHS	SURFACE DRESSING	20	85	146	345	190	63	328	25	338	13	15	145	364	300	82	410	37	20
28.000 LHS	SURFACE DRESSING	20	32	-5		25	237	20	223	-7		15	145	193	300		410		
30.000 RHS	SURFACE DRESSING	20	32	-2		2	3280	-2		12	318	15	145	145	300		410		
32.000 LHS	SURFACE DRESSING	20	61	-3		25	236	6	1090	5	2021	15	145	253	300		410		
34.000 RHS	SURFACE DRESSING	20	32	-6		28	262	0		3	2291	15	145	193	300		410		
36.000 LHS	SURFACE DRESSING	20	32	-6		6	1084	2	3516	3	2196	15	145	181	300		410		
38.000 RHS	SURFACE DRESSING	20	89	103	232	59	59	616	9	238	16	15	145	205	300	17	410	19	11
40.000 LHS	SURFACE DRESSING	20	85	120	190	88	61	614	22	80	100	15	145	193	300	44	410	19	34
42.000 RHS	SURFACE DRESSING	20	73	-2		82	211	30	320	0		15	145	351	300		410		
44.000 LHS	SURFACE DRESSING	20	79	134	278	148	18	458	19	262	8	15	145	277	300	35	410	7	16
46.000 RHS	SURFACE DRESSING	20	62	-2		122	173	254	56	628	13	15	145	217	300	63	410	37	14
48.000 LHS	SURFACE DRESSING	6	409	114	375	572	68	182	27	148	64	15	145	351	300	72	410	76	54
50.000 RHS	SURFACE DRESSING	20	32	7	1204	9	370	53	256	0		15	145	277	300		410		
52.000 LHS	SURFACE DRESSINNG	20	207	146	184	190	109	244	52	422	106	15	145	205	300	130	410	63	90
54.000 RHS	SURFACE DRESSING	20	64	5	1564	17	189	38	415	-2		15	145	327	300		410		
56.000 LHS	SURFACE DRESSING	20	32	8	500	70	97	28	276	3	4041	15	145	229	300		410		
58.000 RHS	SURFACE DRESSING	20	32	-8		30	237	32	145	-6		15	145	205	300		410		
ROAD 14.1a		**20**	**37**	**133**	**224**	**189**	**72**	**385.8**	**29**	**318.6**	**20**	**15**	**145**	**239**	**300**	**64**	**410**	**38**	**22**

Road Maintenance and Rehabilitation Project

Dynamic Cone Penetrometer Test **Summary**

Road Name: Road Code:

Test Location and Pavement Assessment		Layer Characteristics										Pavement Layer Characteristics							
Chainage	Condition	Layer 1		Layer 2		Layer 3		Layer 4		Layer 5		SF	BS		SB		SSG		SG
		Thk	Str	Thk	Str	Thk	Str	Thk	Str	Thk	Str	Thick	Thick	Str	Thick	Str	Thick	Str	Str
(km)		(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	(mm)	CBR	(mm)	CBR	(mm)	CBR	CBR
60.000 LHS	SURFACE DRESSING	20	62	22	328	29	269	18	513	6	2332	20	145	302	300		410		
62.000 RHS	SURFACE DRESSING	20	32	10	556	41	134	39	399	0		20	145	315	300		410		
64.000 RHS	SURFACE DRESSING	20	95	165	142	455	53	244	68	156	15	20	145	164	300	72	410	50	44
66.000 RHS	SURFACE DRESSING	20	32	10	826	14	473	12	535	0		20	145	251	300		410		
68.000 LHS	SURFACE DRESSING	20	32	-8		21	269	23	411	0		20	145	251	300		410		
70.000 LHS	SURFACE DERSSING	20	115	104	109	92	204	50	437	80	372	20	145	139	300	302	410	173	
ROAD 14.1b		**20**	**32**	**134.5**	**125**	**248**	**93**	**244**	**68**	**156**	**15**	**20**	**145**	**237**	**300**	**72**	**410**	**50**	**44**
ROAD 14.1a		**20**	**37**	**133**	**224**	**189**	**72**	**385.8**	**29**	**318.6**	**20**	**15**	**145**	**239**	**300**	**64**	**410**	**38**	**22**
ROAD 14.1		***20***	***34***	***134***	***175***	***219***	***83***	***315***	***48***	***237***	***18***	***18***	***145***	***238***	***300***	***68***	***410***	***44***	***33***

Road Maintenance and Rehabilitation Project

Dynamic Cone Penetrometer Test **Summary**

Road Name: Road Code:

Test Location and Pavement Assessment		Layer Characteristics										Pavement Layer Characteristics							
Chainage	Condition	Layer 1		Layer 2		Layer 3		Layer 4		Layer 5		SF	BS		SB		SSG		SG
		Thk	Str	Thk	Str	Thk	Str	Thk	Str	Thk	Str	Thick	Thick	Str	Thick	Str	Thick	Str	Str
(km)		(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	(mm)	CBR	(mm)	CBR	(mm)	CBR	CBR
0.000 LHS	SURFACE DRESSING	20	488	104	153	194	103	226	99	482	34	20	210	161	345	139	500	91	38
2.000 RHS	SURFACE DRESSING	20	32	-2		32	193	39	263	11	1487	20	210	186	345		500		
4.000 LHS	SURFACE DRESSING	20	243	113	88	335	26	285	64	269	13	20	210	81	345	28	500	42	34
6.000 RHS	SURFACE DRESSING	20	32	88	276	248	55	206	60	460	24	20	210	161	345	51	500	63	27
8.000 RHS	SURFACE DRESSING	9	197	89	183	258	27	433	32	231	45	20	210	108	345	30	500	26	38
10.000 RHS	SURFACE DRESSING	20	32	4	1848	98	242	222	54	678	13	20	210	186	345	51	500	13	13
12.000 LHS	SURFACE DRESSING	20	85	90	247	270	44	304	27	338	11	20	210	145	345	40	500	31	18
14.000 LHS	SURFACE DRESSING	20	637	180	154	202	90	282	53	338	22	20	210	202	345	106	500	63	35
16.000 LHS	SURFACE DRESSING	12	231	220	246	265	44	143	137	18	691	20	210	260	345	95	500	44	237
16.000 LHS	SURFACE DRESSING	20	541	200	209	234	60	189	108	15	807	20	210	260	345	95	500	44	237
18.000 RHS	SURFACE DRESSING	20	85	5	2914	86	355	263	60	648	12	20	210	268	345	62	500	20	12
20.000 LHS	SURFACE DRESSING	20	213	146	69	231	24	110	81	501	31	20	210	81	345	15	500	65	32
22.000 RHS	SURFACE DRESSING	20	51	69	102	86	67	83	34	764	10	20	210	74	345	25	500	10	10
24.000 LHS	SURFACE DRESSING	20	141	182	95	65	120	290	15	465	7	20	210	97	345	72	500	18	7
26.000 RHS	SURFACE DRESSING	20	239	146	175	154	153	364	108	299	99	20	210	178	345	139	500	140	104
28.000 LHS	SURFACE DRESSING	20	32	-2		9	522	-9		6	1050	20	210	97	345		500		
30.000 RHS	SURFACE DRESSING	20	74	146	193	190	57	240	27	426	12	20	210	178	345	40	500	31	15
32.000 LHS	SURFACE DRESSING	20	32	-3		11	550	-8		5	1641	20	210	137	345		500		
34.000 RHS	SURFACE DRESSING	20	32	-6		20	323	11	577	8	1459	20	210	161	345		500		
36.000 LHS	SURFACE DRESSING	20	628	277	49	323	46	214	54	202	49	20	210	113	345	40	500	44	51
38.000 RHS	SURFACE DRESSING	20	79	48	137	140	86	450	18	364	10	20	210	105	345	19	500	20	12
40.000 LHS	SURFACE DRESSING	20	70	66	100	151	86	92	33	693	12	20	210	97	345	40	500	10	13
42.000 RHS	SURFACE DRESSING	20	32	30	259	119	184	302	60	551	12	20	210	169	345	62	500	44	16
44.000 LHS	SURFACE DRESSING	20	32	-2		26	181	6	1084	0		20	210	89	345		500		
46.000 RHS	SURFACE DRESSING	20	32	20	397	49	62	51	241	8	1450	20	210	178	345		500		
48.000 LHS	SURFACE DRESSING	20	32	11	747	182	114	192	65	617	25	20	210	153	345	62	500	35	28
50.000 RHS	SURFACE DRESSING	20	118	229	166	36	50	55	33	682	27	20	210	178	345	72	500	29	28
52.000 LHS	SURFACE DRESSING	20	32	58	286	51	220	191	53	702	10	20	210	178	345	30	500	13	9
54.000 RHS	SURFACE DRESSING	20	89	128	140	208	29	484	19	182	48	20	210	113	345	19	500	24	30
56.000 LHS	SURFACE DRESSING	20	32	0		20	361	46	196	0		20	210	145	345		500		
ROAD 14.2a		**19.42**	**144**	**112**	**171**	**173.9**	**101**	**247.9**	**47**	**494.3**	**20**	**20**	**210**	**144**	**345**	**51**	**500**	**34**	**22**

Road Maintenance and Rehabilitation Project

Dynamic Cone Penetrometer Test **Summary**

Road Name: Road Code: 14.2

Test Location and Pavement Assessment			Layer Characteristics										Pavement Layer Characteristics								
Chainage		Condition	Layer 1		Layer 2		Layer 3		Layer 4		Layer 5		SF	BS		SB		SSG		SG
			Thk	Str	Thk	Str	Thk	Str	Thk	Str	Thk	Str	Thick	Thick	Str	Thick	Str	Thick	Str	Str
(km)			(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	(mm)	CBR	(mm)	CBR	(mm)	CBR	CBR
58.000	RHS	SURFACE DRESSING	20	154	256	49	195	35	273	32	278	9	20	210	66	345	30	500	42	19
60.000	LHS	SURFACE DRESSING	20	85	146	258	314	46	204	52	338	36	20	210	219	345	40	500	44	45
62.000	RHS	SURFACE DRESSING	20	829	178	91	142	75	198	38	484	25	20	210	161	345	83	500	44	25
ROAD 14.2b			**20**	**85**	**193.3**	**133**	**217**	**52**	**225**	**41**	**366.7**	**23**	**20**	**210**	**149**	**345**	**51**	**500**	**43**	**30**
ROAD 14.2a			**19**	**144**	**112**	**171**	**173.9**	**101**	**247.9**	**47**	**494.3**	**20**	**20**	**210**	**144**	**345**	**51**	**500**	**34**	**22**
ROAD 14.2			**20**	**114**	**152.7**	**152**	**195.4**	**77**	**236.4**	**44**	**430.5**	**21**	**20**	**210**	**146**	**345**	**51**	**500**	**39**	**26**

Road Maintenance and Rehabilitation Project

Dynamic Cone Penetrometer Test **Summary**

Road Name: Zomba to Blantyre Road Code: 15

Test Location and Pavement Assessment		Layer Characteristics										Pavement Layer Characteristics							
Chainage	Condition	Layer 1		Layer 2		Layer 3		Layer 4		Layer 5		SF	BS		SB		SSG		SG
		Thk	Str	Thk	Str	Thk	Str	Thk	Str	Thk	Str	Thick	Thick	Str	Thick	Str	Thick	Str	Str
(km)		(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	CBR	(mm)	(mm)	CBR	(mm)	CBR	(mm)	CBR	CBR
0.000 LHS	SURFACE DRESSING	20	32	4	1446	32	188	12	1339	15	978	35	175	291	280		450		
2.000 RHS	SURFACE DRESSING	20	32	0		13	931	9	1215	5	2448	35	175	291	280		450		
4.000 LHS	SURFACE DRESSING	20	32	-2		38	249	6	1632	12	945	35	175	268	280		450		
6.000 RHS	SURFACE DRESSING	20	32	-14		36	350	32	382	18	708	35	175	325	280		450		
8.000 LHS	SURFACE DRESSING	20	32	0		20	657	13	845	18	520	35	175	291	280		450		
10.000 RHS	SURFACE DRESSING	20	32	-11		15	520	9	904	7	1165	35	175	212	280		450		
12.000 LHS	SURFACE DRESSING MACADAM 200 mm	20	77	69	20	379	53	167	15	367	30	35	175	59	280	52	450	40	29
14.000 RHS	SURFACE DRESSING MACADAM 200mm	20	32	146	49	190	32	328	19	338	17	35	175	49	280	39	450	23	20
16.000 LHS	SURFACE DRESSING MACADAM 110mm	20	32	116	18	107	5	441	13	338	11	35	175	19	280	7	450	14	13
18.000 RHS	SURFACE DRESSING MACADAM 300mm	20	32	0		336	14	575	12	74	48	35	175	49	280	12	450	20	16
20.000 LHS	SURFACE DRESSING MACADAM 200mm	20	32	33	303	178	59	95	131	652	18	35	175	123	280	109	450	40	17
22.000 RHS	SURFACE DRESSING MACADAM 200mm	20	32	113	42	238	21	195	14	456	10	35	175	39	280	25	450	20	11
24.000 LHS	SURFACE DRESSING MACADAM 200mm	20	58	220	29	142	20	302	22	291	16	35	175	39	280	25	450	23	19
26.000 RHS	SURFACE DRESSING 250mm MACADAM	20	32	93	36	299	8	220	19	361	9	35	175	28	280		450	15	14
28.000 LHS	SURFACE DRESSING MACADAM 250mm	20	32	33	157	175	15	249	11	545	7	35	175	49	280	12	450	9	9
30.000 RHS	SURFACE DRESSING MACADAM 300mm	20	67	113	49	92	96	229	13	516	7	35	175	91	280	25	450	15	9
32.000 LHS	SURFACE DRESSING MACADAM 300mm	20	32	0		16	282	-2		2	2362	35	175	123	280		450		
34.000 RHS	SURFACE DRESSING MACADAM 300mm	20	121	187	62	218	13	259	16	338	14	35	175	80	280	25	450	15	17
36.000 LHS	SURFACE DRESSING MACADAM 250mm	20	32	30	597	216	29	481	34	261	16	35	175	145	280	33	450	43	25
38.000 RHS	SURFACE DRESSING MACADAM 250mm	20	32	210	36	126	9	328	10	338	9	35	175	121	280		450		
40.000 LHS	SURFACE DRESSING MACADAM 250mm	20	2	22	254	213	21	252	6	515	17	35	175	49	280	25	450	9	15
42.000 RHS	SURFACE DRESSING	20	32	-2		6	1033	3	1807	-3		35	175	167	280		450		
44.000 LHS	SURFACE DRESSING	20	32	128	25	86	81	51	296	29	961	35	175	39	280	227	450	127	
46.000 RHS	SURFACE DRESSING MACADAM 200mm	20	32	146	13	190	3	328	13	236	11	35	175	9	280	25	450	1	13
48.000 0	SURFACE DRESSING MACADAM 250mm	20	32	75	47	187	34	142	28	598	8	35	175	45	280	39	450	23	9
50.000 RHS	SURFACE DRESSING MACADAM 150mm	20	4	274	8	240	9	150	9	294	10	35	175	2	280	10	450	12	10
52.000 LHS	SURFACE DRESSING MACADAM 200mm	20	32	53	245	117	59	118	8	596	8	35	175	134	280	12	450	12	8
54.000 RHS	SURFACE DRESSING MACADAM 200mm	20	17	40	103	186	20	146	7	604	15	35	175	49	280	12	450	9	16
56.000 LHS	SURFACE DRESSING	20	48	72	69	264	10	328	17	301	20	35	175	39	280	20	450	14	19
58.000 LHS	SURFACE DRESSING MACADAM 200mm	20	62	22	906	186	64	199	28	569	21	35	175	200	280	47	450	23	23
ROAD 15		**20**	**40**	**95.38**	**182**	**196.3**	**30**	**230.8**	**23**	**445.8**	**13**	**35**	**175**	**65**	**280**	**30**	**450**	**19**	**16**

Road Maintenance and Rehabilitation Project

Roughton International

Test Pit and Material Logging Investigation

in association with **Jatula Partners**

Road Name: Karonga - Songwe Road Code: 1 S.Length: 1 Date: 27/07/98

Chainage: 4.30 LHS Location Number: L01/P06 Operator: CSJ

Point Number 6 GPS Co-ordinates: S 9 ' 54.614 " E 33 ' 55.61 "

General Description of Area

The road surface is cracked and rutted. It is founded on an embankment. The surrounding area is dry bush.

Layer	From (mm)	To (mm)	Material Description	Field Tests: MC (%)	Field Tests: % MDD	Field Tests: InSitu MDD (kg/m3)	Field Tests: CBR (DCP) %	Laboratory Results: PI (%)	Laboratory Results: OMC (%)	Laboratory Results: MDD (kg/m3)	Laboratory Results: CBR (Soaked) 98%	Laboratory Results: Estimated CBR (ORN31) %	MOWS COMPLIANCE	ORN31 COMPLIANCE
Surface	0	20	The surface is double surface dressing with 15mm chip size. The surface was hard and dry.											
Base	20	200	The base was found not to react with HCl. The material was loose, damp, grey, clayey, crushed stone base with gneiss gravel aggregate, with a mixture of decomposed rock fines.	0.0	0	-	128	NP	-	-	-		✗	✗
Subbase	200	330	The subbase was found not to react with HCl. The material was a loose, damp, orangey brown, silty, quartz gravel.	-	-	-	68	NP	-	-			✓	✗
Subgrade	330	670+	The subgrade was found not to react with HCl. The material was a firm, damp, dark brown sandy clay.	-	-		22	-	-	-		11		

Road Maintenance and Rehabilitation Project

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Road Name: Karonga - Songwe　Road Code: 1　S.Length: NA　Date: 22/07/98

Chainage: 10.80 RHS　Location Number: L01/10.8　Operator: ECB

Point Number NA　GPS Co-ordinates: ####### #VALUE!

General Description of Area

The road surface is becoming rutted, potholes have appeared and patched in some areas. Parts of the surface are starting to bleed.. It is founded on an embankment. The surrounding area is wet agricultural land, possibly rice paddies.

Layer	From (mm)	To (mm)	Material Description	Field Tests: MC (%)	Field Tests: % MDD	Field Tests: InSitu MDD (kg/m3)	Field Tests: CBR (DCP) %	Laboratory Results: PI (%)	Laboratory Results: OMC (%)	Laboratory Results: MDD (kg/m3)	Laboratory Results: CBR (Soaked) 98%	Laboratory Results: Estimated CBR (ORN31) %	MOWS COMPLIANCE	ORN31 COMPLIANCE
Surface	0	20	The surface is double surface dressing with 15mm chip size. The surface was hard and dry.	-	-	-	-	-	-	-	-	-	-	-
Base	20	220	The base was found not to react with HCl. The material was a relatively loose, grey clayey coarse crushed rock (gneiss) with decomposed rock fines.	-	-	-	-	-	-	-	-	-	-	-
Subbase	220	370	The subbase was found not to react with HCl. The material was a relatively loose moist orangey brown clayey sandy GRAVEL with occasional rounded cobbles.	-	-	-	-	-	-	-	-	-	-	-
Subgrade				-	-	-	-	-	-	-	-	-	-	-
Subgrade II			The subgrade was found not to react with HCl. The material was a firm, damp, dark brown sandy clay.	-	-	-	-	-	-	-	-	-	-	-

Road Maintenance and Rehabilitation Project

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Road Name: Karonga - Songwe | Road Code: 1 | S.Length: 2 | Date: 27/07/98

Chainage: 23.58 RHS | Location Number: L01/P23 | Operator: CSJ

Point Number: 23 | GPS Co-ordinates: S 9 ' 54.637 " | E 33 ' 55.576 "

General Description of Area

The road surface is becoming rutted, potholes have appeared and patched in some areas. Parts of the surface are starting to bleed.. It is founded on an embankment. The surrounding area is wet agricultural land, possibly rice paddies.

Layer	From (mm)	To (mm)	Material Description	Field Tests				Laboratory Results						
				MC (%)	% MDD	InSitu MDD (kg/m3)	CBR (DCP) %	PI (%)	OMC (%)	MDD (kg/m3)	CBR (Soaked) 98%	Estimated CBR (ORN31) %	MOWS COMPLIANCE	ORN31 COMPLIANCE
Surface	0	20	The surface is double surface dressing with 15mm chip size. The surface was hard and dry.											
Base	20	175	The base was found not to react with HCl. The material was loose, damp, grey, clayey, crushed stone base with gneiss gravel aggregate, with a mixture of decomposed rock fines.	0.0	0	-	138	13	-	-	-		✗	✗
Subbase	175	260	The subbase was found not to react with HCl. The material was a loose, damp, orangey brown, silty, often with gneiss upto coarse gravel aggregate.	-	-	-	69	13	-	-			✓	✗
Subgrade	260	440	The subgrade was found not to react with HCl. The material was a firm, damp, dark brown sandy clay.											
Subgrade II	440	600+	The subgrade was found not to react with HCl. The material was a firm, damp, dark brown clay.	-	-		12	16	-	-		22		

Road Maintenance and Rehabilitation Project

Test Pit and Material Logging Investigation

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Road Name: Karonga - Songwe   Road Code: 1   S.Length: 3   Date: 27/07/98

Chainage: 31.77 LHS   Location Number: L01/P49   Operator: CSJ

Point Number 49   GPS Co-ordinates: S 9 ' 45.062 "   E 33 ' 49.752 "

General Description of Area

The road surface is becoming cracked and rutted, potholes and patches are prevalent. It is founded on an embankment. The surrounding area is dry bush.

Layer	From (mm)	To (mm)	Material Description	Field Tests: MC (%)	Field Tests: % MDD	Field Tests: InSitu MDD (kg/m3)	Field Tests: CBR (DCP) %	Laboratory Results: PI (%)	Laboratory Results: OMC (%)	Laboratory Results: MDD (kg/m3)	Laboratory Results: CBR (Soaked) 98%	Laboratory Results: Estimated CBR (ORN31) %	MOWS COMPLIANCE	ORN31 COMPLIANCE
Surface	0	20	The surface is double surface dressing with 15mm chip size. The surface was hard and dry.											
Base	20	320	The base was found not to react with HCl. The material was loose, damp, grey, clayey, crushed stone base with gneiss gravel aggregate, with a mixture of decomposed rock fines.	0.0	0	-	132	15	-	-	-		✗	✗
Subbase	320	320		-	-	-	26	30	-	-			✗	✗
Subgrade	320	740+	The subbase was found not to react with HCl. The material was a firm, damp, orangey brown, silty, clay.	-	-		35	-	-	-		6		

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Road Name: Mzuzu - Bwengu Road Code: 2.1 S.Length: 1 Date: 27/07/98

Chainage: 6.35 LHS Location Number: L02.1/P00 Operator: JDR

Point Number 0 GPS Co-ordinates: S 11 ' 25.925 " E 34 ' 0.172 "

General Description of Area

The road surface is good, no apparent damage., at natural ground level.

Layer	From (mm)	To (mm)	Material Description	Field Tests: MC (%)	Field Tests: % MDD	Field Tests: InSitu MDD (kg/m3)	Field Tests: CBR (DCP) %	Laboratory Results: PI (%)	Laboratory Results: OMC (%)	Laboratory Results: MDD (kg/m3)	Laboratory Results: CBR (Soaked) 98%	Laboratory Results: Estimated CBR (ORN31) %	MOWS COMPLIANCE	ORN31 COMPLIANCE
Surface	0	25	The surface is double surface dressing with 25mm chip size. The surface was very hard and dry.											
Base	25	200	The base was found not to react with HCl. The material was very hard, dry, grey, crushed stone base with gneiss gravel aggregate and fines.	4.4	0	1721	198	NP	-	-	-		✗	✗
Subbase	200	300	The subbase was found not to react with HCl. The material was a hard, poorly graded, clayey, silty sand with some quartz gravel.	-	-	-	38	21	-	-			✗	✗
Subgrade	300	470+	The subgrade was found not to react with HCl. The material was a firm, damp, orangey brown sandy clay.	-	-		21	23	-	-		6		

Road Maintenance and Rehabilitation Project

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Road Name: Mzuzu - Bwengu Road Code: 2.1 S.Length: 2 Date: 27/07/98

Chainage: 13.09 LHS Location Number: L02.1/P25 Operator: JDR

Point Number 25 GPS Co-ordinates: S 11 ' 25.691 " E 33 ' 59.637 "

General Description of Area

The road surface is good, but deformations are beginning to appear. The road is founded on an embankment, surrounded by savannah.

Layer	From (mm)	To (mm)	Material Description	Field Tests: MC (%)	Field Tests: % MDD	Field Tests: InSitu MDD (kg/m3)	Field Tests: CBR (DCP) %	Laboratory Results: PI (%)	Laboratory Results: OMC (%)	Laboratory Results: MDD (kg/m3)	Laboratory Results: CBR (Soaked) 98%	Laboratory Results: Estimated CBR (ORN31) %	MOWS COMPLIANCE	ORN31 COMPLIANCE
Surface	0	30	The surface is double surface dressing with 25mm chip size. The surface was very hard and dry.											
Base	30	190	The base was found not to react with HCl. The material was very hard, dry, grey, crushed stone base with gneiss gravel aggregate and fines.	2.6	0	1945	158	NP	-	-	-		✗	✗
Subbase	190	350	The subbase was found not to react with HCl. The material was a hard, poorly graded, clayey, silty sand with some quartz gravel.	-	-	-	18	19	-	-			✗	✗
Subgrade	350	550+	The subgrade was found not to react with HCl. The material was a firm, damp, orangey brown sandy clay.	-	-		14	27	-	-		4		

Road Maintenance and Rehabilitation Project

Test Pit and Material Logging Investigation

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Road Name: Mzuzu - Bwengu | Road Code: 2.1 | S.Length: 3 | Date: 27/07/98

Chainage: 37.26 LHS | Location Number: L02.1/P59 | Operator: JDR

Point Number: 59 | GPS Co-ordinates: S 11 ' 53.605 " E 33 ' 35.817 "

General Description of Area

The road surface is good, but deformations are beginning to appear. The road is founded on an embankment, surrounded by savannah.

Layer	From (mm)	To (mm)	Material Description	Field Tests: MC (%)	Field Tests: % MDD	Field Tests: InSitu MDD (kg/m3)	Field Tests: CBR (DCP) %	Laboratory Results: PI (%)	Laboratory Results: OMC (%)	Laboratory Results: MDD (kg/m3)	Laboratory Results: CBR (Soaked) 98%	Laboratory Results: Estimated CBR (ORN31) %	MOWS COMPLIANCE	ORN31 COMPLIANCE
Surface	0	25	The surface is double surface dressing with 20mm chip size. The surface was hard and dry.											
Base	25	175	The base was found not to react with HCl. The material was very hard, dry, grey, crushed stone base with gneiss gravel aggregate and fines.	5.0	0	2201	207	NP	-	-	-		✗	✗
Subbase	175	375	The subbase was found not to react with HCl. The material was a hard, poorly graded, clayey, silty sand with some quartz gravel.	-	-	-	36	8	-	-			✓	✗
Subgrade	375	575+	The subgrade was found not to react with HCl. The material was a hard, damp, reddy orange clayey sand.	-	-		15	31	-	-		22		

Road Maintenance and Rehabilitation Project

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Test Pit and Material Logging Investigation

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Road Name: Mzuzu - Bwengu   Road Code: 2.1   S.Length: 4   Date: 25/07/98

Chainage: 60.34 LHS   Location Number: L02.1/P82   Operator: JDR

Point Number 82   GPS Co-ordinates: S 11 ' 2.182 " E 33 ' 54.145 "

General Description of Area

The road surface is cracked, rutted and deformed. The road is founded on a dry embankment, surrounded by savannah.

Layer	From (mm)	To (mm)	Material Description	Field Tests: MC (%)	Field Tests: % MDD	Field Tests: InSitu MDD (kg/m3)	Field Tests: CBR (DCP) %	Laboratory Results: PI (%)	Laboratory Results: OMC (%)	Laboratory Results: MDD (kg/m3)	Laboratory Results: CBR (Soaked) 98%	Laboratory Results: Estimated CBR (ORN31) %	MOWS COMPLIANCE	ORN31 COMPLIANCE
Surface	0	25	The surface is double surface dressing with 20mm chip size. The surface was hard and dry.											
Base	25	210	The base was found not to react with HCl. The material was very hard, dry, grey, crushed stone base with gneiss gravel aggregate and fines.	7.3	0	1999	126	11	-	-	-		✗	✗
Subbase	210	310	The subbase was found not to react with HCl. The material was a hard, poorly graded, clayey, silty sand with some quartz gravel.	-	-	-	29	21	-	-			✗	✗
Subgrade	310	480+	The subgrade was found not to react with HCl. The material was a hard, damp, reddy orange sandy clay.	-	-		28	-	-	-		11		

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Road Name: Bwengu - Chiweta   Road Code: 2.2   S.Length: 1   Date: 25/07/98

Chainage: 6.35 LHS   Location Number: L02.2/P16   Operator: CSJ

Point Number 16   GPS Co-ordinates: S 11 ' 25.925 " E 34 ' 0.172 "

General Description of Area

The road surface is cracked, rutted, patched and deformed. The road is founded at natural ground level and surrounded by dry savannah.

Layer	From (mm)	To (mm)	Material Description	Field Tests				Laboratory Results						
				MC (%)	% MDD	InSitu MDD (kg/m3)	CBR (DCP) %	PI (%)	OMC (%)	MDD (kg/m3)	CBR (Soaked) 98%	Estimated CBR (ORN31) %	MOWS COMPLIANCE	ORN31 COMPLIANCE
Surface	0	25	The surface is double surface dressing with 20mm chip size. The surface was hard and dry.											
Base	25	210	The base was found not to react with HCl. The material was very hard, dry, grey, crushed stone base with gneiss gravel aggregate and fines.	5.8	0	2230	166	13	-	-	-		✗	✗
Subbase	210	310	The subbase was found not to react with HCl. The material was a firm damp, poorly graded reddish clayey sand, with occasional quartz gravel.	-	-	-	51	12	-	-			✓	✗
Subgrade	310	480+	The subgrade was found not to react with HCl. The material was a firm, wet, poorly graded, orange clayey sand.	-	-		35	16	-	-		22		

Road Maintenance and Rehabilitation Project

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Road Name: Bwengu - Chiweta Road Code: 2.2 S.Length: 2 Date: 26/07/98

Chainage: 13.09 LHS Location Number: L02.2/P33 Operator: CSJ

Point Number 33 GPS Co-ordinates: S 11 ' 25.691 " E 33 ' 59.637 "

General Description of Area

The road surface is cracked, rutted, patched and deformed. The road is founded at natural ground level and surrounded by dry savannah.

Layer	From (mm)	To (mm)	Material Description	Field Tests				Laboratory Results						
				MC (%)	% MDD	InSitu MDD (kg/m3)	CBR (DCP) %	PI (%)	OMC (%)	MDD (kg/m3)	CBR (Soaked) 98%	Estimated CBR (ORN31) %	MOWS COMPLIANCE	ORN31 COMPLIANCE
Surface	0	20	The surface is double surface dressing with 20mm chip size. The surface was very hard and dry.											
Base	20	200	The base was found not to react with HCl. The material was very hard, dry, grey, crushed stone base with gneiss gravel aggregate and fines.	0.0	0	-	149	16	-	-	-		✗	✗
Subbase	200	480	The subbase was found not to react with HCl. The material was a firm damp, poorly graded brwonish clayey gravel.	-	-	-	29	23	-	-			✗	✗
Subgrade	480	650+	No subgrade located	-	-		21	-	-	-		22		

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Road Name: Bwengu - Chiweta   Road Code: 2.2   S.Length: 3   Date: 26/07/98

Chainage: 37.26 LHS   Location Number: L02.2/P39   Operator: CSJ

Point Number 39   GPS Co-ordinates: S 11 ' 53.605 " E 33 ' 35.817 "

General Description of Area

The road surface is cracked and has been patched. The road is founded in a step into the side of a hill. The cutting being closest to the pit. The surrounding area is dry bush.

Layer	From (mm)	To (mm)	Material Description	Field Tests				Laboratory Results						
				MC (%)	% MDD	InSitu MDD (kg/m3)	CBR (DCP) %	PI (%)	OMC (%)	MDD (kg/m3)	CBR (Soaked) 98%	Estimated CBR (ORN31) %	MOWS COMPLIANCE	ORN31 COMPLIANCE
Surface	0	25	The surface is double surface dressing with 20mm chip size. The surface was hard and dry.											
Base	25	195	The base was found to react with HCl, but no phenolphaline. The material was very hard, dry, grey, crushed stone base with gneiss gravel aggregate and fines, also present was a matrix of orange silty sand, between the crushed stone.	0.0	0	-	209	12	-	-	-		✗	✗
Subbase	195	300	The subbase was found not to react with HCl. The material was a firm damp, poorly graded brownish clayey sandy gravel.	-	-	-	75	14	-	-			✓	✗
Subgrade	300	650+	No subgrade located, the subbase continued until 700mm	-	-		23	-	-	-		6		

Road Maintenance and Rehabilitation Project

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Road Name: Mzuzu - Nkhata Bay   Road Code: 4   S.Length: 1   Date: 23/07/98

Chainage: 8.99 RHS   Location Number: L04/P12   Operator: JDR

Point Number 12   GPS Co-ordinates: S 11 ' 29.958 " E 34 ' 3.808 "

General Description of Area

The road surface is rutted, deformed, potholed and patched. The road is founded at natural ground level through dry bush.

Layer	From (mm)	To (mm)	Material Description	Field Tests: MC (%)	Field Tests: % MDD	Field Tests: InSitu MDD (kg/m3)	Field Tests: CBR (DCP) %	Laboratory Results: PI (%)	Laboratory Results: OMC (%)	Laboratory Results: MDD (kg/m3)	Laboratory Results: CBR (Soaked) 98%	Laboratory Results: Estimated CBR (ORN31) %	MOWS COMPLIANCE	ORN31 COMPLIANCE
Surface	0	20	The surface is double surface dressing with 14mm chip size. The surface was very hard and dry.											
Base	20	150	The base was found not to react with HCl. The material was very hard, dry, reddy orange lateritic quartz gravel.	6.4	87	1778	95	31	9	2055	22		✗	✗
Subbase	150	250	The subbase was found not to react with HCl. The material was a firm damp, poorly graded orangey brown silty sandy gravel.	-	-	-	69	21	-	-			✗	✗
Subgrade	250	410+	The subgrade was found not to react with HCl. The material was a firm, damp, poorly graded, orangey grey, clayey sand.	-	-		15	28	-	-		11		

Road Maintenance and Rehabilitation Project

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Road Name: Mzuzu - Nkhata Bay   Road Code: 4   S.Length: NA   Date: 23/07/98

Chainage: 6.40 RHS   Location Number: L04/6.4   Operator: JDR

Point Number NA   GPS Co-ordinates: ####### #VALUE!

General Description of Area

The road surface is rutted, deformed, potholed and patched. The road is founded at natural ground level through dry bush.

Layer	From (mm)	To (mm)	Material Description	Field Tests: MC (%)	% MDD	InSitu MDD (kg/m3)	CBR (DCP) %	Laboratory Results: PI (%)	OMC (%)	MDD (kg/m3)	CBR (Soaked) 98%	Estimated CBR (ORN31) %	MOWS COMPLIANCE	ORN31 COMPLIANCE
Surface	0	20	The surface is double surface dressing with 14mm chip size. The surface was very hard and dry.											
Base	20	90	The base was found not to react with HCl. The material was a red clayey sandy quartz GRAVEL.	4.8	0	2040	209	17	-	-	-		✗	✗
Subbase	90	210	The subbase was found not to react with HCl. The material was a red lateritic sandy CLAY.	-	-	-			-	-			✓	✗
Subgrade	210	420+	The subgrade was found not to react with HCl. The material was a dark red sandy CLAY.	15	-		23	21	-	-		6		

Road Maintenance and Rehabilitation Project

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Road Name: Mzuzu - Nkhata Bay   Road Code: 4   S.Length: NA   Date: 24/07/98

Chainage: 19.60 RHS   Location Number: L04/P19.6   Operator: JDR

Point Number NA   GPS Co-ordinates: ####### #VALUE!

General Description of Area

The road surface is cracked with pumping in evidence, the surface is also deformed, potholed and patched. The road is founded at natural ground level through dry bush.

Layer	From (mm)	To (mm)	Material Description	Field Tests MC (%)	% MDD	InSitu MDD (kg/m3)	CBR (DCP) %	Laboratory Results PI (%)	OMC (%)	MDD (kg/m3)	CBR (Soaked) 98%	Estimated CBR (ORN31) %	MOWS COMPLIANCE	ORN31 COMPLIANCE
Surface	0	20	The surface is double surface dressing with 20mm chip size. The surface was very hard and dry.											
Base	20	170	The base was found to react with HCl, but not phenolphaline. The material was reddish brwon clayey sandy quartz GRAVEL.			-							✗	✗
Subbase	170	320	The subbase was found not to react with HCl. The material was a firm damp, orangey brown clayey quartz gravel.			-							✓	✗
Subgrade	320	450+	The subgrade was found not to react with HCl. The material was a firm, damp, poorly graded, reddy orange, clayey sandy gravel.		-									

Road Maintenance and Rehabilitation Project

Roughton International

Test Pit and Material Logging Investigation

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Road Name: Mzuzu - Nkhata Bay   Road Code: 4   S.Length: 2   Date: 24/07/98

Chainage: 22.18 RHS   Location Number: L04/P16   Operator: JDR

Point Number 16   GPS Co-ordinates: S 11 ' 32.144 " E 34 ' 7.508 "

General Description of Area

The road surface is cracked with pumping in evidence, the surface is also deformed, potholed and patched. The road is founded at natural ground level through dry bush.

Layer	From (mm)	To (mm)	Material Description	Field Tests: MC (%)	% MDD	InSitu MDD (kg/m3)	CBR (DCP) %	Laboratory Results: PI (%)	OMC (%)	MDD (kg/m3)	CBR (Soaked) 98%	Estimated CBR (ORN31) %	MOWS COMPLIANCE	ORN31 COMPLIANCE
Surface	0	10	The surface is double surface dressing with 20mm chip size. The surface was very hard and dry.											
Base	10	100	The base was found to react with HCl, but not phenolphaline. The material was very hard, dry, light brown, sandy quartz gravel.	0.0	0	-	246	NP	-	-	-		✗	✗
Subbase	100	220	The subbase was found not to react with HCl. The material was a firm damp, orangey brown clayey quartz gravel.	-	-	-	103	16	-	-			✗	✗
Subgrade	220	350+	The subgrade was found not to react with HCl. The material was a firm, damp, poorly graded, reddy orange, clayey sandy gravel.	-	-		18	17	-	-		6		

Road Maintenance and Rehabilitation Project

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Road Name: Mzuzu - Nkhata Bay | Road Code: 4 | S.Length: 3 | Date: 24/07/98

Chainage: 43.06 LHS | Location Number: L04/P42 | Operator: JDR

Point Number 42 | GPS Co-ordinates: S 11 ' 36.534 " E 34 ' 15.817 "

General Description of Area

The road surface is cracked with rutting in evidence, the surface is also potholed and patched. The road is founded at natural ground level through dry bush.

Layer	From (mm)	To (mm)	Material Description	Field Tests: MC (%)	Field Tests: % MDD	Field Tests: InSitu MDD (kg/m3)	Field Tests: CBR (DCP) %	Laboratory Results: PI (%)	Laboratory Results: OMC (%)	Laboratory Results: MDD (kg/m3)	Laboratory Results: CBR (Soaked) 98%	Laboratory Results: Estimated CBR (ORN31) %	MOWS COMPLIANCE	ORN31 COMPLIANCE
Surface	0	10	The surface is double surface dressing with 20mm chip size. The surface was very hard and dry.											
Base	10	170	The base was found to react with HCl, but not phenolphaline. The material was very hard, dry, light brown, clayey gravel.	0.0	0	-	190	31	7	1938	8		✗	✗
Subbase	170	280	The subbase was found not to react with HCl. The material was a firm damp, reddy orangey brown clayey quartz gravel.	-	-	-	30	17	-	-			✗	✗
Subgrade	280	410	The subgrade was found not to react with HCl. The material was a firm, damp, poorly graded, light brown , clayey sand.											
Subgrade II	410	860+	The second layer of sub grade was an off-white clayey silt. It was firm until augured when the material became very powder like, decomposed granitic gneiss.	-	-		16	28	-	-		6		

Road Maintenance and Rehabilitation Project

Test Pit and Material Logging Investigation

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Road Name: Salima - Senga Bay   Road Code: 11   S.Length: 1   Date: 02/08/98

Chainage: 5.99 RHS   Location Number: L11/P01   Operator: EC/AD/JR

Point Number: 1   GPS Co-ordinates: S 13 ' 46.685 " E 34 ' 30.474 "

General Description of Area

The road surface is cracked, potholed and has been patched. The road is founded at natural ground level, through a dry bush area.

Layer	From (mm)	To (mm)	Material Description	Sample No.	Material	0.075mm percent limit	MOWS CBR Spec	ORN 31 Spec	Field Tests: MC (%)	Field Tests: % MDD	Field Tests: InSitu MDD (kg/m3)	Field Tests: CBR (DCP) %	Laboratory Results: PI (%)	Laboratory Results: OMC (%)	Laboratory Results: MDD (kg/m3)	Laboratory Results: CBR (Soaked) 98%	Laboratory Results: Estimated CBR (ORN31) %	MOWS COMPLIANCE	ORN31 COMPLIANCE
Surface	0	10	The surface is double surface dressing with 10mm chip size. The surface was firm and dry.	L11/P01/SF	DSD														
Base	10	155	The base was found not to react with HCl. The material was a very hard, dry, moderately well graded, orange lateritic sandy gravel.	L11/P01/BC	GN	25	80	80	0.0	0	-	147	13	8	2210	-		✗	✗
Subbase	155	270	The subbase was found not to react with HCl. The material was a hard, damp, poorly graded, light grey gravely sand.	L11/P01/SB	GN	600	25	30	-	-	-	104	15	-	-			✓	✗
				L11/P01/SSG		0	0												
Subgrade	270	365+	The subgrade was found not to react with HCl. The material was a firm, damp, poorly graded, light brown decomposing granite.	L11/P01/SG	GN	25	15	15	-	-		19	19	-	-		22		

Road Maintenance and Rehabilitation Project

Roughton International

Test Pit and Material Logging Investigation

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Road Name: Salima - Senga Bay Road Code: 11 S.Length: 2 Date: 13/07/98

Chainage: 18.08 RHS Location Number: L11/05 Operator: ECB

Point Number NA GPS Co-ordinates: S 13 ' 44.384 " E 34 ' 35.835 "

General Description of Area

The road surface is cracked, potholed and has been patched. The road is founded at natural ground level, through a dry bush area.

Layer	From (mm)	To (mm)	Material Description	Field Tests: MC (%)	Field Tests: % MDD	Field Tests: InSitu MDD (kg/m3)	Field Tests: CBR (DCP) %	Laboratory Results: PI (%)	Laboratory Results: OMC (%)	Laboratory Results: MDD (kg/m3)	Laboratory Results: CBR (Soaked) 98%	Laboratory Results: Estimated CBR (ORN31) %	MOWS COMPLIANCE	ORN31 COMPLIANCE
Surface	0	20	The surface is double surface dressing with 10mm chip size. The surface was firm and dry.											
Base	20	180	The base was found not to react with HCl. The material was a light brown, slightly clayey fine to medium sand, with occasional laterite particles.	0.0	0	-	-	NP	8	2279	40		✗	✗
Subbase	180	240	The subbase was found not to react with HCl. The material was a light brown, silty, slightly gravelly sand.	-	-	-	-	22	-	-			✓	✗
					#N/A									

Road Maintenance and Rehabilitation Project

Test Pit and Material Logging Investigation

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Road Name: Salima - Senga Bay   Road Code: 11   S.Length: 3   Date: 13/07/98

Chainage: 18.08 RHS   Location Number: L11/15   Operator: ECB

Point Number NA   GPS Co-ordinates: S 13 ' 44.384 " E 34 ' 35.835 "

General Description of Area

The road surface is cracked, potholed and has been patched. The road is founded at natural ground level, through a dry bush area.

Layer	From (mm)	To (mm)	Material Description	Field Tests: MC (%)	Field Tests: % MDD	Field Tests: InSitu MDD (kg/m3)	Field Tests: CBR (DCP) %	Laboratory Results: PI (%)	Laboratory Results: OMC (%)	Laboratory Results: MDD (kg/m3)	Laboratory Results: CBR (Soaked) 98%	Laboratory Results: Estimated CBR (ORN31) %	MOWS COMPLIANCE	ORN31 COMPLIANCE
Surface	0	20	The surface is double surface dressing with 10mm chip size. The surface was firm and dry.											
Base	20	250	The base was found not to react with HCl. The material was a dense yellow brown clayey sand, with occasional laterite gravel particles.	0.0	0	-	-	13	8	2210	8		✗	✗
Subbase	250	450	The subbase was found not to react with HCl. The material was a yellow silty sand (low PI Non Plastic), with occasional laterite gravel particles.	-	-	-	-	-	-	-			✓	✗
					#N/A									

Road Maintenance and Rehabilitation Project

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Test Pit and Material Logging Investigation

Road Name: Benga - Nkhotakota
Road Code: 12.1
S.Length: 1
Date: 03/08/98

Chainage: 6.49 RHS
Location Number: L12.1/P71
Operator: CSJ

Point Number: 71
GPS Co-ordinates: S 13 ' 5.366 " E 34 ' 18.646 "

General Description of Area

The road surface is rutted, otherwise appears good. The road is founded on fill, through wet bush area.

Layer	From (mm)	To (mm)	Material Description	Field Tests				Laboratory Results						
				MC (%)	% MDD	InSitu MDD (kg/m3)	CBR (DCP) %	PI (%)	OMC (%)	MDD (kg/m3)	CBR (Soaked) 98%	Estimated CBR (ORN31) %	MOWS COMPLIANCE	ORN31 COMPLIANCE
Surface	0	25	The surface is asphaltic premix. The surface was hard and dry.											
Base	25	145	The base was found not to react with HCl. The material was a hard, damp, well graded, light grey, crushed stone base with upto 40mm aggregate.	0.0	0	-	216	NP	-	-	-		✗	✗
Subbase	145	300	The subbase was found not to react with HCl. The material was a firm, damp, orangey red, sandy gravel.	-	-	-	69	28	-	-			✓	✗
Subgrade	300	425+	The subgrade was found not to react with HCl. The material was a firm damp, uniformly graded, brown clayey sand.	-	-		41	NP	-	-		22		

Road Maintenance and Rehabilitation Project

Roughton International

Test Pit and Material Logging Investigation

in association with **Jatula Partners**

Road Name: Benga - Nkhotakota   Road Code: 12.1   S.Length: 2   Date: 03/08/98

Chainage: 22.13 LHS   Location Number: L12.1/P44   Operator: AD/KA

Point Number 45   GPS Co-ordinates: S 13 ' 1.429 " E 34 ' 17.826 "

General Description of Area

The road surface is cracked, potholed and has been patched. The road is founded at natural ground level, through a dry bush area.

Layer	From (mm)	To (mm)	Material Description	Field Tests				Laboratory Results						
				MC (%)	% MDD	InSitu MDD (kg/m3)	CBR (DCP) %	PI (%)	OMC (%)	MDD (kg/m3)	CBR (Soaked) 98%	Estimated CBR (ORN31) %	MOWS COMPLIANCE	ORN31 COMPLIANCE
Surface	0	30	The surface was found to be asphaltic premix. The surface was hard and dry.											
Base	30	140	The base was found to react with HCl, but no colour change with phenolphaline was observed. The material was a hard, damp, gap graded, light grey, crushed stone base with upto 70mm aggregate.	0.0	0	-	283	NP	-	-	-		✗	✗
Subbase	140	280	The subbase was found not to react with HCl. The material was a stiff, damp, orangey red, sandy silty lateritic clay.	-	-	-	129	18	-	-			✓	✗
Subgrade	280	390+	The subgrade was found not to react with HCl. The material was a firm damp, yellowish greeny brown, sandy silty clay with whitey orange gravels of decomposing granite..	-	-		#N/A	19	-	-		11		

Road Maintenance and Rehabilitation Project

Roughton International

Test Pit and Material Logging Investigation

in association with **Jatula Partners**

Road Name: Nkhotakota - Dwangwa Road Code: 12.2 S.Length: 4 Date: 02/08/98

Chainage: 40.56 RHS Location Number: L12.2/P05 Operator: CS J

Point Number 5 GPS Co-ordinates: S 12 ' 41.689 " E 34 ' 9.906 "

General Description of Area

The road surface is cracked, potholed and has been patched. The road is founded at natural ground level, through a dry bush area.

Layer	From (mm)	To (mm)	Material Description	Field Tests				Laboratory Results						
				MC (%)	% MDD	InSitu MDD (kg/m3)	CBR (DCP) %	PI (%)	OMC (%)	MDD (kg/m3)	CBR (Soaked) 98%	Estimated CBR (ORN31) %	MOWS COMPLIANCE	ORN31 COMPLIANCE
Surface	0	80	The surface was found to be a 20mm deep section of 15mm chips on 60mm of asphaltic premix. The surface was very hard and dry.											
Base	80	190	The base was found to react with HCl, but no colour change with phenolphaline was observed. The material was a hard, damp, moderately well graded, light brown slightly silty sandy lateritic gravel.	0.0	0	-	292	15	9	2088	-		✗	✗
Subbase	190	510	The subbase was found not to react with HCl. The material was a hard, damp, well graded, light orange clayey gravel.	-	-	-	58	22	-	-			✓	✗
Subgrade	510	610+	Not located at upto 610mm depth, just subbase continuation	-	-		25	-	-	-		22		

Road Maintenance and Rehabilitation Project

Test Pit and Material Logging Investigation

Roughton International

in association with **Jatula Partners**

Road Name: Benga - Nkhotakota | Road Code: 12.1 | S.Length: 1 | Date: 02/08/98

Chainage: 1.10 RHS | Location Number: L12.1/1.1 | Operator: CS J

Point Number NA | GPS Co-ordinates: S 13 ' 5.366 " E 34 ' 18.646 "

General Description of Area

The road surface is cracked, potholed and has been patched. The road is founded at natural ground level, through a dry bush area.

Layer	From (mm)	To (mm)	Material Description	Field Tests: MC (%)	Field Tests: % MDD	Field Tests: InSitu MDD (kg/m3)	Field Tests: CBR (DCP) %	Laboratory Results: PI (%)	Laboratory Results: OMC (%)	Laboratory Results: MDD (kg/m3)	Laboratory Results: CBR (Soaked) 98%	Laboratory Results: Estimated CBR (ORN31) %	MOWS COMPLIANCE	ORN31 COMPLIANCE
Surface	0	20	The surface was found to be a double surface dressing, with 20mm chip size.											
Base	20	170	Coarsley graded crushed stone (granitic gneiss) with silty fines (macadam)	0.0	0	-	119	13	8	2210	15		✗	✗
Subbase	170	320	Cement stabilised (carbonated) red brown clayey sandy lateritic and quartz gravel.	-	-	-	93	-	-	-			✓	✗
Subgrade	320	470	Red brown clayey sandy lateritic and quartz gravel.											
SubgradeII	470	610+	Dark grey to black high plasticity silty sandy CLAY (black cotton type)	-	-		153	22	-	-		-		

Road Maintenance and Rehabilitation Project

Test Pit and Material Logging Investigation

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Road Name: Chingeni - Liwonde Road Code: 13.1 S.Length: 1 Date: 03/08/98

Chainage: 7.09 LHS Location Number: L13.1/P07 Operator: CSJ

Point Number 7 GPS Co-ordinates: S 14 ' 59.394 " E 34 ' 57.112 "

General Description of Area

The road surface is rutted, otherwise appears good. The road is founded on fill, through wet bush area.

Layer	From (mm)	To (mm)	Material Description	Field Tests				Laboratory Results						
				MC (%)	% MDD	InSitu MDD (kg/m3)	CBR (DCP) %	PI (%)	OMC (%)	MDD (kg/m3)	CBR (Soaked) 98%	Estimated CBR (ORN31) %	MOWS COMPLIANCE	ORN31 COMPLIANCE
Surface	0	30	The surface was asphalt premix. The surface was hard and dry.											
Base	30	150	The base was found to react with HCl, but not phenolphaline. The material was a very hard, damp, well graded, light orange brown, stabilised gravel base.	0.0	0	-	240	NP	8	2127	60		✗	✗
Subbase	150	320	The subbase was found not to react with HCl. The material was a hard, damp, well graded, orangey brown gravel.	-	-	-	45	16	-	-			✓	✗
Subgrade	320	490+	The subgrade was found not to react with HCl. The material was a firm damp, moderately graded, brown clayey sand.	-	-		21	17	-	-		11		

Road Maintenance and Rehabilitation Project

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Test Pit and Material Logging Investigation

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Road Name: Chingeni - Liwonde | Road Code: 13.1 | S.Length: 2 | Date: 03/08/98

Chainage: 20.28 RHS | Location Number: L13.1/P19 | Operator: CSJ

Point Number 19 | GPS Co-ordinates: S 15 ' 1.106 " E 35 ' 3.007 "

General Description of Area

The road surface is cracked and rutted, with some patching. The road is founded on an embankment, through dry bush.

Layer	From (mm)	To (mm)	Material Description	Field Tests: MC (%)	Field Tests: % MDD	Field Tests: InSitu MDD (kg/m3)	Field Tests: CBR (DCP) %	Laboratory Results: PI (%)	Laboratory Results: OMC (%)	Laboratory Results: MDD (kg/m3)	Laboratory Results: CBR (Soaked) 98%	Laboratory Results: Estimated CBR (ORN31) %	MOWS COMPLIANCE	ORN31 COMPLIANCE
Surface	0	20	The surface was double surface dressing with 10mm chip size. The surface was hard and dry.											
Base	20	140	The base was found to react with HCl, but not phenolphaline. The material was a very hard, damp, well graded, light orange brown, stabilised gravel base.	0.0	0	-	164	18	-	-	-		✗	✗
Subbase	140	295	The subbase was found not to react with HCl. The material was a hard, damp, well graded, brown sandy gravel.	-	-	-	72	NP	-	-			✓	✗
Subgrade	295	460+	The subgrade was found not to react with HCl. The material was a firm damp, moderately graded, orangey brown clayey sand.	-	-		22	15	-	-		6		

Road Maintenance and Rehabilitation Project

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Test Pit and Material Logging Investigation

Road Name: Chingeni - Liwonde
Road Code: 13.1
S.Length: 3
Date: 07/08/98

Chainage: 26.87 LHS
Location Number: L13.1/P30
Operator: JDR

Point Number: 30
GPS Co-ordinates: S 15 ' 1.566 " E 35 ' 7.729 "

General Description of Area

The road surface is cracked and rutted, with some patching. The road is founded on an embankment, through dry bush.

Layer	From (mm)	To (mm)	Material Description	Field Tests: MC (%)	Field Tests: % MDD	Field Tests: InSitu MDD (kg/m3)	Field Tests: CBR (DCP) %	Laboratory Results: PI (%)	Laboratory Results: OMC (%)	Laboratory Results: MDD (kg/m3)	Laboratory Results: CBR (Soaked) 98%	Laboratory Results: Estimated CBR (ORN31) %	MOWS COMPLIANCE	ORN31 COMPLIANCE
Surface	0	15	The surface was double surface dressing with 10mm chip size. The surface was hard and dry.											
Base	15	165	The base was found to react with HCl, but no colour change with phenolphaline was observed. The material was a hard, damp, well graded, orange brown, stabilised gravel base.	0.0	0	-	107	NP	10	2090	42		✗	✗
Subbase	165	275	The subbase was found not to react with HCl. The material was a hard, damp, well graded, light brownish orange, slightly gravely sandy silt.	-	-	-	118	22	-	-			✓	✗
Subgrade	275	600+	The subgrade was found not to react with HCl. The material was a firm damp, moderately graded, orangey brown clayey sandy silt..	-	-		41	21	-	-		11		

Road Maintenance and Rehabilitation Project

Test Pit and Material Logging Investigation

Roughton International

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Road Name: Liwonde - Zomba | Road Code: 13.2 | S.Length: 4 | Date: 07/08/98

Chainage: 43.86 LHS | Location Number: L13.2/P49 | Operator: JDR

Point Number: 49 | GPS Co-ordinates: S 15 ' 7.335 " E 35 ' 14.518 "

General Description of Area

The road surface is cracked and rutted, with some patching and slight deformation. The road is founded on an embankment, through dry bush.

Layer	From (mm)	To (mm)	Material Description	Field Tests: MC (%)	% MDD	InSitu MDD (kg/m3)	CBR (DCP) %	Laboratory Results: PI (%)	OMC (%)	MDD (kg/m3)	CBR (Soaked) 98%	Estimated CBR (ORN31) %	MOWS COMPLIANCE	ORN31 COMPLIANCE
Surface	0	20	The surface was double surface dressing with 10mm chip size. The surface was hard and dry.											
Base	20	165	The base was found to react with HCl, but no colour change with phenolphaline was observed. The material was a hard, damp, well graded, orange brown, with some greyish white decomposing granite, stabilised gravel base.	0.0	0	-	124	17	10	2116	13		✗	✗
Subbase	165	300	The subbase was found not to react with HCl. The material was a hard, damp, well graded, light brownish orange, slightly gravely silty sand with small nodules of black laterite.	-	-	-	87	14	-	-			✓	✗
Subgrade	300	600+	The subgrade was found not to react with HCl. The material was a firm damp, moderately graded, orangey brown clayey gravel.	-	-		39	19	-	-		22		

Road Maintenance and Rehabilitation Project

Test Pit and Material Logging Investigation

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Road Name: Liwonde - Zomba | Road Code: 13.2 | S.Length: 5 | Date: 08/08/98

Chainage: 66.93 RHS | Location Number: L13.2/P55 | Operator: JDR

Point Number: 55 | GPS Co-ordinates: S 15 ' 14.19 " E 35 ' 22.779 "

General Description of Area

The road surface is cracked and rutted, with some patching and slight deformation. The road is founded on an embankment, through dry bush.

Layer	From (mm)	To (mm)	Material Description	Field Tests: MC (%)	% MDD	InSitu MDD (kg/m3)	CBR (DCP) %	Laboratory Results: PI (%)	OMC (%)	MDD (kg/m3)	CBR (Soaked) 98%	Estimated CBR (ORN31) %	MOWS COMPLIANCE	ORN31 COMPLIANCE
Surface	0	40	The surface was asphalt with 5mm chip size. The surface was very hard and dry.											
Base	40	200	The base was found to react with HCl, but no colour change with phenolphaline was observed. The material was a hard, damp, well graded, orange brown, stabilised gravel base, with some laterite.	0.0	0	-	160	15	8	2242	64		✗	✗
Subbase	200	300	The subbase was found to react with HCl, but no colour change with phenolphaline was observed. The material was a hard, damp, well graded, yellowish orange clayey silty sandy gravel.	-	-	-	78	14	-	-			✓	✗
Subgrade	300	500+	The subgrade was found not to react with HCl. The material was a firm damp, moderately graded, light greyish orangey brown gravelly silty clay.	-	-		26	-	-	-		11		

Road Maintenance and Rehabilitation Project

Roughton International

Test Pit and Material Logging Investigation

in association with **Jatula Partners**

Road Name: Liwonde - Zomba | Road Code: 13.2 | S.Length: 6 | Date: 08/08/98

Chainage: 88.41 LHS | Location Number: L13.2/P85 | Operator: JDR

Point Number: 85 | GPS Co-ordinates: S 15 ' 22.35 " | E 35 ' 19.121 "

General Description of Area

The road surface is showing signs of ravelling, and is also deformed. It is formed at natural ground level, near bush and a flowing river.

Layer	From (mm)	To (mm)	Material Description	Field Tests: MC (%)	Field Tests: % MDD	Field Tests: InSitu MDD (kg/m3)	Field Tests: CBR (DCP) %	Laboratory Results: PI (%)	Laboratory Results: OMC (%)	Laboratory Results: MDD (kg/m3)	Laboratory Results: CBR (Soaked) 98%	Laboratory Results: Estimated CBR (ORN31) %	MOWS COMPLIANCE	ORN31 COMPLIANCE
Surface	0	20	The surface was double surface dressing with 10mm chip size. The surface was very hard and dry.											
Base	20	150	The base was found not to react with HCl. The material was a very hard, slightly damp, gap graded, orangey brown, slightly sandy laterite gravel..	0.0	0	-	404	20	10	2210	16		✗	✗
Subbase	150	250	The sub- base was found not to react with HCl. The material was a hard, damp, well graded, yellowish orange clayey silty sandy laterite.	-	-	-	72	-	-	-			✓	✗
Subgrade	250	400+	The subgrade was found not to react with HCl. The material was a firm damp, moderately graded, light greyish white weathered gneiss.	-	-		28	18	-	-		11		

Road Maintenance and Rehabilitation Project

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Test Pit and Material Logging Investigation

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Road Name: Liwonde - Mangochi | Road Code: 14.1 | S.Length: 1 | Date: 04/08/98

Chainage: 5.95 LHS | Location Number: L14.1/P00 | Operator: CSJ

Point Number: 0 | GPS Co-ordinates: S 15 ' 0.366 " | E 35 ' 10.391 "

General Description of Area

The road surface is cracked, rutted and patched. It is formed at natural ground level, through dry bush.

Layer	From (mm)	To (mm)	Material Description	Field Tests: MC (%)	Field Tests: % MDD	Field Tests: InSitu MDD (kg/m3)	Field Tests: CBR (DCP) %	Laboratory Results: PI (%)	Laboratory Results: OMC (%)	Laboratory Results: MDD (kg/m3)	Laboratory Results: CBR (Soaked) 98%	Laboratory Results: Estimated CBR (ORN31) %	MOWS COMPLIANCE	ORN31 COMPLIANCE
Surface	0	13	The surface was double surface dressing with 14mm chip size. The surface was very hard and dry.											
Base	13	110	The base was found not to react with HCl. The material was a very hard, slightly damp, well graded, light greyey brown, crushed stone base with 40mm gneiss aggregate.	0.0	0	-	-	9	-	-	-		✗	✗
Subbase	110	260	The sub- base was found not to react with HCl. The material was a hard, damp, moderately graded, light brown sandy gravel.	-	-	-	-	-	-	-			✗	✗
Subgrade	260	350+	The subgrade was found not to react with HCl. The material was a firm damp, poorly graded, brown gravely clay.	-	-		-	18	-	-		-		

Road Maintenance and Rehabilitation Project

Test Pit and Material Logging Investigation

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Road Name: Liwonde - Mangochi   Road Code: 14.1   S.Length: 2   Date: 04/08/98

Chainage: 13.69 LHS   Location Number: L14.1/P24   Operator: CSJ

Point Number 24   GPS Co-ordinates: S 14 ' 55.952 " E 35 ' 11.271 "

General Description of Area

The road surface is cracked, rutted and patched. It is formed at natural ground level, through dry bush.

Layer	From (mm)	To (mm)	Material Description	Field Tests				Laboratory Results						
				MC (%)	% MDD	InSitu MDD (kg/m3)	CBR (DCP) %	PI (%)	OMC (%)	MDD (kg/m3)	CBR (Soaked) 98%	Estimated CBR (ORN31) %	MOWS COMPLIANCE	ORN31 COMPLIANCE
Surface	0	60	The surface was double surface dressing with 14mm chip size. The surface was very hard and dry.											
Base	60	140	The base was found not to react with HCl. The material was a very hard, slightly damp, well graded, light greyey brown, crushed stone base with 70mm gneiss aggregate.	0.0	0	-	-	20	-	-	-		✗	✗
Subbase	140	200	The sub- base was found not to react with HCl. The material was a hard, damp, moderately graded, light brown sandy gravel.	-	-	-	-	14	-	-			✗	✗
Subgrade	200	290+	The subgrade was found not to react with HCl. The material was a firm damp, poorly graded, brown gravely clay.	-	-		-	NP	-	-		6		

Road Maintenance and Rehabilitation Project

Test Pit and Material Logging Investigation

Roughton International

in association with **Jatula Partners**

Road Name: Liwonde - Mangochi | Road Code: 14.1 | S.Length: 3 | Date: 04/08/98

Chainage: 44.46 LHS | Location Number: L14.1/P32 | Operator: AD

Point Number: 32 | GPS Co-ordinates: S 14 ' 43.27 " E 35 ' 10.456 "

General Description of Area

The road surface is cracked, deformed, rutted and patched. It is formed at natural ground level, through dry bush.

Layer	From (mm)	To (mm)	Material Description	Field Tests: MC (%)	% MDD	InSitu MDD (kg/m3)	CBR (DCP) %	Laboratory Results: PI (%)	OMC (%)	MDD (kg/m3)	CBR (Soaked) 98%	Estimated CBR (ORN31) %	MOWS COMPLIANCE	ORN31 COMPLIANCE
Surface	0	15	The surface was a double surface dressing. It was hard and dry.											
Base	15	160	The base was found not to react with HCl. The material was a hard, damp, well graded greyish brown, crushed gneiss base.	0.0	0	-	188	17	-	-	7		✗	✗
Subbase	160	380	The sub- base was found not to react with HCl. The material was a firm, damp, very silty very sandy brown clay with fragments of decomposed granitic gneiss.	-	-	-	68	16	-	-			✓	✗
Subgrade	380	510	The subgrade was found not to react with HCl. The material was a moist dark brown silty sandy clay, with occasional yellow angular gravel.											
Subgrade II	510	610+	The lower subgrade was found to be a soft dark grey, black silty clay with some organic matter.	-	-		15	20	-	-		11		

Road Maintenance and Rehabilitation Project

Test Pit and Material Logging Investigation

Roughton International

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Road Name: Mangochi - Monkey Bay | Road Code: 14.2 | S.Length: 5 | Date: 05/08/98

Chainage: 86.71 LHS | Location Number: L14.2/P15 | Operator: CSJ

Point Number 15 | GPS Co-ordinates: S 14 ' 25.682 " E 35 ' 13.015 "

General Description of Area

The road surface is cracked, deformed, rutted and patched. It is formed at natural ground level, through dry bush.

Layer	From (mm)	To (mm)	Material Description	Field Tests: MC (%)	% MDD	InSitu MDD (kg/m3)	CBR (DCP) %	Laboratory Results: PI (%)	OMC (%)	MDD (kg/m3)	CBR (Soaked) 98%	Estimated CBR (ORN31) %	MOWS COMPLIANCE	ORN31 COMPLIANCE
Surface	0	25	The surface was a double surface dressing with 15mm chip size. It was hard and dry.											
Base	25	210	The base was found to react with HCl, but no colour change with phenolphaline was observed. The material was a hard, damp, gap graded brown sandy gravel.	0.0	0	-	-	NP	9	2176	36		✗	✗
Subbase	210	720	The sub- base was found not to react with HCl. The material was a hard, damp, moderately graded, dark brown sandy clay.	-	-	-	-	26	-	-			✗	✗
Subgrade	720	720+	Not located	-	-		-	-	-	-		22		

Road Maintenance and Rehabilitation Project

Roughton International

Test Pit and Material Logging Investigation

in association with **Jatula Partners**

Road Name: Mangochi - Monkey Bay   Road Code: 14.2   S.Length: #N/A   Date: 05/08/98

Chainage: #N/A LHS   Location Number: L14b/P15   Operator: CSJ

Point Number: 15   GPS Co-ordinates: #N/A   #N/A

General Description of Area

The road surface is cracked, deformed, rutted and patched. It is formed at natural ground level, through dry bush.

Layer	From (mm)	To (mm)	Material Description	Field Tests: MC (%)	Field Tests: % MDD	Field Tests: InSitu MDD (kg/m3)	Field Tests: CBR (DCP) %	Laboratory Results: PI (%)	Laboratory Results: OMC (%)	Laboratory Results: MDD (kg/m3)	Laboratory Results: CBR (Soaked) 98%	Laboratory Results: Estimated CBR (ORN31) %	MOWS COMPLIANCE	ORN31 COMPLIANCE
1	0	70	A hard reddish brown, gravelly, sandy, clayey silt.											
2	70	180	A stiff dark drown, silty clay.	0.0	0	-	193	16	8	2195	35		✗	✗
3	180	310	A hard greenish grey, very silty sandy carbonaceous natural clay	-	-	-	85	13	-	-			✓	✗
				-	-		31	14	-	-		11		

Road Maintenance and Rehabilitation Project

Test Pit and Material Logging Investigation

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Road Name: Mangochi - Monkey Bay   Road Code: 14.2   S.Length: 6   Date: 05/08/98

Chainage: 98.30 RHS   Location Number: L14.2/P27   Operator: CSJ

Point Number 27   GPS Co-ordinates: S 14 ' 21.628 " E 35 ' 10.02 "

General Description of Area

The road surface is cracked, deformed, rutted, potholed and patched. It is formed at natural ground level, through dry bush.

Layer	From (mm)	To (mm)	Material Description	Field Tests: MC (%)	Field Tests: % MDD	Field Tests: InSitu MDD (kg/m3)	Field Tests: CBR (DCP) %	Laboratory Results: PI (%)	Laboratory Results: OMC (%)	Laboratory Results: MDD (kg/m3)	Laboratory Results: CBR (Soaked) 98%	Laboratory Results: Estimated CBR (ORN31) %	MOWS COMPLIANCE	ORN31 COMPLIANCE
Surface	0	25	The surface was a double surface dressing with 15mm chip size. It was hard and dry.											
Base	25	130	The base was found to react with HCl, but no colour change with phenolphaline was observed. The material was a hard, damp, gap graded greyish sandy gravel.	0.0	0	-	-	17	-	-	-		✗	✗
Subbase	130	185	The sub- base was found not to react with HCl. The material was a hard, damp, moderately graded, dark brown clay.	-	-	-	-	30	-	-			✗	✗
Old surface	185	195	Fine sand seal of old road, with 2 - 5 mm chippings											
Base	195	515+	An orangey brown sandy gravel, hard and slightly damp.	-	-		-	-	-	-		22		

Road Maintenance and Rehabilitation Project

Roughton International

Test Pit and Material Logging Investigation

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Road Name: Mangochi - Monkey Bay   Road Code: 14.2   S.Length: 7   Date: 05/08/98

Chainage: 111.99 RHS   Location Number: L14.2/P32   Operator: CSJ

Point Number 32   GPS Co-ordinates: S 14 ' 16.977 " E 35 ' 5.616 "

General Description of Area

The road surface is cracked, deformed, rutted, potholed and patched. It is formed at natural ground level, through dry bush.

Layer	From (mm)	To (mm)	Material Description	Field Tests				Laboratory Results						
				MC (%)	% MDD	InSitu MDD (kg/m3)	CBR (DCP) %	PI (%)	OMC (%)	MDD (kg/m3)	CBR (Soaked) 98%	Estimated CBR (ORN31) %	MOWS COMPLIANCE	ORN31 COMPLIANCE
Surface	0	20	The surface was a double surface dressing with 15mm chip size. It was hard and dry.											
Base	20	200	The base was found not to react with HCl. The material was a hard, damp, gap graded greyish brown gneiss crushed stone base.	0.0	0	-	-	17	-	-	-		✗	✗
Sub-Base	185	300	The subbase was found not to react with HCl. The material was a stiff reddish brown, silty sandy gravely clay.	-	-	-	-	30	-	-			✗	✗
Subgrade	300	410+	The subgrade was found not to react with HCl. The material was a stiff brownish clayey sand.	-	-		-	-	-	-		22		

Road Maintenance and Rehabilitation Project

Roughton International

Test Pit and Material Logging Investigation

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Road Name: Mangochi - Monkey Bay   Road Code: 14.2   S.Length: 8   Date: 06/08/98

Chainage: 128.30 LHS   Location Number: L14.2/P57   Operator: AD

Point Number 48   GPS Co-ordinates: S 14 ' 6.44 "   E 34 ' 55.066 "

General Description of Area

Gravel Road by point 48 on road 14b, 'The rutting was approx 20mm

Layer	From (mm)	To (mm)	Material Description	Field Tests				Laboratory Results						
				MC (%)	% MDD	InSitu MDD (kg/m3)	CBR (DCP) %	PI (%)	OMC (%)	MDD (kg/m3)	CBR (Soaked) 98%	Estimated CBR (ORN31) %	MOWS COMPLIANCE	ORN31 COMPLIANCE
Surface	0	20	The surface was a double surface dressing with 15mm chip size. It was hard and dry.											
Base	20	195	The base was found not to react with HCl. The material was a very, very hard, dry, reddish brown lateritic, silty, sandy, gravelly clay.	0.0	0	-	193	16	8	2195	35		✗	✗
Subbase	195	270	The sub- base was found not to react with HCl. The material was a hard, damp, dark brown clayey silt.	-	-	-	85	13	-	-			✓	✗
Subgrade	270	475+	The subgrade was found not to react with HCl. The material was a hard, damp, orangey brown sandy clayey silt. (same material as subbase but becoming less strong).	-	-		31	14	-	-		11		

Lab Sample Number	PERCENTAGE PASSING SCREENS (mm)													LL	PI	LS	PI FROM LS	AASHTO
	Description	37.5	26.5	19	13.2	9.5	4.75	2.36	0.6	0.425	0.3	0.15	0.075					
L01/P06/BC	Crushed Stone	100	77	55	42	34	23	18	14	13	11	10	7	N	NP	#N/A	#N/A	A-1-a(0)
L01/P23/BC	Crushed Stone	100	90	73	57	47	29	22	14	12	11	9	6	30	13	3.6	7.7	A-2-6(0)
L01/P49/BC	Crushed Stone	100	90	78	61	47	29	21	14	13	12	11	8	31	15	5	10.7	A-2-6(0)
L02.1/P00/BC	Crushed Stone	100	90	85	73	64	49	40	28	20	18	13	8	N	NP	#N/A	#N/A	A-1-a(0)
L02.1/P25/BC	Crushed Stone	97	93	82	71	59	41	33	23	19	16	10	5	N	NP	#N/A	#N/A	A-1-a(0)
L02.1/P59/BC	Crushed Stone	100	86	72	60	51	36	29	21	19	17	11	8	N	NP	#N/A	#N/A	A-1-a(0)
L02.1/P82/BC	Crushed Stone	100	96	78	69	63	53	44	27	24	21	17	12	27	11	2.1	4.5	A-2-6(0)
L02.2/P16/BC	Crushed Stone	100	95	87	81	76	61	52	38	33	31	24	18	28	13	5	10.7	A-2-6(0)
L02.2/P33/BC	Crushed Stone	100	96	81	69	61	47	40	26	23	20	15	11	N	16	3.5	7.5	A-2-4(0)
L02.2/P39/BC	Crushed Stone Macadam	98	87	67	55	43	31	26	18	16	14	11	8	28	12	3.6	7.7	A-2-6(0)
L03/P10/BC	Crushed Stone	100	91	81	69	63	46	37	26	21	18	11	6	N	NP	#N/A	#N/A	A-1-a(0)
L03/P11/BC	Crushed Stone	100	94	85	73	62	45	35	23	17	14	7	3	N	NP	#N/A	#N/A	A-1-a(0)
L03/P42/BC	Crushed Stone	100	95	86	79	72	55	46	32	22	18	10	5	N	NP	#N/A	#N/A	A-1-a(0)
L03/P66/BC	Crushed Stone	98	79	60	44	35	21	17	12	9	7	4	2	N	NP	#N/A	#N/A	A-1-a(0)
L04/P12/BC	Laterite/Quartz Gravel	100	97	90	83	73	63	56	50	44	38	36	32	53	31	12.9	27.5	A-2-7(4)
L04/P16/BC	Stab. Quartz Gravel	100	87	79	71	63	49	42	28	22	18	13	10	N	NP	#N/A	#N/A	A-1-a(0)
L04/P42/BC	Stab. Quartz Gravel		100	93	89	85	76	70	46	36	31	24	17	38	31	5.7	12.1	A-2-6(0)
L05/P02/BC	Crushed Stone	94	89	81	74	66	53	44	29	26	24	19	14	28	21	4.3	9.2	A-2-6(0)
L06/P08/BC	Clayey Sandy Gravel			100	99	96	83	73	52	45	39	28	19	29	14	5.7	12.1	A-2-6(0)
L06/P17/BC	"As Dug" Laterite Gravel		100	98	94	89	66	55	40	34	29	22	20	31	13	6	12.8	A-2-6(0)
L07/P10/BC	"As Dug" Laterite Gravel		100	99	97	91	68	51	32	28	24	20	16	35	19	86	183.2	A-2-6(0)
L07/P19/BC	"As Dug" Laterite Gravel		100	98	96	91	69	58	36	28	22	17	15	29	16	7.9	16.8	A-2-6(0)
L07/P36/BC	"As Dug" Laterite Gravel		100	99	97	93	76	60	37	29	24	17	12	24	13	3.6	7.7	A-2-6(0)
L08/P08/BC	"As Dug" Laterite Gravel		100	98	97	93	79	66	40	32	27	18	14	26	14	6.4	13.6	A-2-6(0)
L08/P24/BC	"As Dug" Laterite Gravel			100	98	97	84	69	44	37	33	26	21	35	25	7.9	16.8	A-2-6(1)
L09/P03/BC	Crushed Stone Macadam	100	92	78	67	57	40	31	15	13	11	8	4	N	NP	#N/A	#N/A	A-1-a(0)
L09/P24/BC	Crushed Stone Macadam	100	87	70	55	48	38	34	26	23	20	13	9	N	NP	#N/A	#N/A	A-1-a(0)
L09/P34/BC	Crushed Stone Macadam	100	97	81	64	55	43	36	23	16	14	8	5	N	NP	#N/A	#N/A	A-1-a(0)
L10/P10/BC	Crushed Stone	100	87	66	52	48	38	33	23	19	16	11	7	N	NP	#N/A	#N/A	A-1-a(0)
L10/P26/BC	Crushed Stone	82	50	41	27	22	14	11	9	8	7	5	3	27	11	3	6.4	A-2-6(0)
L10/P57/BC	Crushed Stone	97	74	63	57	51	40	35	26	23	18	13	10	N	15	#N/A	#N/A	A-1-a(0)
L11/P01/BC	Laterite Gravel		100	99	98	96	82	71	48	44	39	33	28	38	19	10.7	22.8	A-2-6(2)
L11/05/BC	Sandy Clay			100	100	99	91	85	66	56	45	29	17	NP	NP	#N/A	#N/A	A-2-4(0)
L11/15/BC	Sandy Clay				100	100	97	91	75	68	62	46	30	23	13	#N/A	#N/A	A-2-6(1)
L12.1/P44/BC	Stab	100	80	59	49	40	30	26	19	17	14	9	5	N	NP	#N/A	#N/A	A-1-a(0)

Lab Sample Number	PERCENTAGE PASSING SCREENS (mm)													LL	PI	LS	PI FROM LS	AASHTO
	Description	37.5	26.5	19	13.2	9.5	4.75	2.36	0.6	0.425	0.3	0.15	0.075					
L12.1/P71/BC	Crushed Stone	95	84	79	73	69	55	46	33	29	24	15	19	N	NP	#N/A	#N/A	A-1-b(0)
L12.2/P05/BC	Stab Sandy Gravel	100	99	96	89	83	75	62	44	38	21	21	16	30	15	3.6	7.7	A-2-6(0)
L13.1/P07/BC	Stab Gravel	100	94	83	76	65	48	36	22	18	14	9	5	N	NP	#N/A	#N/A	A-1-a(0)
L13.1/P19/BC	Stab Gravel				100	98	89	80	48	39	34	25	18	36	18	5	10.7	A-2-6(0)
L13.1/P30/BC	Stab Gneiss Gravel			100	99	97	88	77	50	42	35	23	15	N	NP	#N/A	#N/A	A-1-b(0)
L13.2/P49/BC	Stab Gneiss Gravel		100	99	99	96	79	61	39	29	26	23	21	38	17	7.1	15.1	A-2-6(0)
L13.2/P55/BC	Stab Laterite Gravel		100	98	94	87	65	54	36	31	28	22	17	27	15	5.7	12.1	A-2-6(0)
L13.2/P85/BC	"As Dug" Laterite Gravel			100	100	98	81	65	44	38	33	26	22	37	20	12.1	25.8	A-2-6(1)
L14.1/P00/BC	Crushed Stone	100	95	80	65	63	51	42	29	25	22	15	9	24	9	#N/A	#N/A	A-1-9(0)
L14.1/P24/BC	Crushed Stone	100	89	86	83	78	70	64	46	40	35	24	18	37	20	9.3	19.8	A-2-6(0)
L14.1/P32/BC	Crushed Stone	100	94	80	71	66	55	47	32	27	23	15	9	36	17	#N/A	#N/A	A-1-9(0)
L14.2/P15/BC	Stab Sandy Gravel	100	98	98	95	92	79	66	39	30	25	19	14	N	NP	#N/A	#N/A	A-1-b(0)
L14.2/P27/BC	Stab Sandy gravel	100	99	98	97	96	93	87	51	41	35	28	23	33	17	7.1	15.1	A-2-6(1)
L14.2/P57/BC	Clayey Lat Gravel Sand					100	98	92	71	64	58	40	29	35	16	7.1	15.1	A-2-6(1)
L15/P02/BC	Crushed Stone Macadam	96	86	79	73	68	59	54	43	38	32	22	16	28	16	5	10.7	A-2-6(0)
L15/P35/BC	Crushed Stone Macadam	90	75	59	51	45	37	33	23	19	15	10	6	N	NP	#N/A	#N/A	A-1-a(0)
L15/P54/BC	Crushed Stone Macadam	90	77	64	57	53	45	39	25	21	17	11	6	N	NP	#N/A	#N/A	A-1-a(0)

Lab Sample Number	PERCENTAGE PASSING SCREENS (mm)													LL	PI	LS	PI FROM LS	AASHTO
	Description	37.5	26.5	19	13.2	9.5	4.75	2.36	0.6	0.425	0.3	0.15	0.075					
L01/P06/SB	Laterite/Quartz Gravel	100	98	95	92	88	77	69	49	38	29	20	8	N	NP	#N/A	#N/A	A-1-b(0)
L01/P23/SB	Laterite/Quartz Gravel	69	54	52	45	41	30	25	17	14	13	10	8	30	13	5.7	12.1	A-2-6(0)
L01/P49/SB	Laterite/Quartz Gravel	96	93	92	89	86	78	70	45	40	37	33	30	60	30	20	42.6	A-2-7(3)
L02.1/P00/SB	Gravelly Clay		100	100	96	93	82	75	60	56	52	42	37	42	21	12.9	27.5	A-7-6(5)
L02.1/P25/SB	Clayey Quartz Gravel			100	99	97	87	77	68	56	45	36	29	40	19	8.6	18.3	A-2-6(1)
L02.1/P59/SB	Clayey Quartz Gravel		100	99	98	91	66	54	43	40	36	29	24	21	8	1.4	3.0	A-2-4(0)
L02.1/P82/SB	Gravelly Clay				100	100	97	93	80	73	66	54	44	36	21	806	1716.8	A-6(5)
L02.2/P16/SB	Gravelly Clay					100	98	94	78	68	63	48	33	24	12	6	12.8	A-2-6(0)
L02.2/P33/SB	Gravelly Clay		100	97	96	95	93	89	74	69	66	58	49	40	23	8	17.0	A-6(8)
L02.2/P39/SB	Clayey Quartz Gravel	100	98	96	94	93	89	86	63	52	45	34	26	30	14	7.9	16.8	A-2-6(1)
L03/P10/SB	Clayey Quartz/Lat Gravel			100	99	95	80	69	53	47	41	31	23	24	9	7.9	16.8	A-2-4(0)
L03/P11/SB	Clayey Quartz Gravel	100	99	96	94	90	74	61	45	40	36	33	24	33	17	10	21.3	A-2-6(1)
L03/P42/SB	Gravelly Clay			100	98	96	87	79	63	63	57	45	43	40	20	11.4	24.3	A-6(5)
L03/P66/SB	Clayey Quartz Gravel			100	97	92	77	70	62	59	54	42	32	37	18	10.7	22.8	A-2-6(1)
L04/P12/SB	Sandy Gravel			100	99	98	84	73	56	50	45	36	29	44	21	10	21.3	A-2-7(2)
L04/P12/SB	Gravelly Clay			89	84	81	72	69	60	57	54	50	48	36	16	#N/A	#N/A	A-6(5)
L04/P42/SB	Gravelly Clay				100	99	98	98	86	72	63	48	41	37	17	#N/A	#N/A	A-6(3)
L05/P02/SB	Sandy Gravel	100	96	95	93	88	68	52	31	29	27	22	19	32	16	10	21.3	A-2-6(0)
L06/P08/SB	Gravelly Sand				100	99	88	75	54	46	39	28	19	34	17	5	10.7	A-2-6(0)
L06/P17/SB	Gravelly Sand			100	99	96	80	69	49	45	40	34	27	49	25	13.6	29.0	A-2-7(2)
L07/P10/SB	Silty Sand/Lat Gravel			100	95	90	69	54	37	32	29	24	20	38	19	14.3	30.5	A-2-6(1)
L07/P19/SB	Silty Sand/Lat Gravel					100	99	90	78	66	46	28	16	32	18	9.3	19.8	A-2-6(0)
L07/P36/SB	Lateritic Gravel		100	100	99	97	76	61	48	26	23	19	13	36	19	9.3	19.8	A-2-6(0)
L08/P08/SB	Lateritic Gravel	100	97	96	94	90	77	65	38	26	22	16	13	26	12	3.6	7.7	A-2-6(0)
L08/P24/SB	Lateritic Gravel	100	99	96	95	91	78	63	42	37	34	27	21	34	19	11.4	24.3	A-2-6(1)
L09/P03/SB	Silty Sand			100	98	97	85	70	57	50	46	37	29	32	16	7.9	16.8	A-2-6(1)
L09/P24/SB	Silty Sand			100	99	98	84	70	55	51	46	32	24	38	22	5.7	12.1	A-2-6(1)
L09/P34/SB	Quartz Gravel				100	98	87	79	61	53	46	34	25	30	15	6.4	13.6	A-2-6(1)
L10/P10/SB	Clayey Quartz Gravel	94	91	90	88	86	77	67	47	40	34	23	14	31	16	9.3	19.8	A-2-6(0)
L10/P26/SB	Sandy Gravel			100	99	98	96	92	59	48	42	29	20	37	16	5.7	12.1	A-2-6(0)
L10/P57/SB	Clayey Quartz Gravel		96	94	92	89	74	59	32	28	25	19	15	41	17	10.7	22.8	A-2-7(0)
L11/P01/SB	Gravelly Sand			100	99	97	95	87	70	58	43	27	17	23	15	4.3	9.2	A-2-6(0)
L12.1/P44/SB	Sandy Gravel	100	99	96	93	84	68	62	52	45	39	28	21	33	18	10	21.3	A-2-6(1)

Lab Sample Number	PERCENTAGE PASSING SCREENS (mm)													LL	PI	LS	PI FROM LS	AASHTO
	Description	37.5	26.5	19	13.2	9.5	4.75	2.36	0.6	0.425	0.3	0.15	0.075					
L12.1/P71/SB	Clayey Lat Gravel			100	100	99	94	76	33	25	22	20	18	44	28	10.7	22.8	A-2-7(0)
L12.2/P05/SB	Clayey Lat Gravel			100	99	92	82	65	41	32	23	16	10	41	22	10.7	22.8	A-2-7(0)
L13.1/P07/SB	Quartz Gravel		100	98	96	94	84	73	49	43	39	31	29	32	16	7.1	15.1	A-2-6(1)
L13.1/P19/SB	Sandy Gravel			100	98	96	91	83	59	50	42	31	23	N	NP	#N/A	#N/A	A-1-b(0)
L13.1/P30/SB	Sandy Gravel			100	98	94	82	71	45	38	32	22	14	29	22	5.7	12.1	A-2-6(0)
L13.2/P49/SB	Quartz/Lat Gravel			100	99	96	81	68	51	48	41	30	21	30	14	4.3	9.2	A-2-6(0)
L13.2/P55/SB	Clayey Sandy Gravel			100	98	96	79	64	43	38	34	27	21	26	14	5.3	11.3	A-2-6(0)
	Clayey Sandy Gravel																	
L14.1/P00/SB	Clayey Sandy Gravel																0.0	
L14.1/P24/SB	Clayey Sandy Gravel		100	99	98	96	90	84	62	53	47	35	27	32	14	8.6	18.3	A-2-6(1)
L14.1/P32/SB	Sandy Gravel	100	98	97	96	94	83	72	53	48	43	36	30	35	16	5	10.7	A-2-6(1)
	Sandy Gravel																	
L14.2/P15/SB	Sandy Gravel		100	93	92	92	90	88	63	52	45	34	26	43	26	8.6	18.3	A-2-7(2)
L14.2/P27/SB	Sandy Gravel		100	99	98	94	75	61	46	42	39	31	23	47	30	7.9	16.8	A-2-7(2)
L14.2/P48/SB	Sandy Gravel	100	99	97	96	93	84	75	49	41	34	25	20	N	NP	#N/A	#N/A	A-1-b(0)
L14.2/P57/SB	Clayey Sandy Gravel				100	100	98	92	71	64	58	40	29	26	13	2.1	4.5	A-2-6(0)
	Clayey Sandy Gravel																	
	Clayey Sandy Gravel																	
	Clayey Sandy Gravel																	
L15/P35/SB	Clayey Sandy Gravel	91	86	84	81	78	73	69	56	50	45	33	22	24	11	3.6	7.7	A-2-6(0)
L15/P54/SB	Clayey Sandy Gravel		100	100	98	93	75	65	43	31	25	20	14	24	11	3.6	7.7	A-2-6(0)
L16/P01/SB	Slightly Gravelly Clay	100	97	94	93	90	85	80	68	63	60	54	52	61	31	12.1	25.8	A-7(13)
L31/P08/SB	Quartz/Lat Gravel				100	100	94	82	52	43	35	26	19	35	19	6.4	13.6	A-2-6(0)
L32/P08/SB	ClayeyQuartz/Lat Gravel				100	99	88	77	60	51	45	28	21	31	17	3.6	7.7	A-2-6(0)

Lab Sample Number	PERCENTAGE PASSING SCREENS (mm)												LL	PI	LS	PI FROM LS	AASHTO	CLASS from PI ORN31	CBR from ORN31 PI	CLASS from PI (LS) ORN31	CBR from ORN31 PI (LS)
	Description	37.5	26.5	19	13.2	9.5	4.75	2.36	0.6	0.425	0.3	0.15	0.075									
L01/P23/SG	Silty Clay					100	100	98	93	85	75	61	52	36	16	11.4	24.3	A-6(5)	S4	11	S3	6
L02.1/P00/SG	Clayey Silty Sand						100	99	87	75	62	52	46	45	23	11.4	24.3	A-7-6(7)	S3	6	S3	6
L02.1/P25/SG	Clayey Silty Sand	100	98	95	93	88	71	51	44	40	36	29	24	51	27	12.9	27.5	A-2-7(2)	S3	6	S3	6
L02.1/P59/SG	Clayey Silty Sand					100	99	96	86	81	73	64	58	55	31	15	32.0	A-7-6(15)	S2	3.5	S2	3.5
L02.2/P16/SG	Clayey Silty Sand		100	99	98	98	93	88	70	62	56	45	34	32	16	4.3	9.2	A-2-6(1)	S4	11	S5	22
L03/P10/SG	Clayey Sand		100	95	91	88	83	77	61	55	49	39	31	50	28	10	21.3	A-2-7(3)	S3	6	S3	6
L03/P11/SG	Clayey Sand	100	95	93	91	90	86	84	77	73	70	61	48	48	24	12.4	26.4	A-7-6(8)	S3	6	S3	6
L03/P42/SG	Clayey Sand	100	96	96	95	93	88	77	61	56	53	42	35	54	35	5	10.7	A-2-7(4)	S2	3.5	S4	11
L03/P66/SG	Clayey Sand		100	99	97	93	77	70	61	58	53	42	32	52	34	15	32.0	A-2-7(3)	S2	3.5	S2	3.5
L04/P12/SG	Sandy Clay		100	99	98	98	96	95	71	62	58	49	42	48	28	13.6	29.0	A-7-6(7)	S3	6	S3	6
L04/P16/SG	Clayey Sand	100	93	86	78	68	51	43	33	30	27	21	18	36	17	10.7	22.8	A-2-6(0)	S4	11	S3	6
L04/P42/SG	Sandy Clay		100	97	97	97	95	94	90	87	83	71	59	48	28	10.7	22.8	A-7-6(13)	S3	6	S3	6
L05/P02/SG	Sandy Clay	100	97	97	94	94	89	84	70	66	63	56	49	42	24	12.1	25.8	A-7-6(8)	S3	6	S3	6
L06/P08/SG	Sandy Silt				100	100	98	95	86	77	61	49	41	40	21	11.4	24.3	A-6(4)	S3	6	S3	6
L06/P17/SG	Sandy Silt					100	99	96	76	70	62	46	36	33	18	6.4	13.6	A-6(2)	S4	11	S4	11
L07/P10/SG	Silty Sand	100	100	92	88	85	77	67	51	46	40	30	19	36	17	10	21.3	A-2-6(0)	S4	11	S3	6
L07/P19/SG	Silty Sand	100	96	95	94	94	91	87	73	60	54	33	22	36	17	8.6	18.3	A-2-6(1)	S4	11	S4	11
L07/P36/SG	Silty Sand			100	99	98	91	85	74	66	59	44	35	38	19	10.7	22.8	A-2-6(2)	S4	11	S3	6
L08/P08/SG	Sandy Clay		100	96	95	93	82	68	52	48	44	36	29	44	22	12.1	25.8	A-2-7(2)	S3	6	S3	6
L08/P24/SG	Sandy Clay					100	100	100	85	62	52	35	29	39	24	9.3	19.8	A-2-6(2)	S3	6	S4	11
L08/P24/SG	Sandy Clay				100	99	95	90	75	61	52	42	33	39	24	9.3	19.8	A-2-6(3)	S3	6	S4	11
L09/P03/SG	Gravelly Clay		100	99	98	98	90	85	75	68	59	55	50	38	19	12.1	25.8	A-6(6)	S4	11	S3	6
L09/P24/SG	Gravelly Clay				100	99	90	81	70	64	59	45	33	34	21	8.6	18.3	A-2-6(2)	S3	6	S4	11
L09/P34/SG	Gravelly Clay			100	99	98	96	93	80	76	67	56	45	42	22	10	21.3	A-7-6(6)	S3	6	S3	6
L10/P10/SG	Silty Sand		100	99	99	99	93	84	55	48	43	37	33	40	22	8.6	18.3	A-2-6(2)	S3	6	S4	11
L10/P26/SG	Silty Sand				100	94	88	81	57	47	39	24	10	50	28	14.3	30.5	A-2-7(0)	S3	6	S2	3.5
L10/P57/SG	Silty Clay		100	99	98	89	89	72	48	44	40	28	17	41	18	10.7	22.8	A-2-7(0)	S4	11	S3	6
L11/P01/SG	Clayey Sand			100	100	99	97	95	79	67	59	42	28	33	19	4.3	9.2	A-2-6(1)	S4	11	S5	22
L12.1/P44/SG	Clayey Sand			100	99	97	92	87	70	63	55	41	27	36	19	9.3	19.8	A-2-6(1)	S4	11	S4	11
L12.1/P71/SG	Clayey Sand		100	99	98	96	89	83	65	58	50	36	25	N	NP		0.0	A-1-b(0)	0	0	S5	22
L13.1/P07/SG	Clayey Sand				100	100	98	91	68	57	50	39	28	34	17		0.0	A-2-6(1)	S4	11	S5	22
L13.1/P19/SG	Clayey Sand			100	99	97	91	83	64	58	54	43	32	34	15	7.9	16.8	A-2-6(1)	S4	11	S4	11
L13.1/P30/SG	Clayey Sand			100	99	98	93	87	68	59	51	42	32	36	21	8.6	18.3	A-2-6(2)	S3	6	S4	11
L13.2/P49/SG	Clayey Sand			100	99	98	92	85	64	56	50	44	35	36	19	8.6	18.3	A-2-6(2)	S4	11	S4	11
L13.2/P85/SG	Clayey Sand		100	99	98	95	87	80	60	54	48	39	30	39	18	7.1	15.1	A-2-6(1)	S4	11	S4	11
L14.1/P00/SG	Gravelly Clay			100	100	98	93	88	68	50	39	31	24	35	18	7.1	15.1	A-2-6(1)	S4	11	S4	11
L14.1/P24/SG	Clayey Sand	100	99	96	93	89	82	75	56	49	43	27	19	N	NP	#N/A	#N/A	A-1-b(0)	0	0	0	0
L14.1/P32/SG	Clayey Sand				100	100	99	97	68	54	47	31	21	41	20	10.7	22.8	A-2-7(1)	S3	6	S3	6

Lab Sample Number	PERCENTAGE PASSING SCREENS (mm)													LL	PI	LS	PI FROM LS	AASHTO	CLASS from PI ORN31	CBR from ORN31 PI	CLASS from PI (LS) ORN31	CBR from ORN31 PI (LS)
	Description	37.5	26.5	19	13.2	9.5	4.75	2.36	0.6	0.425	0.3	0.15	0.075									
L14.1/P57/SG	Sandy Clay					100	99	95	80	75	71	62	49	28	12	7.9	16.8	A-6(4)	S4	11	S4	11
L14.2/P57/SG	Sandy Clay					100	99	97	73	65	58	46	35	30	14	6.4	13.6	A-2-6(10	S4	11	S4	11
L15/P02/SG	Sandy Clay		100	98	97	97	97	96	86	77	66	44	32	27	14	5.7	12.1	A-2-6(1)	S4	11	S4	11
L15/P54/SG	Clayey Sand	100	88	84	80	76	69	63	43	35	28	19	11	N	NP		0.0	A-1-b(0)	0	0	S5	22
L15/P54/SG	Clayey Sand	100	88	84	80	76	69	63	43	35	28	19	11	N	NP		0.0	A-1-b(0)	0	0	S5	22
L16/P01/SG	Clay			100	100	99	99	96	86	82	77	72	64	66	36	10	21.3	A-7(17)	S2	3.5	S3	6
L31/P08/SG	Clayey Sand				100	100	98	94	80	23	17	7	1	44	23	6.4	13.6	A-2-7(0)	S3	6	S4	11
L32/P08/SG	Sandy Clay				100	100	98	95	81	74	67	53	46	42	21	13.6	29.0	A-7-6(5)	S3	6	S3	6

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In association with
THE UNIVERSITY OF BIRMINGHAM
and
THE UNIVERSITY OF NOTTINGHAM

Report IV- Appendix II
Field Trials of Modified DCP Apparatus

DFID Department for International Development

February 2000

Appropriate and Efficient Maintenance of Low Cost Rural Roads

Report IV- Appendix II
Field Trials of Modified DCP Apparatus

February 2000

The University of Nottingham
School of Civil Engineering
University Park
Nottingham
NG7 2RD
United Kingdom
www.nottingham.ac.uk/p&g

Roughton International.
321 Millbrook Road West
Southampton
SO15 OHW
United Kingdom
www.roughton.com

University of Birmingham
School of Civil Engineering
Edgbaston
Birmingham
B15 2TT
United Kingdom
www.bham.ac.uk/CivEng/

DFID Department for International Development

Department for International Development
94 Victoria Street
London
SW1E 5JL
www.dfid.gov.uk

Department for International Development
Knowledge and Research (KaR) Programme

Project Title: Appropriate and Efficient Maintenance of Low Cost Rural Roads

DFID Project Reference: R6852

Subsector: *Transport*

Theme: T2

Element A: Review of Procedures, Standards and Methods

Date: *February 2000*

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Appendix II - Calculated Plots and Resilient Moduli

Deflection Bowl Results

These plots have been produced from the results obtained from the full deflection bowls. They provide a calculated Stiffness (Resilient Modulus) for each layer of the pavement.

Peak Deflection and Radius of Curvature Results

The peak deflection and radius of curvature are obtained from the deflection testing regime. From these results, calculations are performed to obtain a Stiffness (Resilient Modulus). The results are shown in this section.

Resilient Moduli :Tables of Calculation and Plots of Data

From the laboratory CBR results and the results obtained from the DCP testing, the relationships developed in Report III and IV are applied to transform these readings of CBR into mm/blow readings which are then correlated against the UK work at Bardon. This provides a Stiffness (Resilient Modulus) interpretation, which can then be compared against the radius of curvature and the deflection bowl stiffness', and the TRL stiffness equation.

Road Maintenance and Rehabilitation Project

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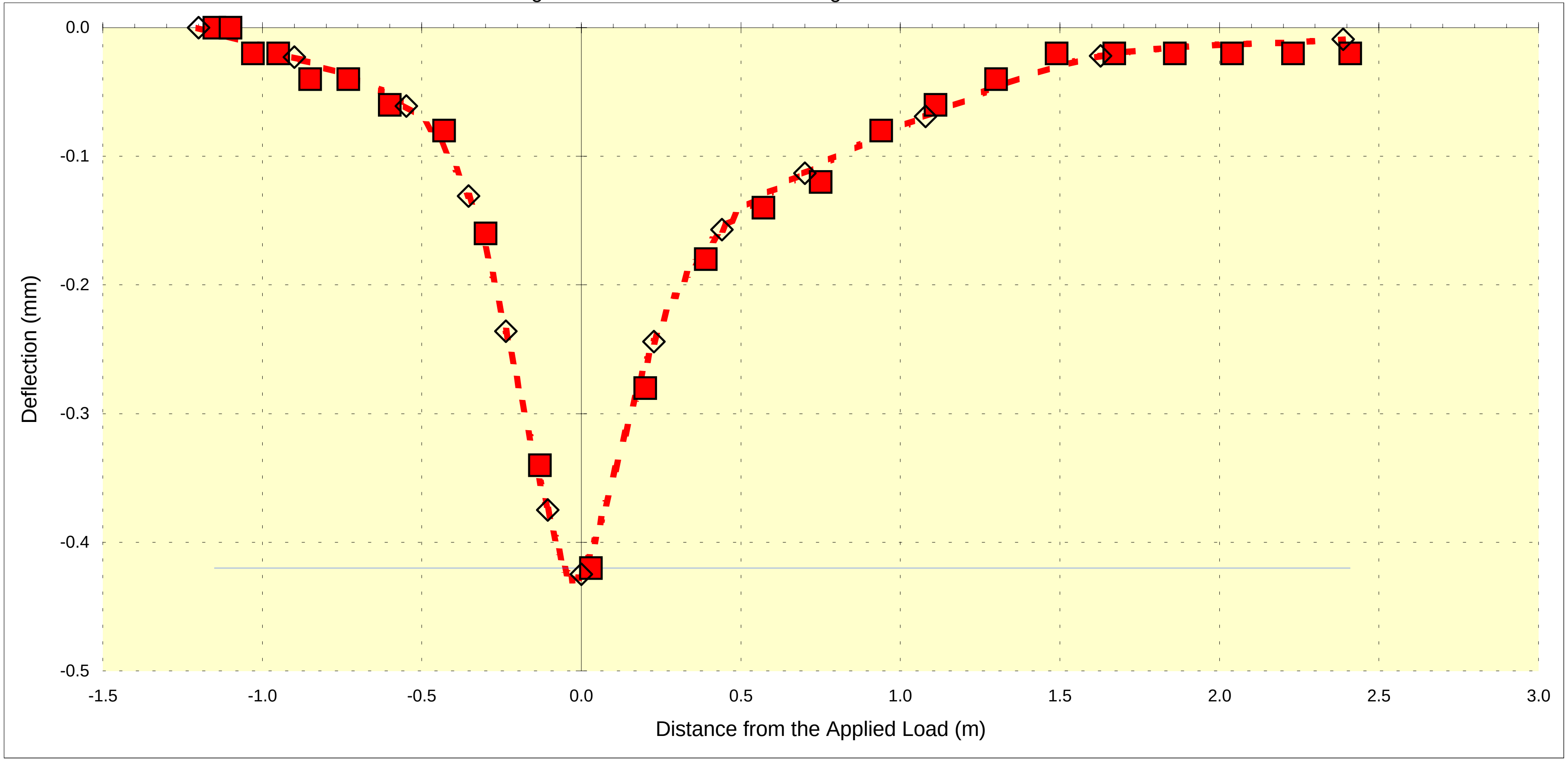
Deflection Bowl Test Results Road Name: Karonga - Songwe

Road Code: 1 Test Section: S.Length 1 Chainage: 3.3 Points: 20 -19



Existing Pavement Structure

Resultant	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
Movement	Layer Thickness (mm)	200	130	1000	Infinite	Layer Thickness (mm)	200	130	1000	Infinite
0.02 mm	- Mr (MPa)	163	65	130	1029	- Mr (MPa)	109	496	82	242

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Deflection Bowl Test Results Road Name: Karonga - Songwe

Road Code: 1 Test Section: S.Length 2 Chainage: 23.1 Points: 26 -25

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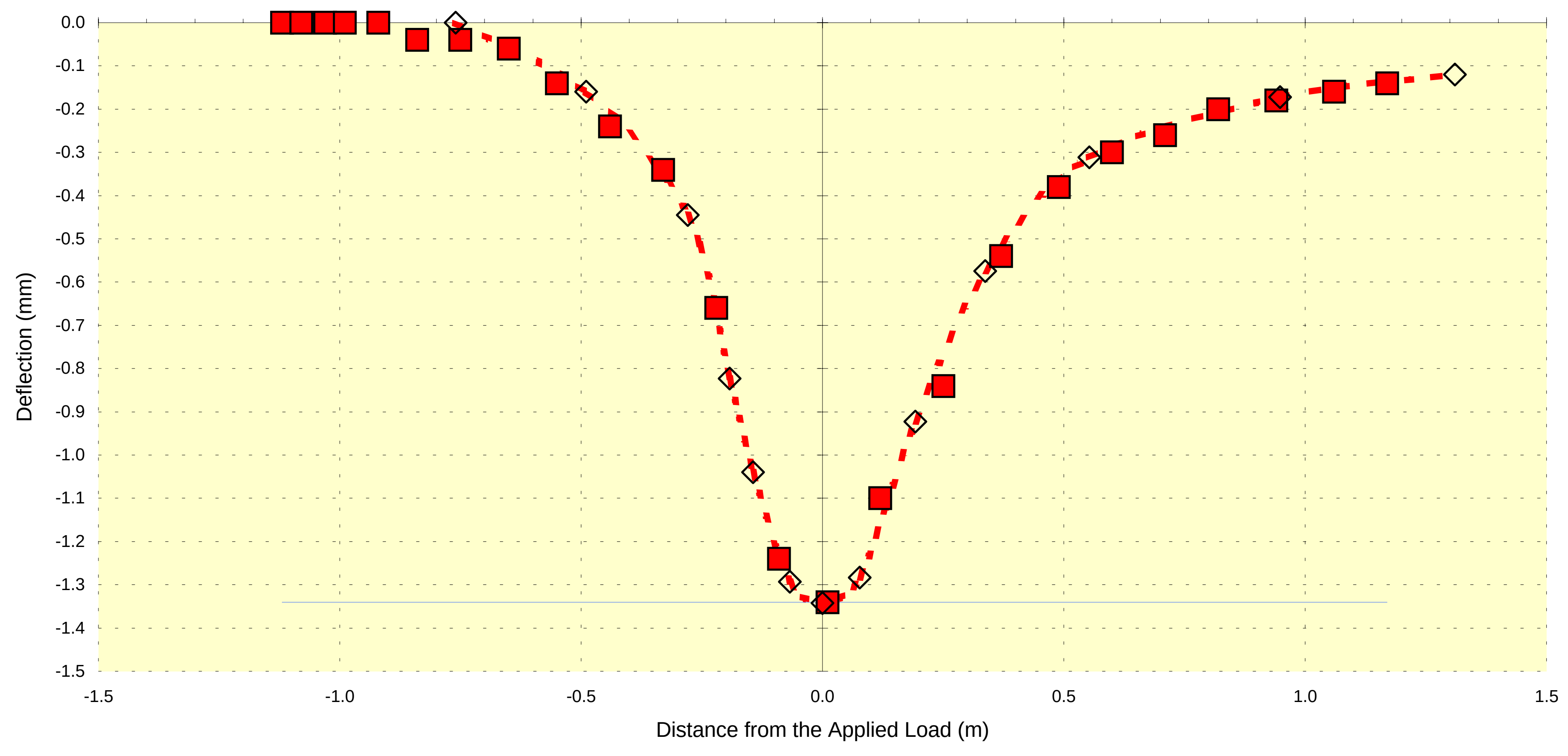

Existing Pavement Structure

Resultant	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
Movement	Layer Thickness (mm)	175	265	1000	Infinite	Layer Thickness (mm)	175	265	1000	Infinite
0.80 mm	- Mr (MPa)	30	36	33	5000	- Mr (MPa)	51	41	22	5000

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Deflection Bowl Test Results Road Name: Karonga - Songwe

Road Code: 1 Test Section: S.Length 3 Chainage: 30.8 Points: 46 -47

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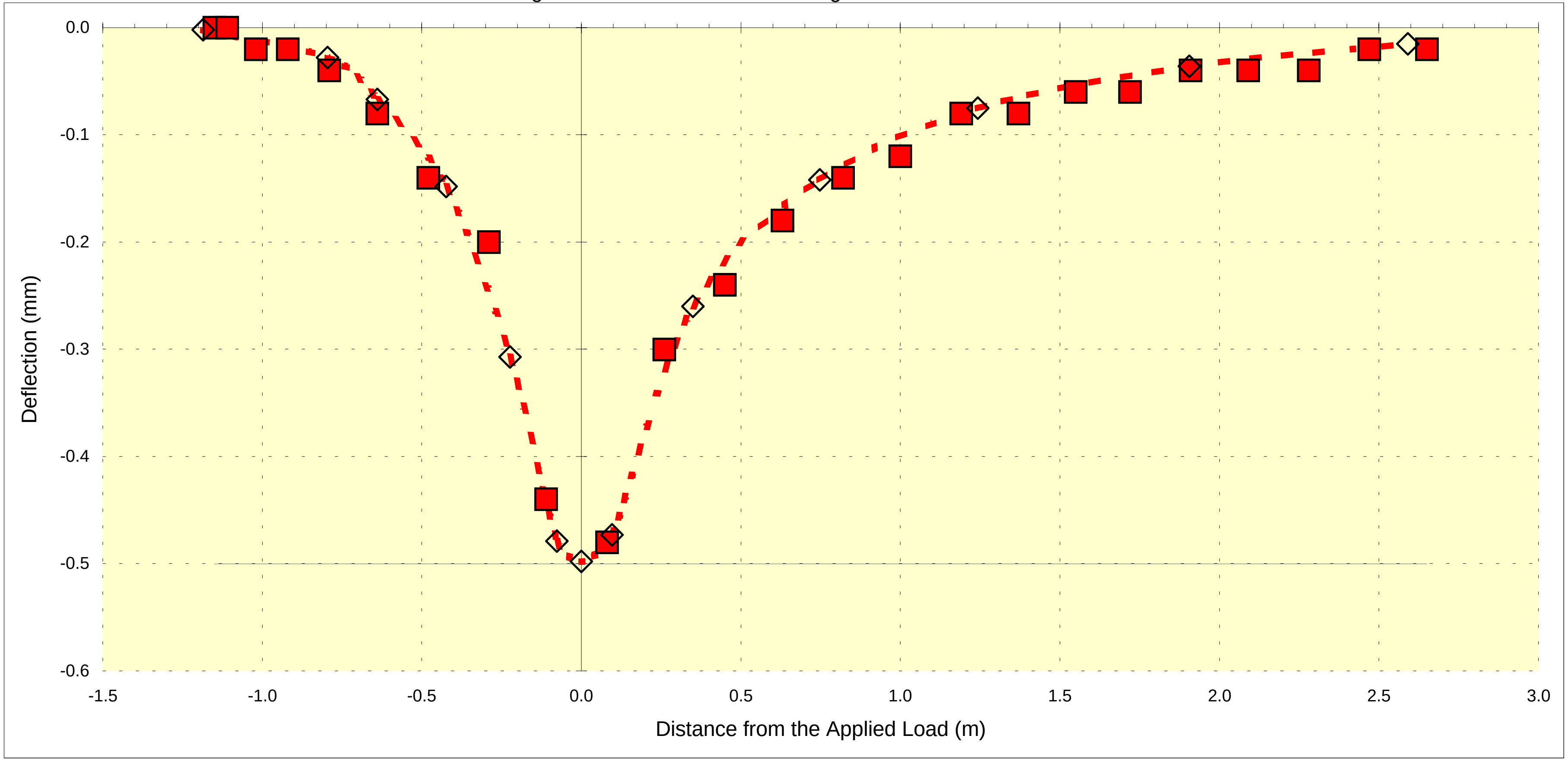

Existing Pavement Structure

Resultant	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
Movement	Layer Thickness (mm)	320	0	1000	Infinite	Layer Thickness (mm)	320	0	1000	Infinite
0.06 mm	- Mr (MPa)	255	67	82	1986	- Mr (MPa)	112	365	74	98

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Deflection Bowl Test Results Road Name: Mzuzu - Bwengu

Road Code: 2.1 Test Section: S.Length 1 Chainage: 5.6 Points: 0 -1

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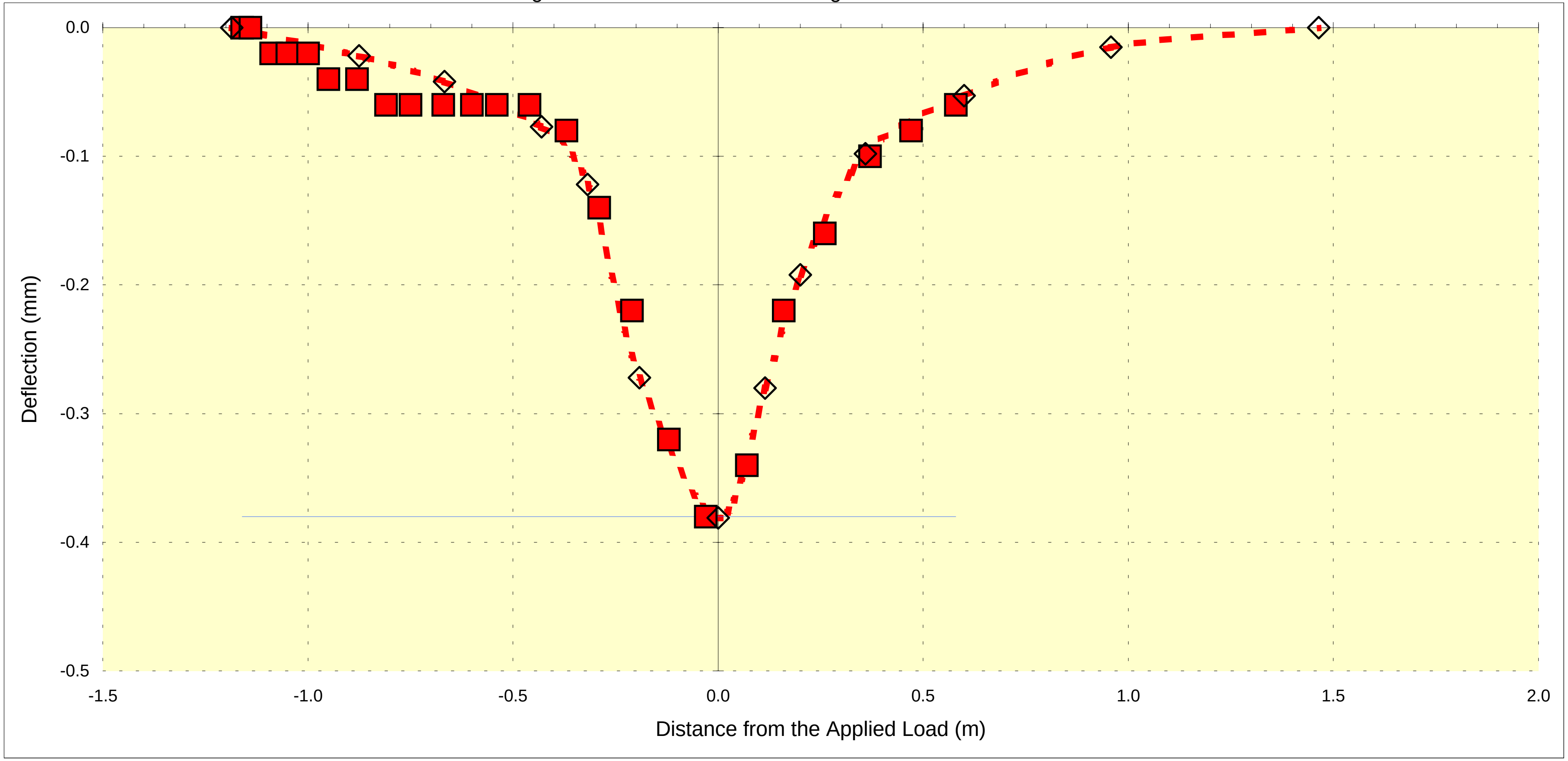

Existing Pavement Structure

Resultant	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
Movement	Layer Thickness (mm)	200	100	1000	Infinite	Layer Thickness (mm)	200	100	1000	Infinite
0.34 mm	- Mr (MPa)	151	73	154	965	- Mr (MPa)	78	313	146	600

Road Maintenance and Rehabilitation Project

Deflection Bowl Test Results Road Name: Mzuzu - Bwengu

Road Code: 2.1 Test Section: S.Length 2 Chainage: 12.1 Points: 18 -19

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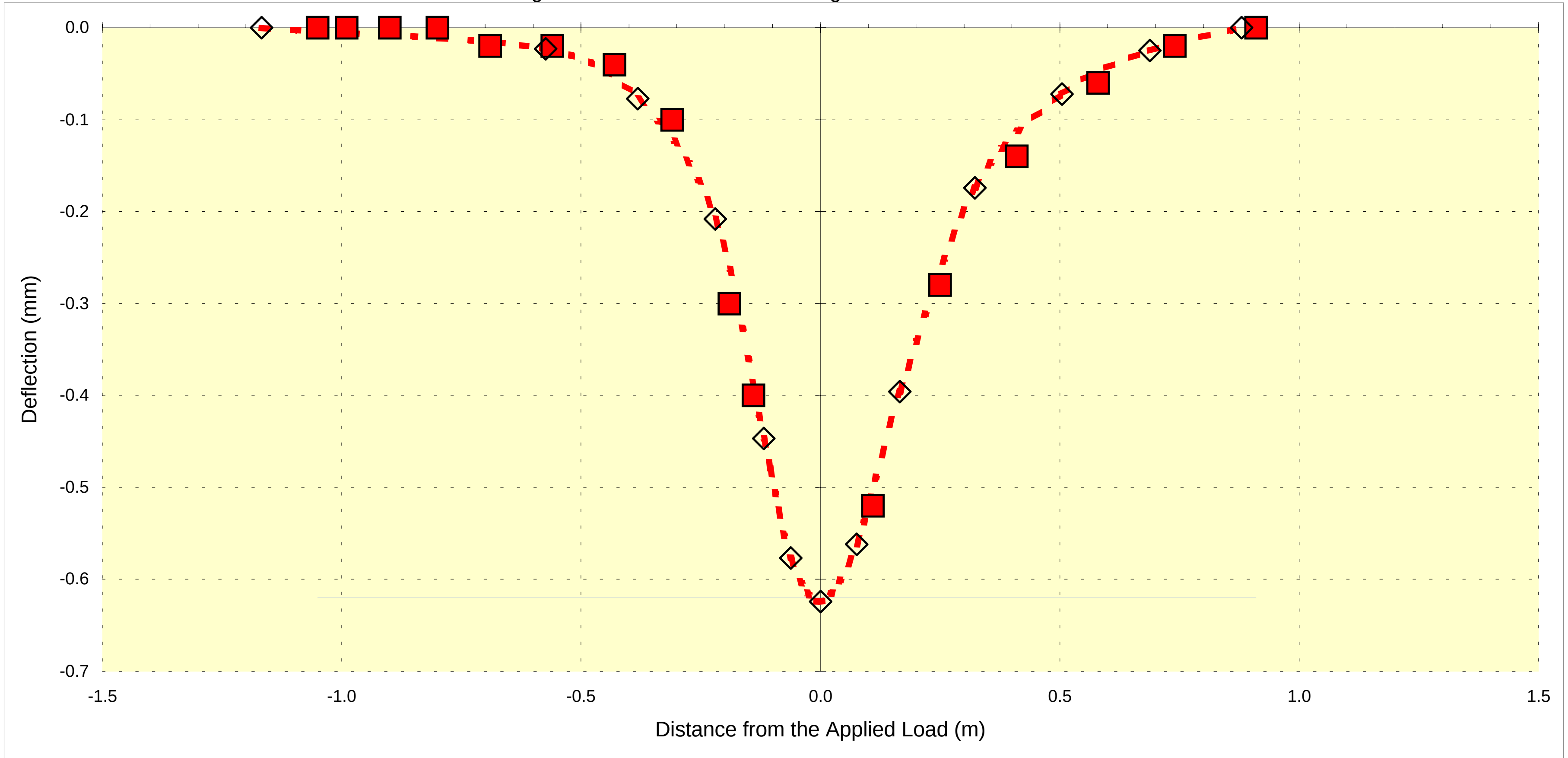

Existing Pavement Structure

Resultant	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
Movement	Layer Thickness (mm)	190	160	1000	Infinite	Layer Thickness (mm)	190	160	1000	Infinite
0.04 mm	- Mr (MPa)	75	36	283	768	- Mr (MPa)	87	52	97	5000

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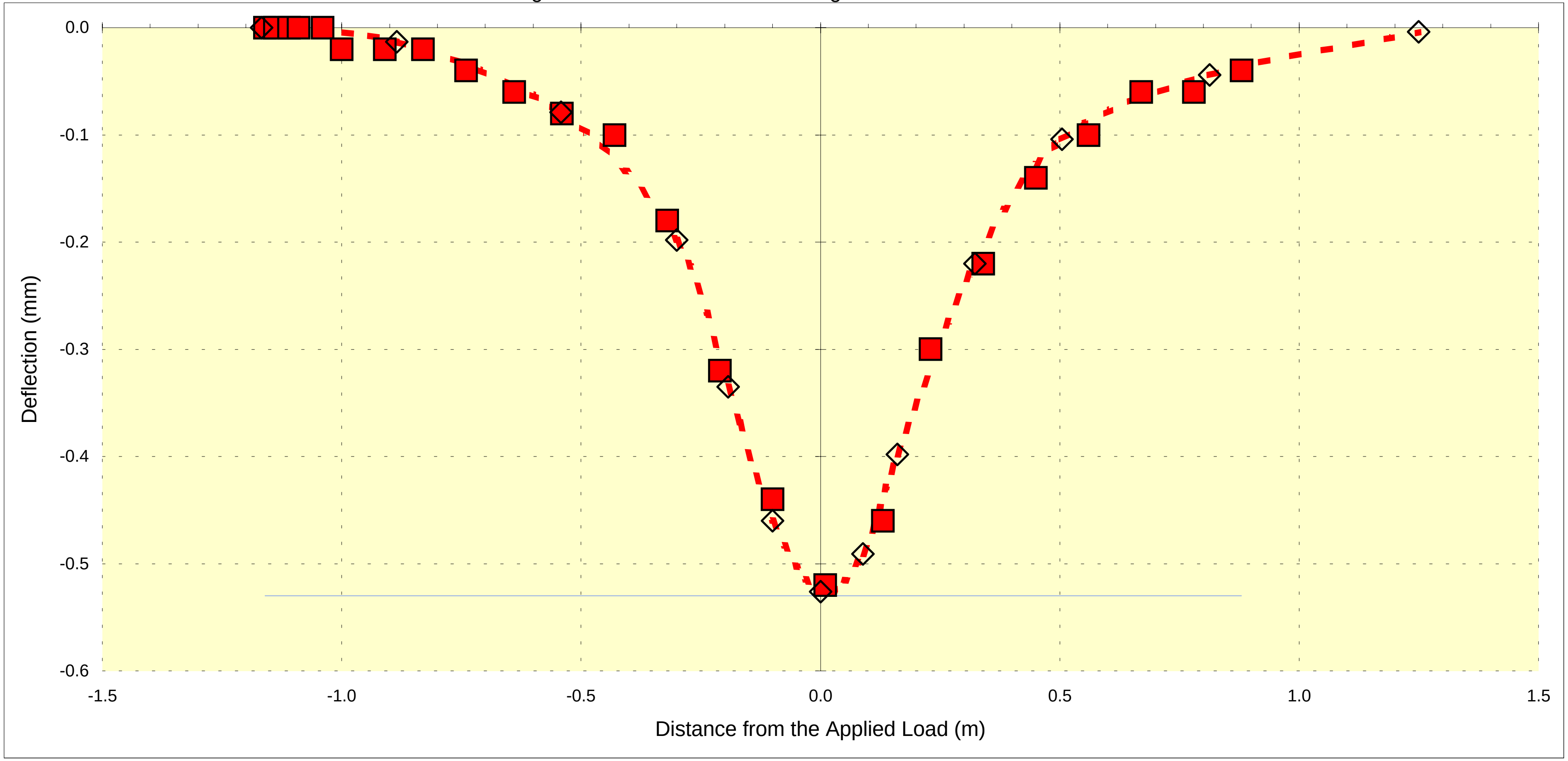
Deflection Bowl Test Results Road Name: Mzuzu - Bwengu

Road Code: 2.1 Test Section: S.Length 3 Chainage: 36.3 Points: 60 -61



Existing Pavement Structure

Resultant	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
Movement	Layer Thickness (mm)	175	200	1000	Infinite	Layer Thickness (mm)	175	200	1000	Infinite
0.50 mm	- Mr (MPa)	122	76	95	2194	- Mr (MPa)	282	45	107	908

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Deflection Bowl Test Results Road Name: Mzuzu - Bwengu

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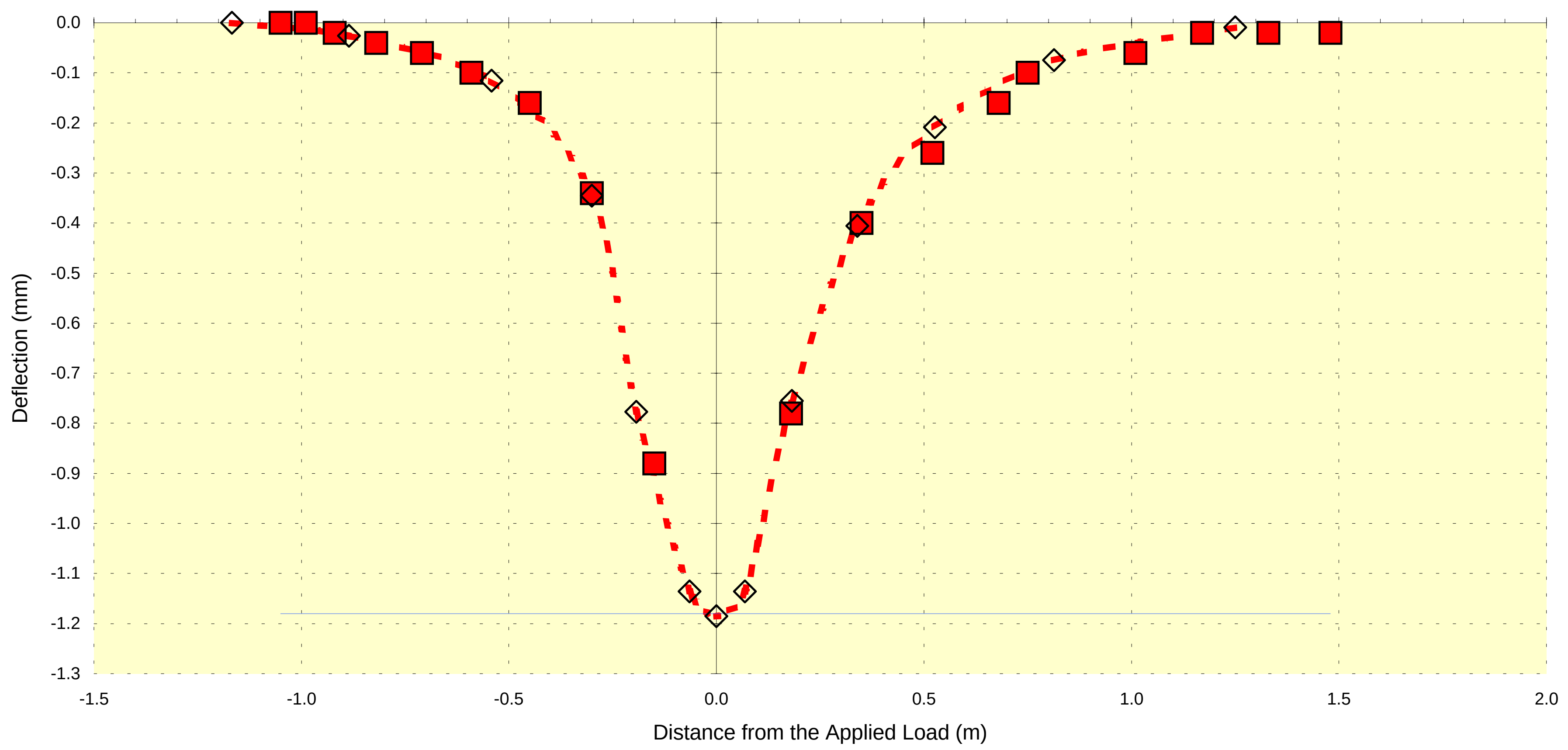
Road Code: 2.1 Test Section: S.Length 4 Chainage: 59.3 Points: 83 -84



Existing Pavement Structure

Resultant	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
Movement	Layer Thickness (mm)	210	100	1000	Infinite	Layer Thickness (mm)	210	100	1000	Infinite
0.14 mm	- Mr (MPa)	38	23	54	3400	- Mr (MPa)	48	43	35	5000

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Deflection Bowl Test Results Road Name: Bwengu - Chiweta

Road Code: 2.2 Test Section: S.Length 5 Chainage: 79.1 Points: 5 -6

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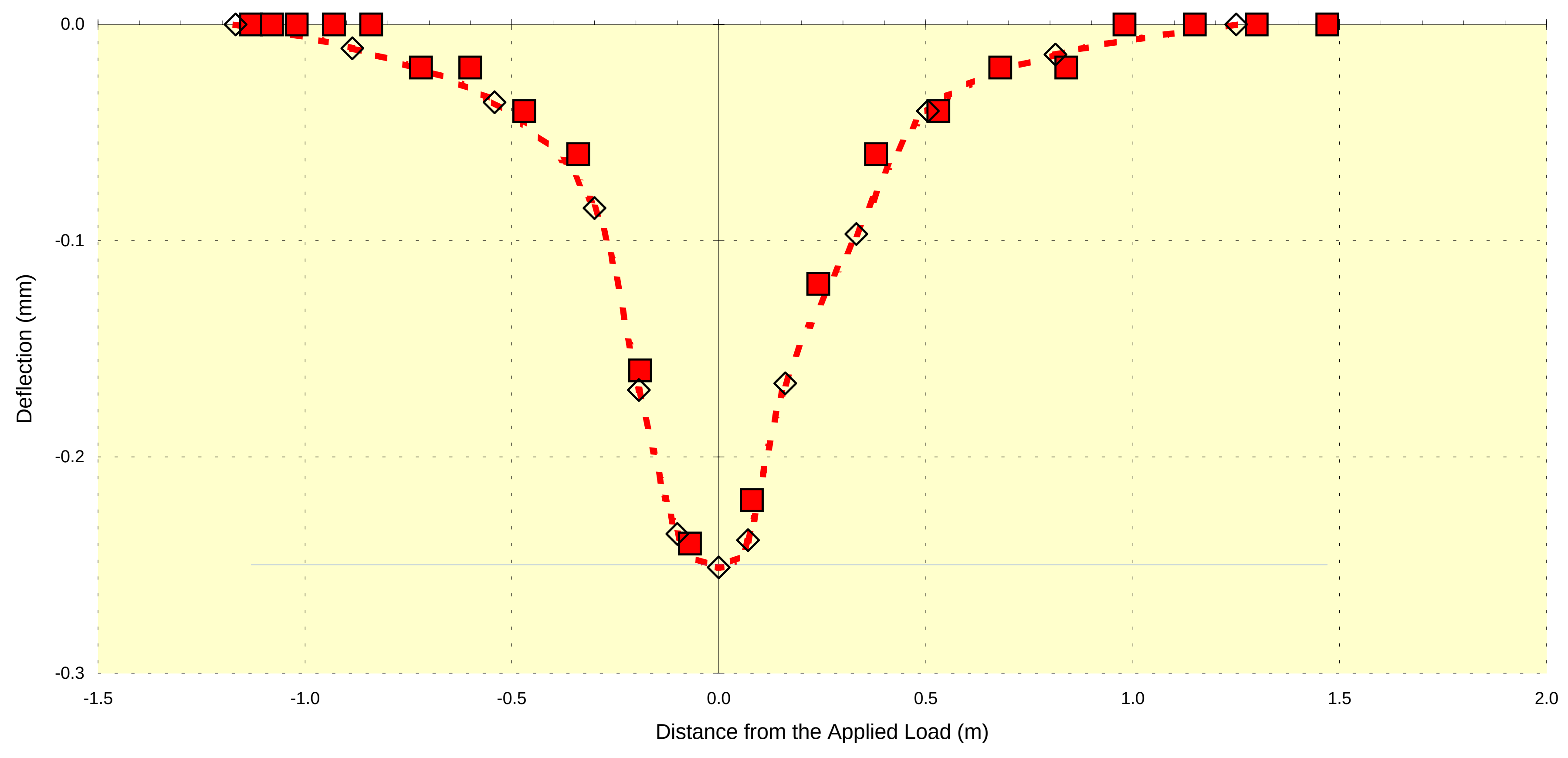

Existing Pavement Structure

Resultant	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
Movement	Layer Thickness (mm)	210	100	1000	Infinite	Layer Thickness (mm)	210	100	1000	Infinite
0.00 mm	- Mr (MPa)	199	122	252	883	- Mr (MPa)	207	98	284	723

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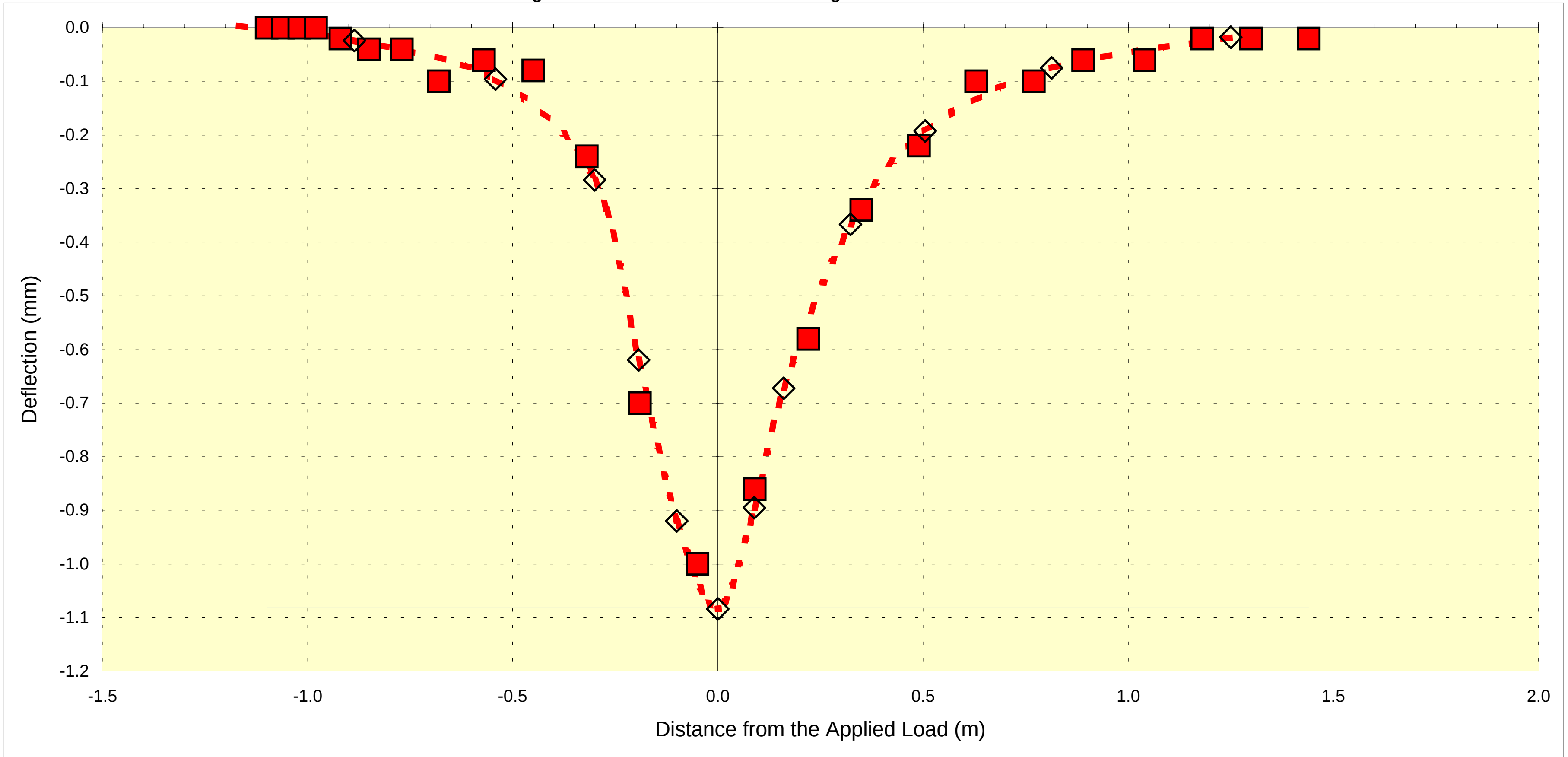
Deflection Bowl Test Results Road Name: Bwengu - Chiweta *in association with* **Jatula Partners**

Road Code: 2.2 Test Section: S.Length 6 Chainage: 102.2 Points: 28 -29



Existing Pavement Structure

Resultant	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
Movement	Layer Thickness (mm)	200	280	1000	Infinite	Layer Thickness (mm)	200	280	1000	Infinite
0.30 mm	- Mr (MPa)	33	41	77	3998	- Mr (MPa)	46	45	43	5000

Road Maintenance and Rehabilitation Project

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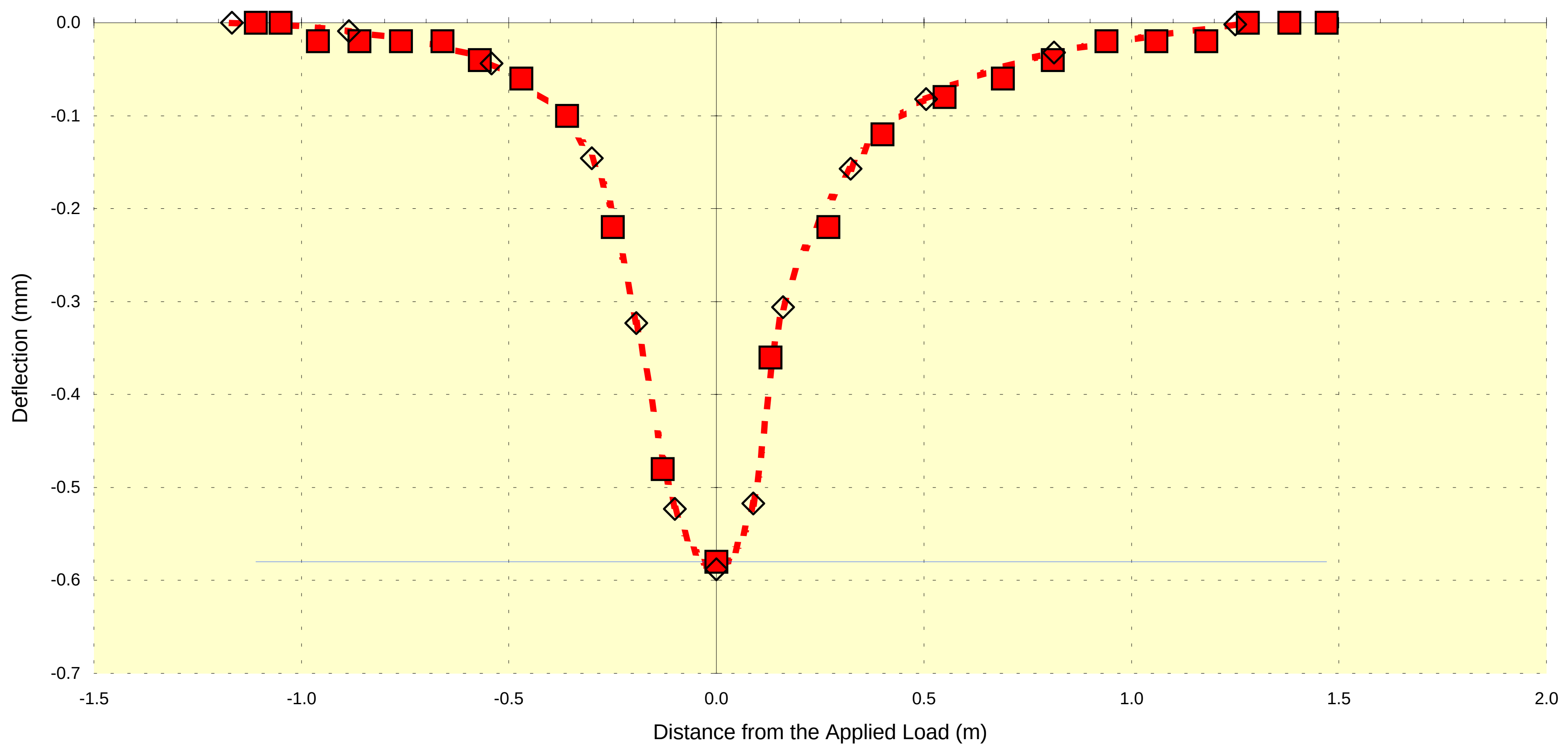
Deflection Bowl Test Results

Road Name: Bwengu - Chiweta

Road Code: 2.2   Test Section: S.Length 7   Chainage: 114.3   Points: 45 -46



Existing Pavement Structure

Resultant	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
Movement	Layer Thickness (mm)	195	105	1000	Infinite	Layer Thickness (mm)	195	105	1000	Infinite
0.04 mm	- Mr (MPa)	75	37	156	946	- Mr (MPa)	134	20	394	691

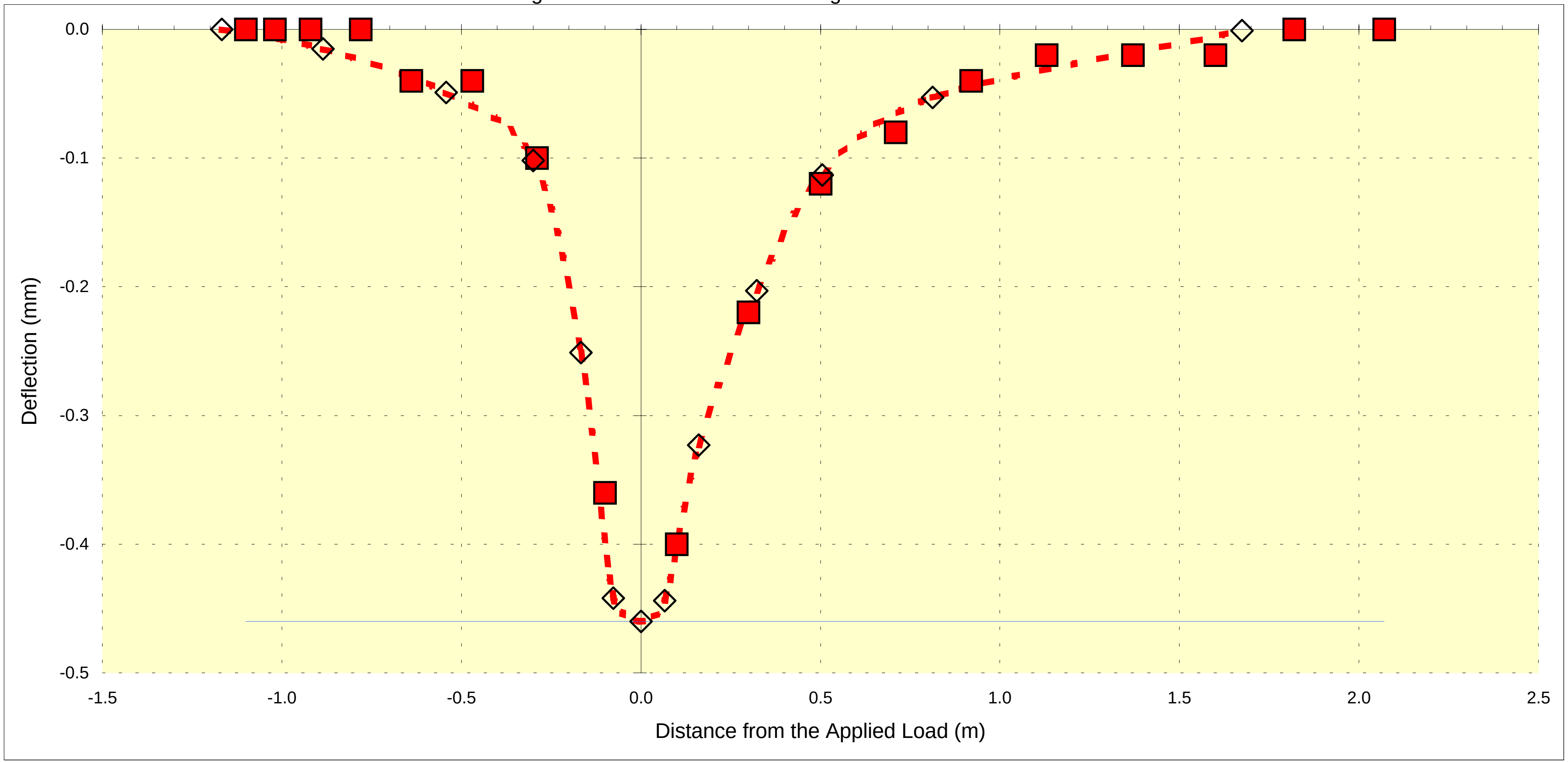
Road Maintenance and Rehabilitation Project

Deflection Bowl Test Results Road Name: Jenda - Chikangawa

Roughton International

in association with **Jatula Partners**

Road Code: 3 Test Section: S.Length 1 Chainage: 11.0 Points: 5 -6



Existing Pavement Structure

Resultant	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
Movement	Layer Thickness (mm)	200	100	1000	Infinite	Layer Thickness (mm)	200	100	1000	Infinite
0.08 mm	- Mr (MPa)	50	215	153	1052	- Mr (MPa)	169	90	88	464

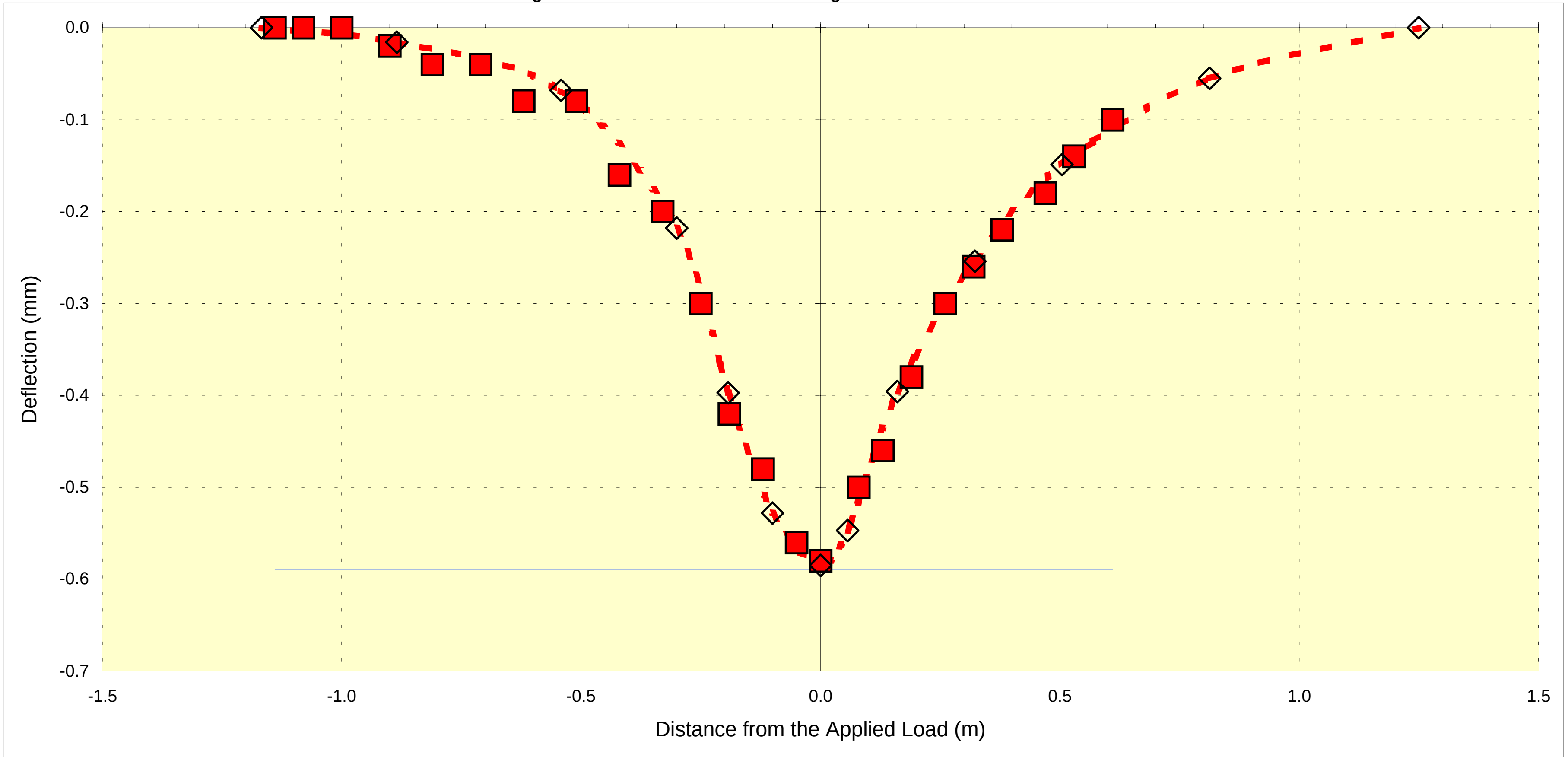
Road Maintenance and Rehabilitation Project

Deflection Bowl Test Results Road Name: Jenda - Chikangawa

Road Code: 3 Test Section: S.Length 2 Chainage: 25.3 Points: 21 -22

Roughton International

in association with **Jatula Partners**



Existing Pavement Structure

Resultant	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
Movement	Layer Thickness (mm)	180	130	1000	Infinite	Layer Thickness (mm)	180	130	1000	Infinite
0.42 mm	- Mr (MPa)	157	33	115	1070	- Mr (MPa)	115	132	56	2418

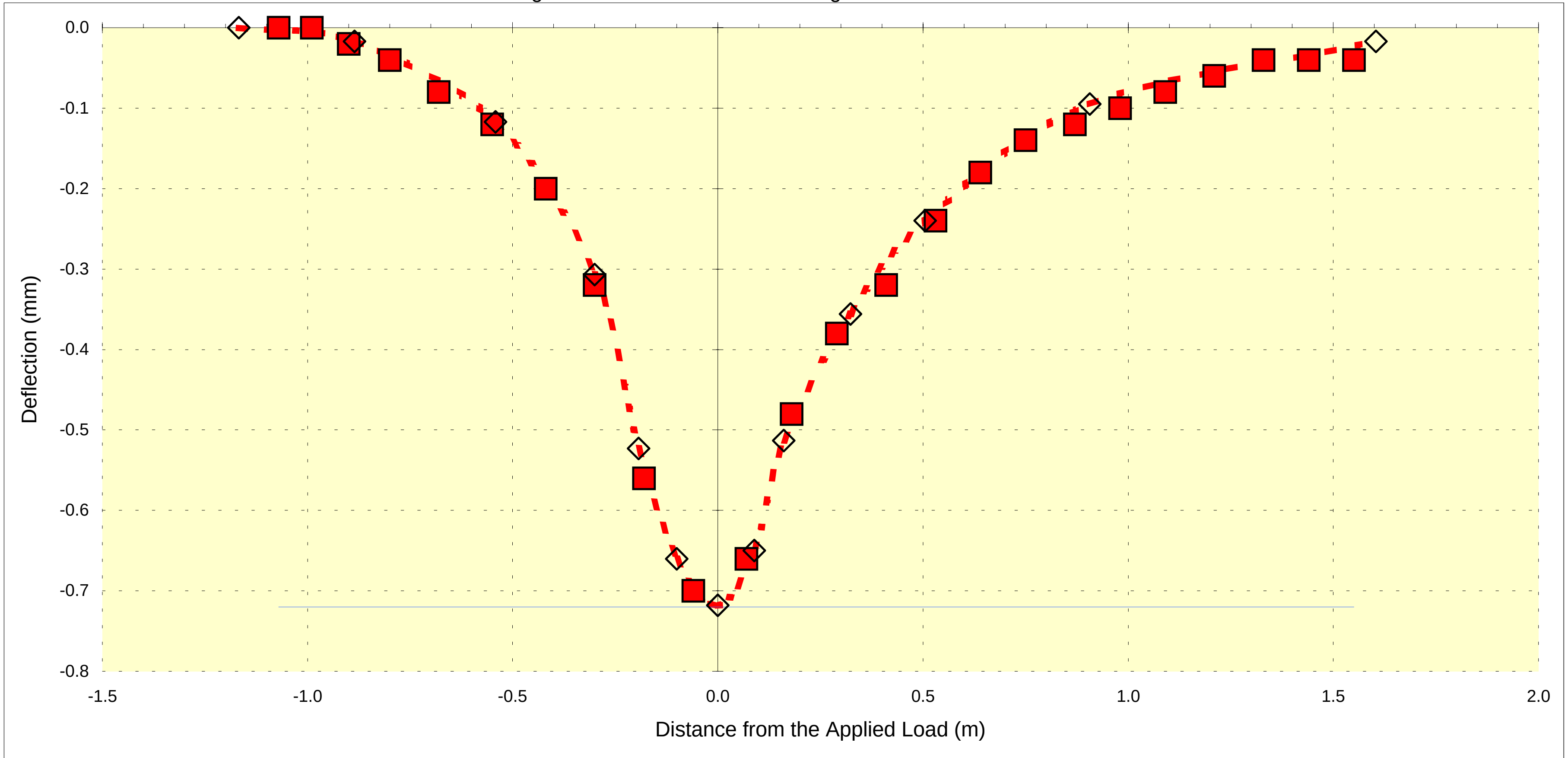
Road Maintenance and Rehabilitation Project

Roughton International

in association with **Jatula Partners**

Deflection Bowl Test Results Road Name: Jenda - Chikangawa

Road Code: 3 Test Section: S.Length 3 Chainage: 61.5 Points: 38 -39



Existing Pavement Structure

Resultant	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
Movement	Layer Thickness (mm)	230	100	1000	Infinite	Layer Thickness (mm)	230	100	1000	Infinite
0.02 mm	- Mr (MPa)	118	29	67	2957	- Mr (MPa)	79	605	35	532

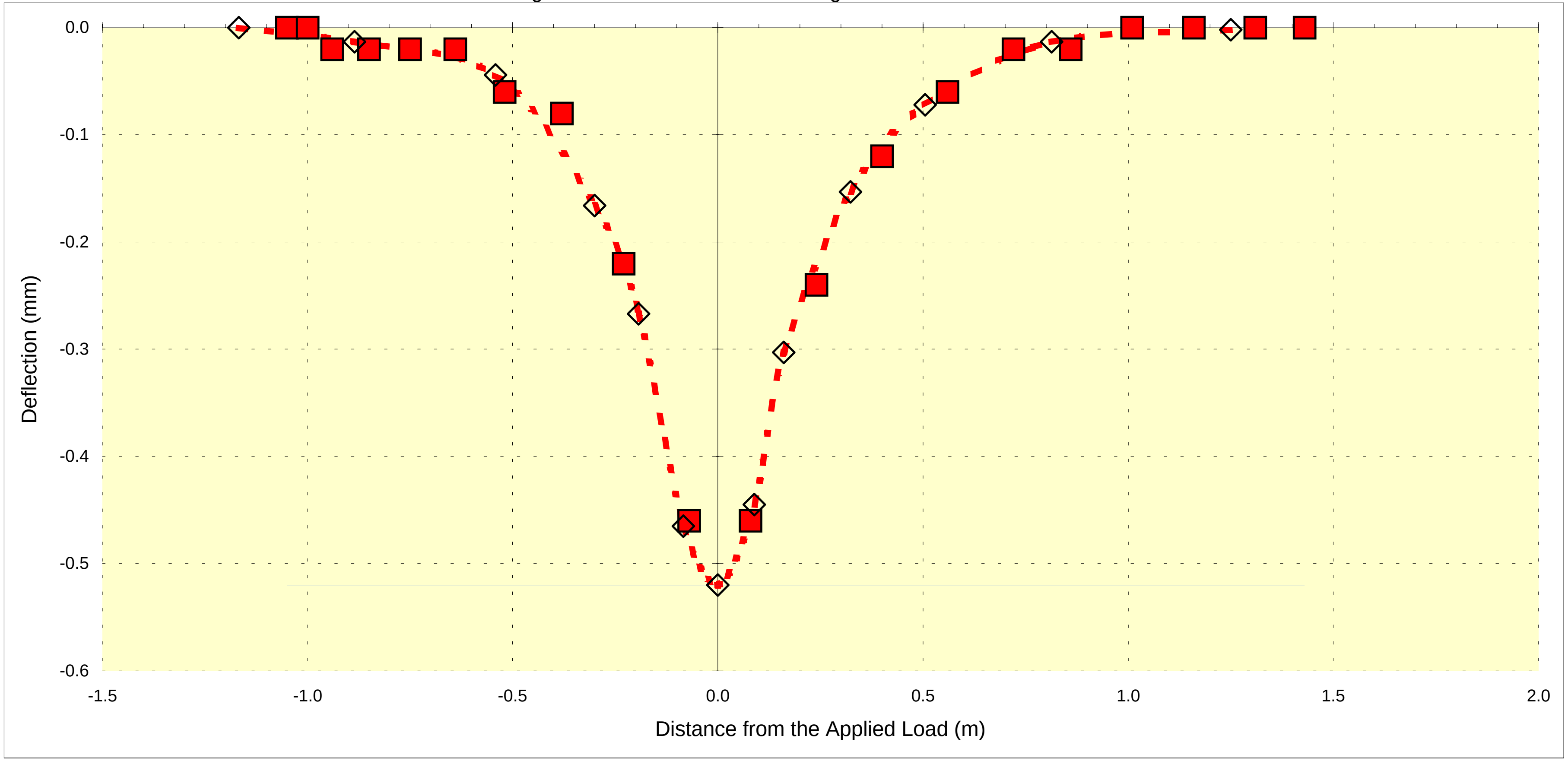
Road Maintenance and Rehabilitation Project

Deflection Bowl Test Results Road Name: Jenda - Chikangawa

Road Code: 3 Test Section: S.Length 4 Chainage: 69.2 Points: 66 -67

Roughton International

in association with **Jatula Partners**



Existing Pavement Structure

Resultant	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
Movement	Layer Thickness (mm)	195	85	1000	Infinite	Layer Thickness (mm)	195	85	1000	Infinite
0.04 mm	- Mr (MPa)	138	24	190	831	- Mr (MPa)	110	47	121	842

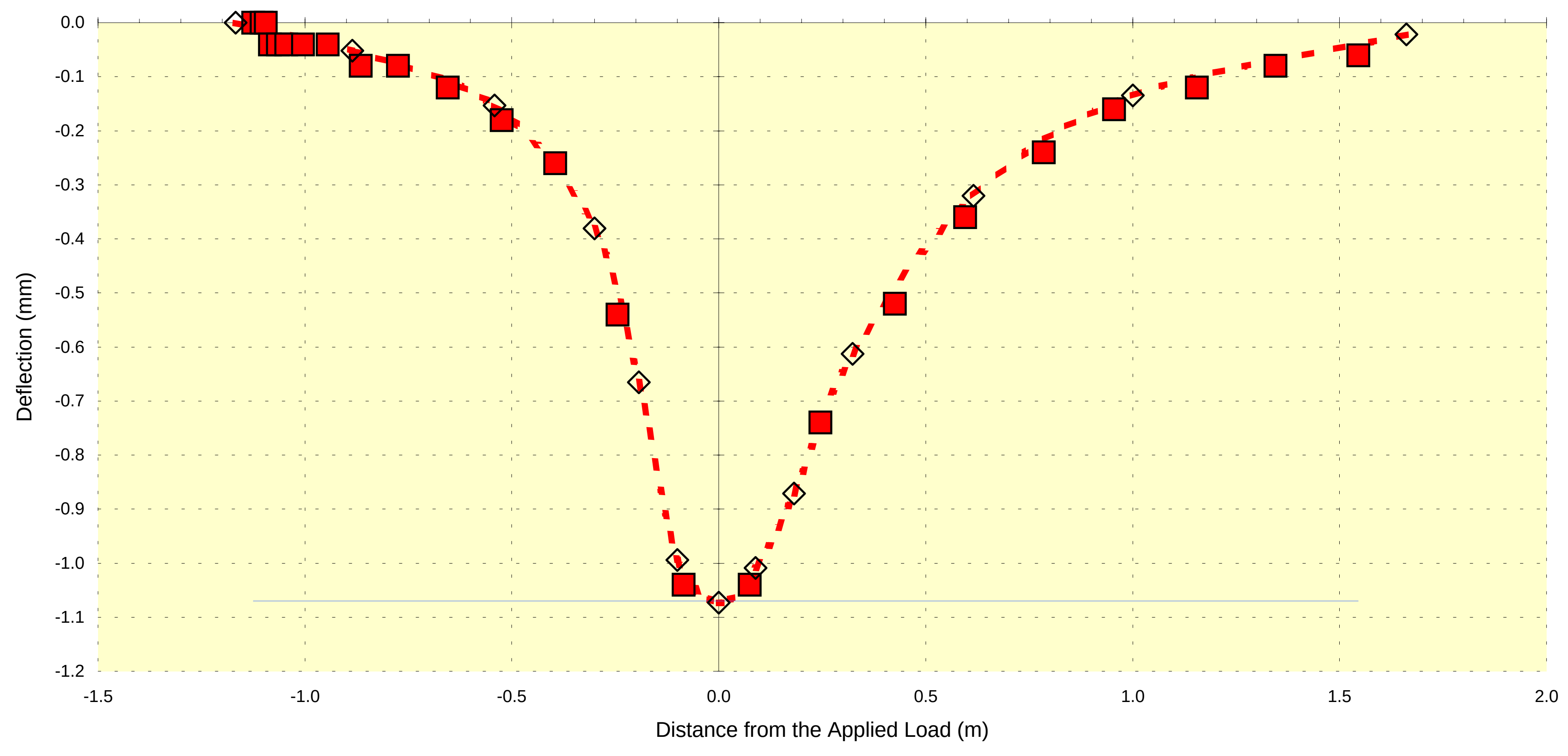
Road Maintenance and Rehabilitation Project

Deflection Bowl Test Results Road Name: Mzuzu - Nkhata Bay

Road Code: 4 Test Section: S.Length 1 Chainage: 8.2 Points: 8 -9

Roughton International

in association with **Jatula Partners**



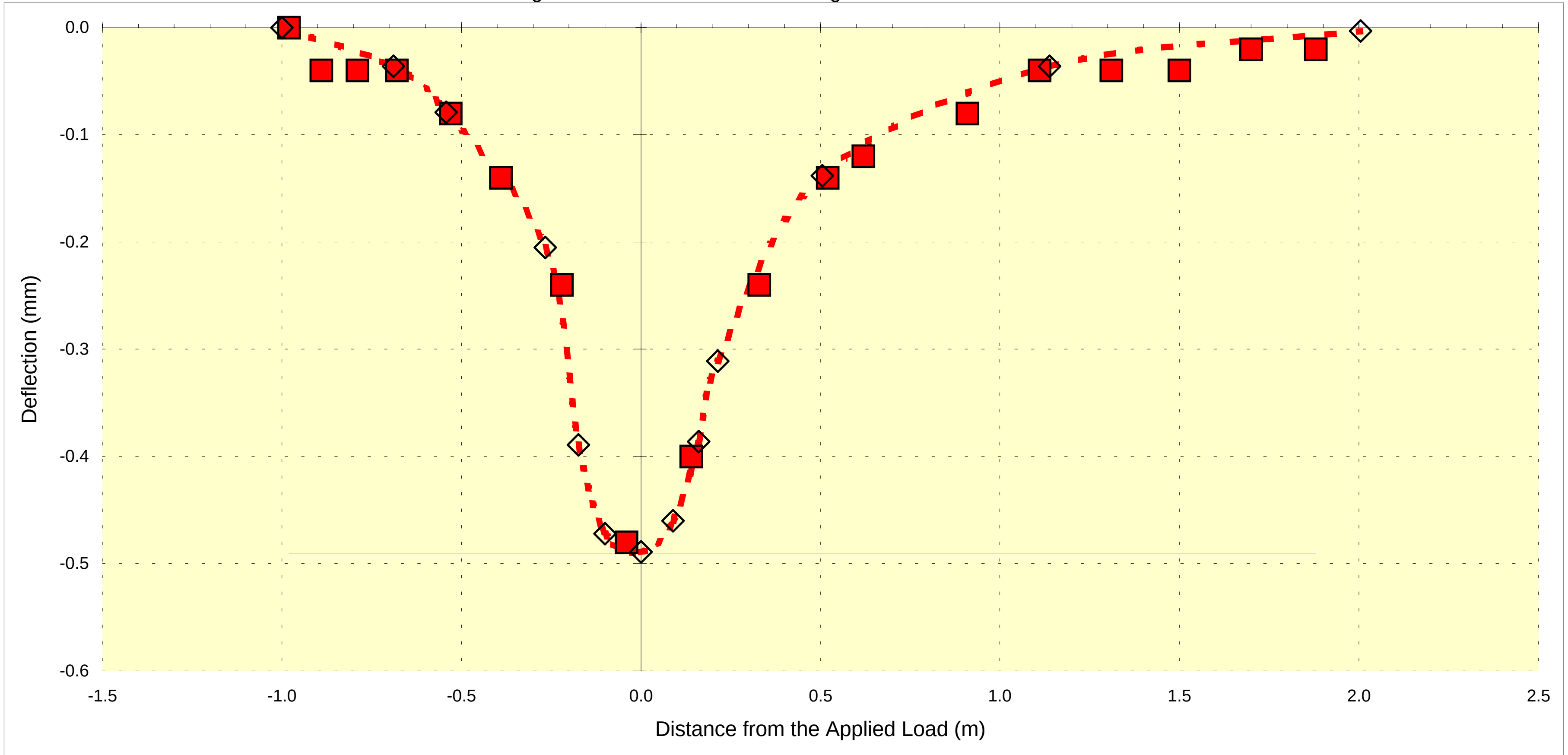
Existing Pavement Structure

Resultant	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
Movement	Layer Thickness (mm)	150	100	1000	Infinite	Layer Thickness (mm)	150	100	1000	Infinite
1.00 mm	- Mr (MPa)	38	49	41	5000	- Mr (MPa)	173	137	24	305

Road Maintenance and Rehabilitation Project
Deflection Bowl Test Results Road Name: Mzuzu - Nkhata Bay

Roughton International
in association with **Jatula Partners**

Road Code: 4 Test Section: S.Length 2 Chainage: 21.4 Points: 28 -29



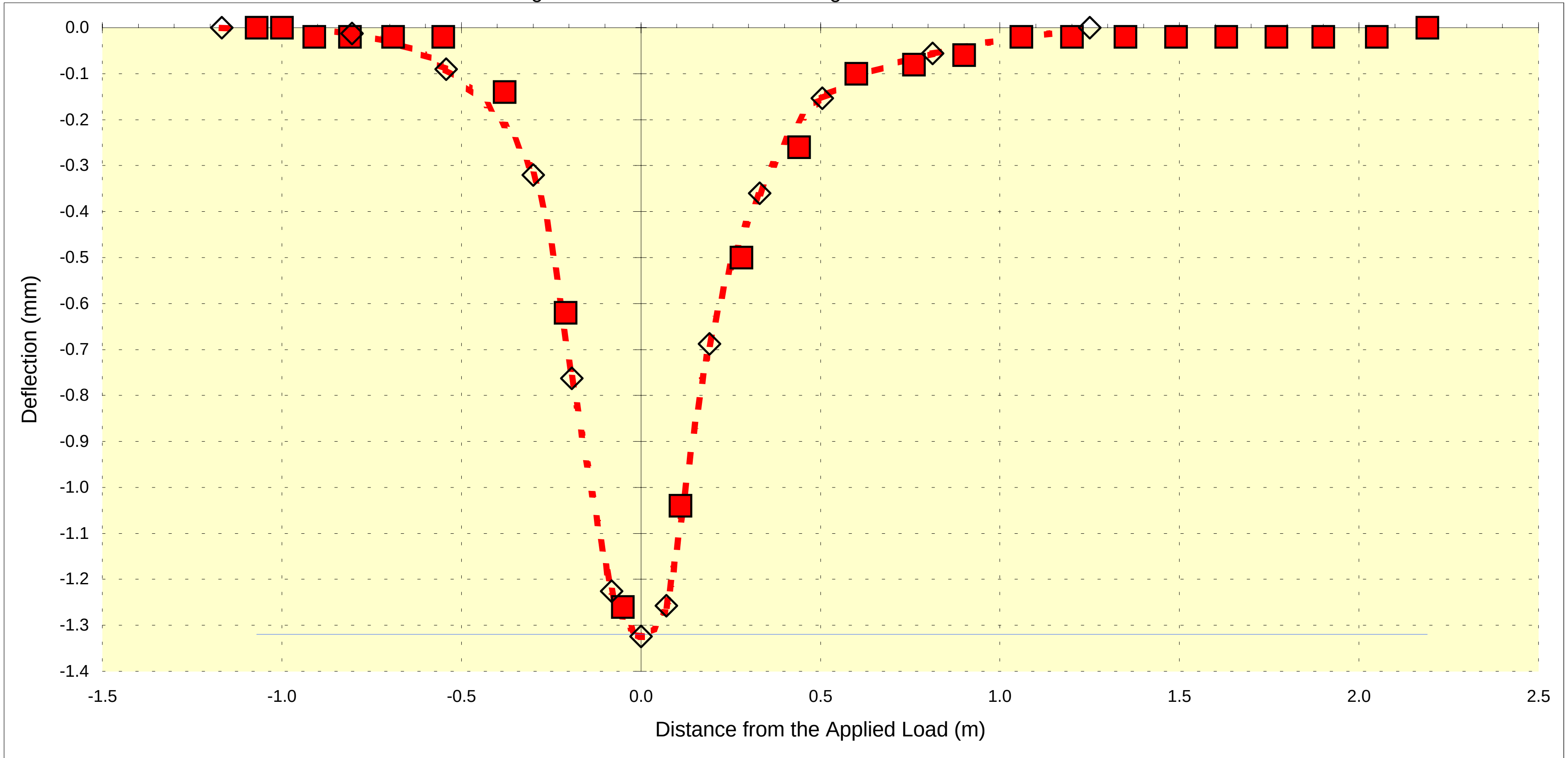
Existing Pavement Structure

Resultant	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
Movement	Layer Thickness (mm)	100	120	1000	Infinite	Layer Thickness (mm)	100	120	1000	Infinite
0.20 mm	- Mr (MPa)	148	299	91	1993	- Mr (MPa)	425	372	90	227

Road Maintenance and Rehabilitation Project
Deflection Bowl Test Results Road Name: Mzuzu - Nkhata Bay

Roughton International
in association with **Jatula Partners**

Road Code: 4 Test Section: S.Length 3 Chainage: 42.3 Points: 41 -42



Existing Pavement Structure

Resultant	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
Movement	Layer Thickness (mm)	170	240	1000	Infinite	Layer Thickness (mm)	170	240	1000	Infinite
0.12 mm	- Mr (MPa)	28	27	75	2064	- Mr (MPa)	46	25	58	1663

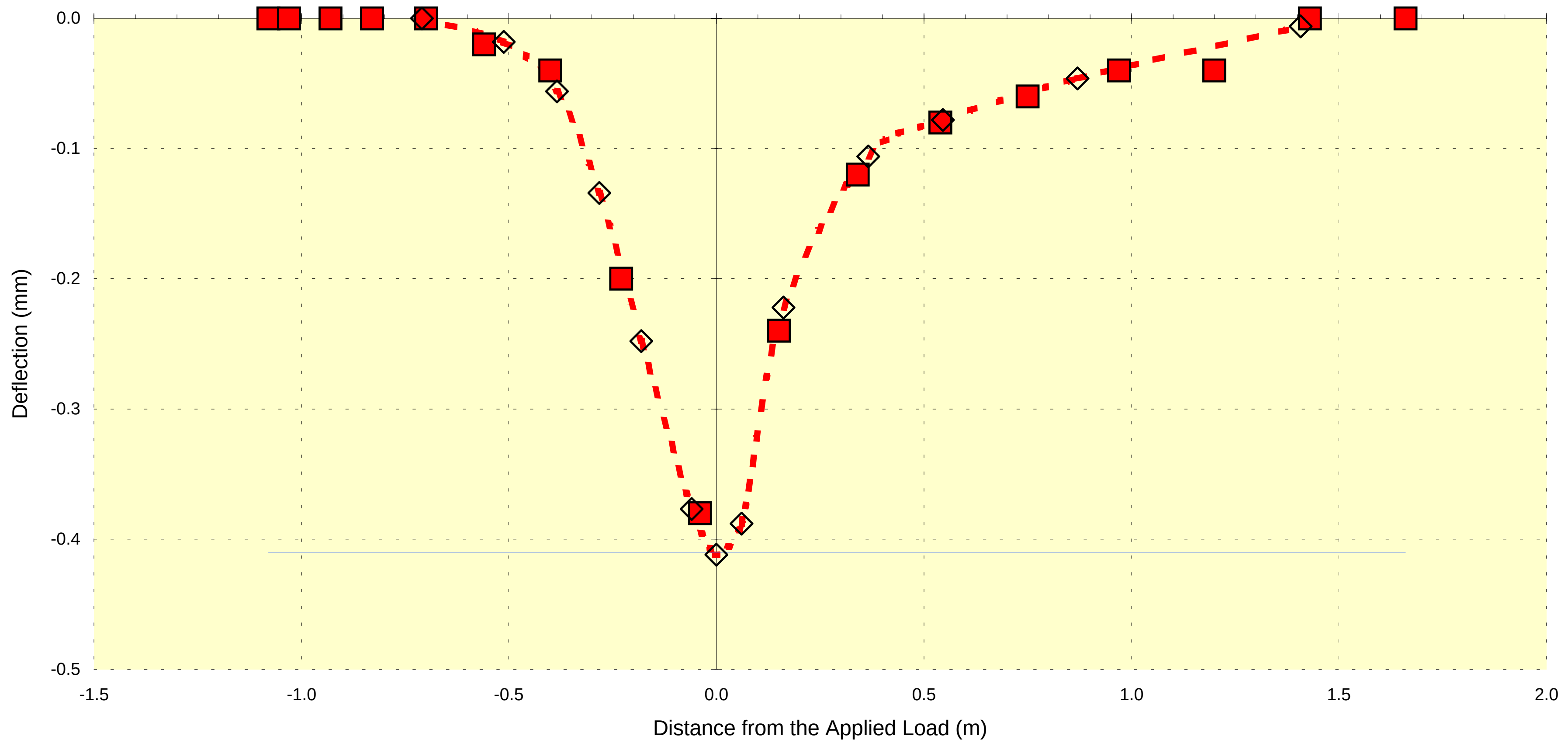
Road Maintenance and Rehabilitation Project

Roughton International

in association with **Jatula Partners**

Deflection Bowl Test Results Road Name: Bwengu - Rumphi

Road Code: 5 Test Section: S.Length 1 Chainage: 3.3 Points: 3 -4



Existing Pavement Structure

Resultant	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
Movement	Layer Thickness (mm)	185	165	1000	Infinite	Layer Thickness (mm)	185	165	1000	Infinite
0.04 mm	- Mr (MPa)	180	36	5000	317	- Mr (MPa)	49	1016	110	742

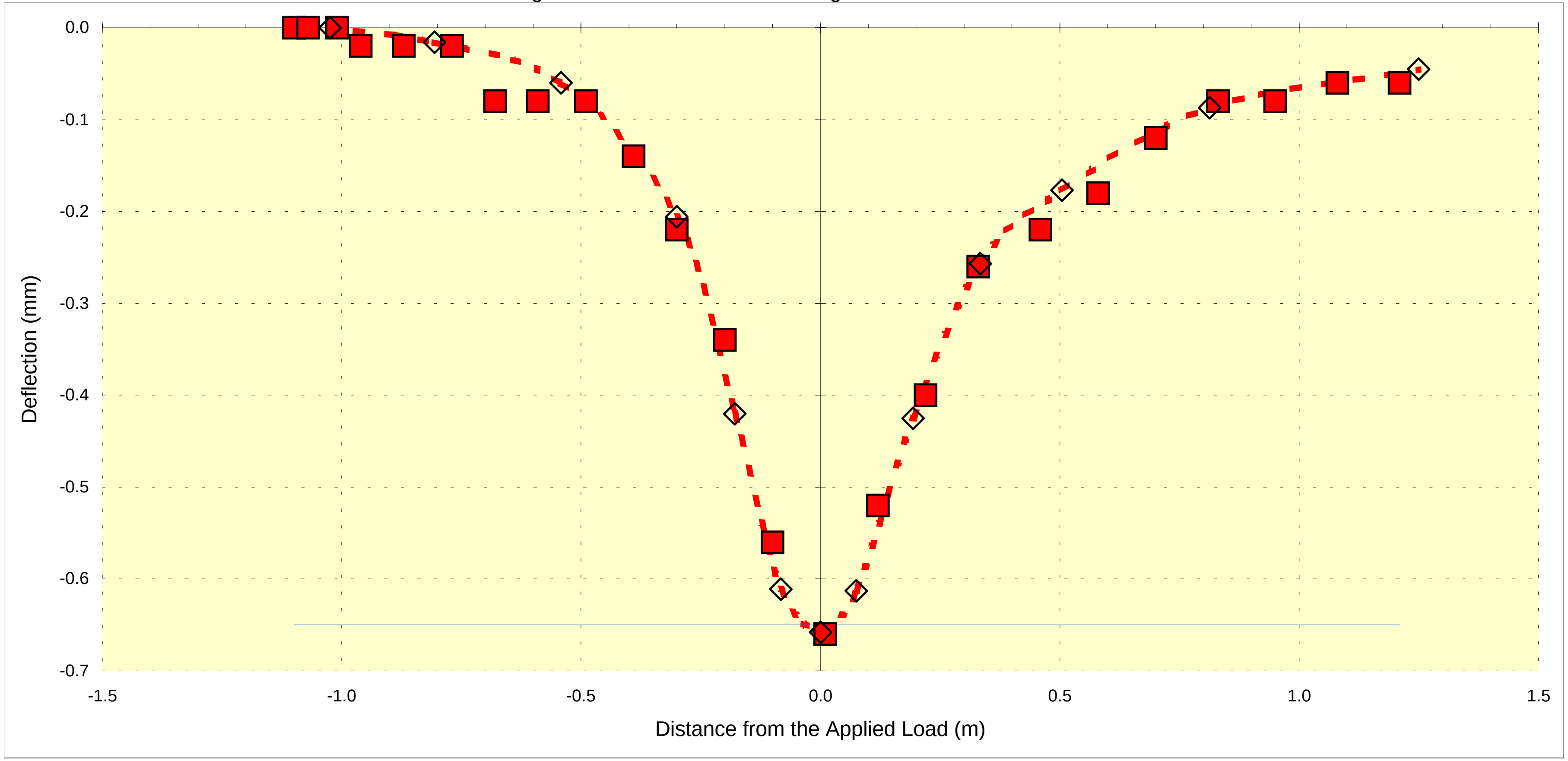
Road Maintenance and Rehabilitation Project

Deflection Bowl Test Results Road Name: Kasungu - Dwangwa

Road Code: 6 Test Section: S.Length 1 Chainage: 6.6 Points: 6 -7

Roughton International

in association with **Jatula Partners**



Existing Pavement Structure

Resultant	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
Movement	Layer Thickness (mm)	200	150	1000	Infinite	Layer Thickness (mm)	200	150	1000	Infinite
0.32 mm	- Mr (MPa)	86	38	115	3052	- Mr (MPa)	68	259	44	3403

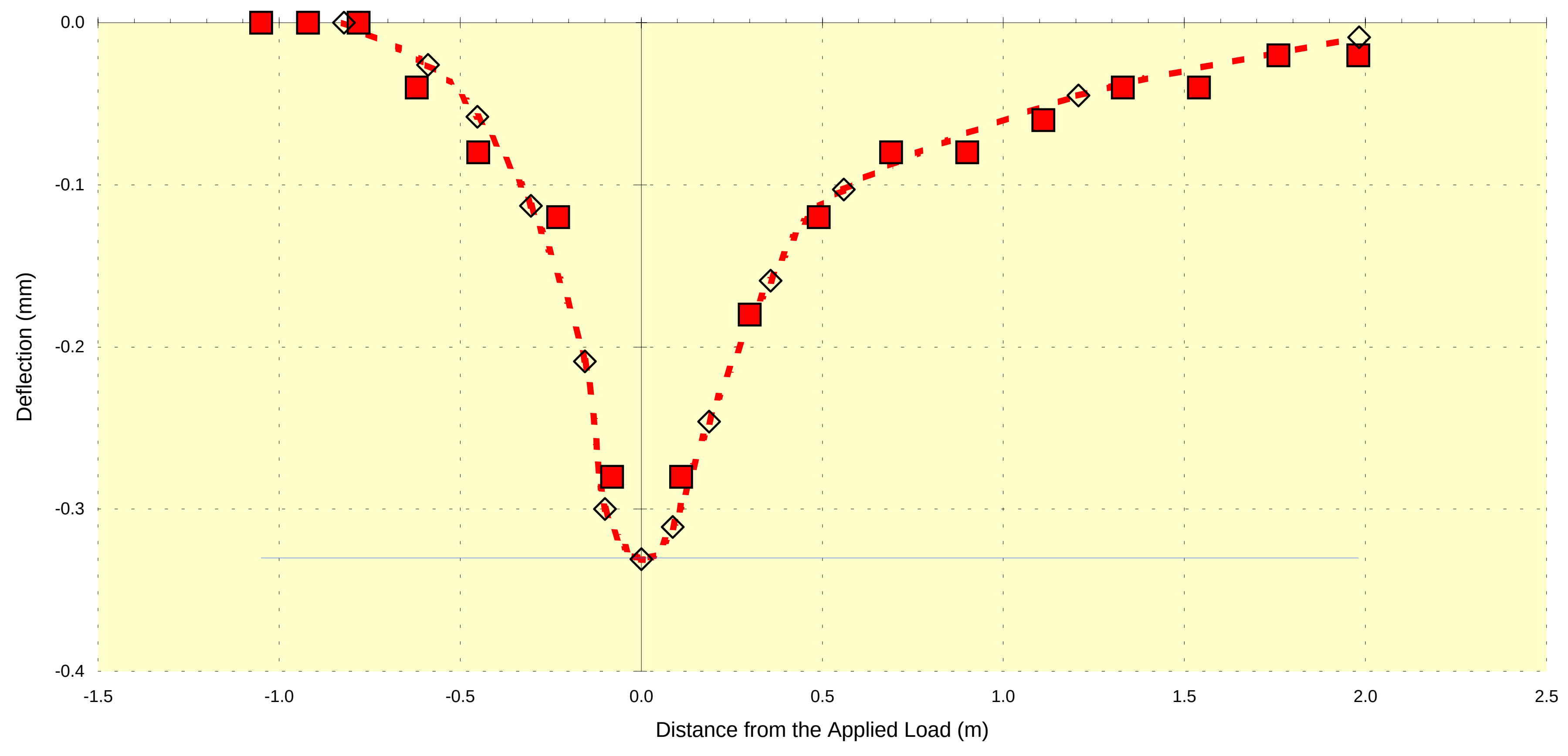
Road Maintenance and Rehabilitation Project

Roughton International

in association with **Jatula Partners**

Deflection Bowl Test Results Road Name: Kasungu - Dwangwa

Road Code: 6 Test Section: S.Length 2 Chainage: 15.4 Points: 18 -19



Existing Pavement Structure

Resultant	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
Movement	Layer Thickness (mm)	140	160	1000	Infinite	Layer Thickness (mm)	140	160	1000	Infinite
0.26 mm	- Mr (MPa)	202	115	150	5000	- Mr (MPa)	290	199	129	165

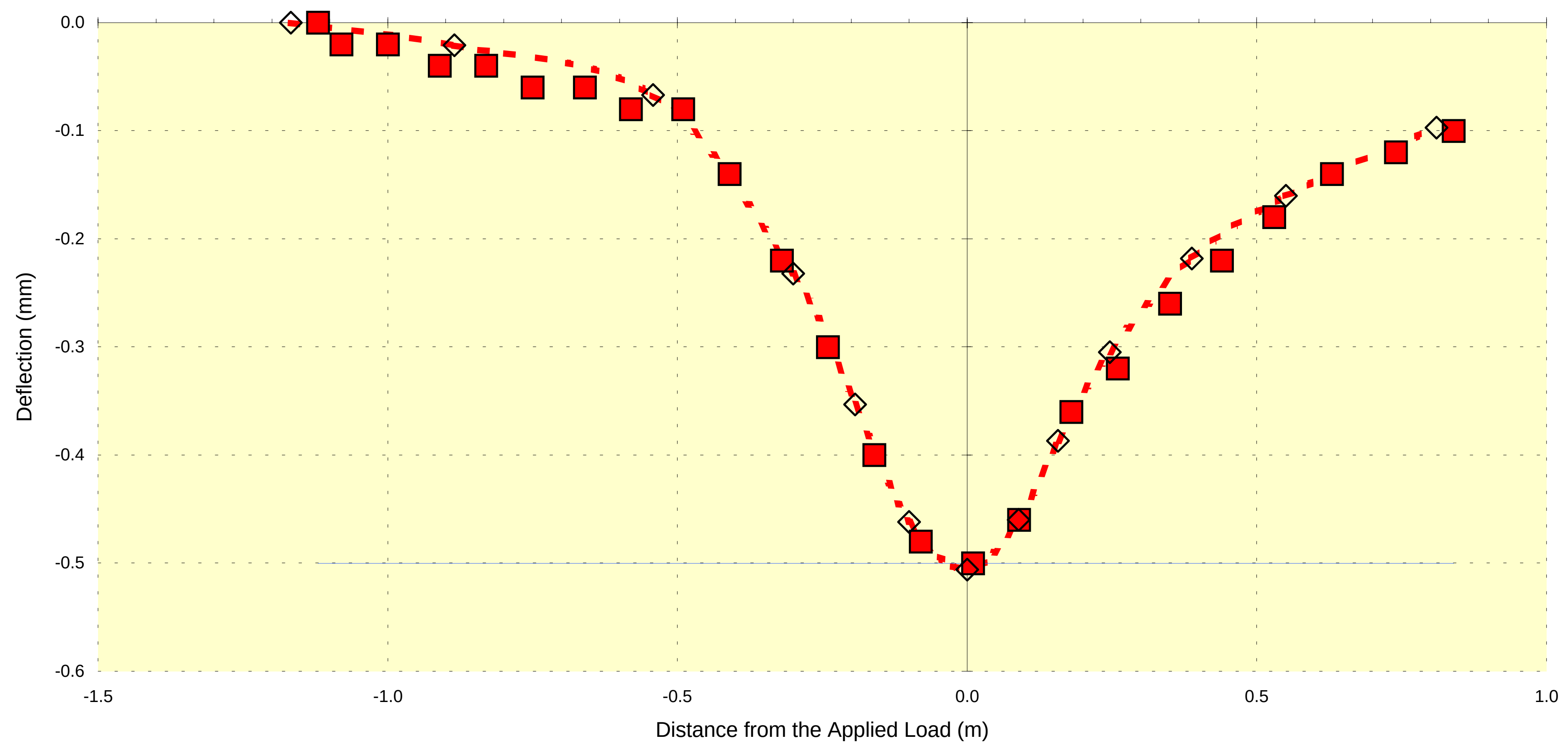
Road Maintenance and Rehabilitation Project

Roughton International

in association with **Jatula Partners**

Deflection Bowl Test Results Road Name: Madisi - Kasungu

Road Code: 7 Test Section: S.Length 2 Chainage: 31.9 Points: 24 -25



Existing Pavement Structure

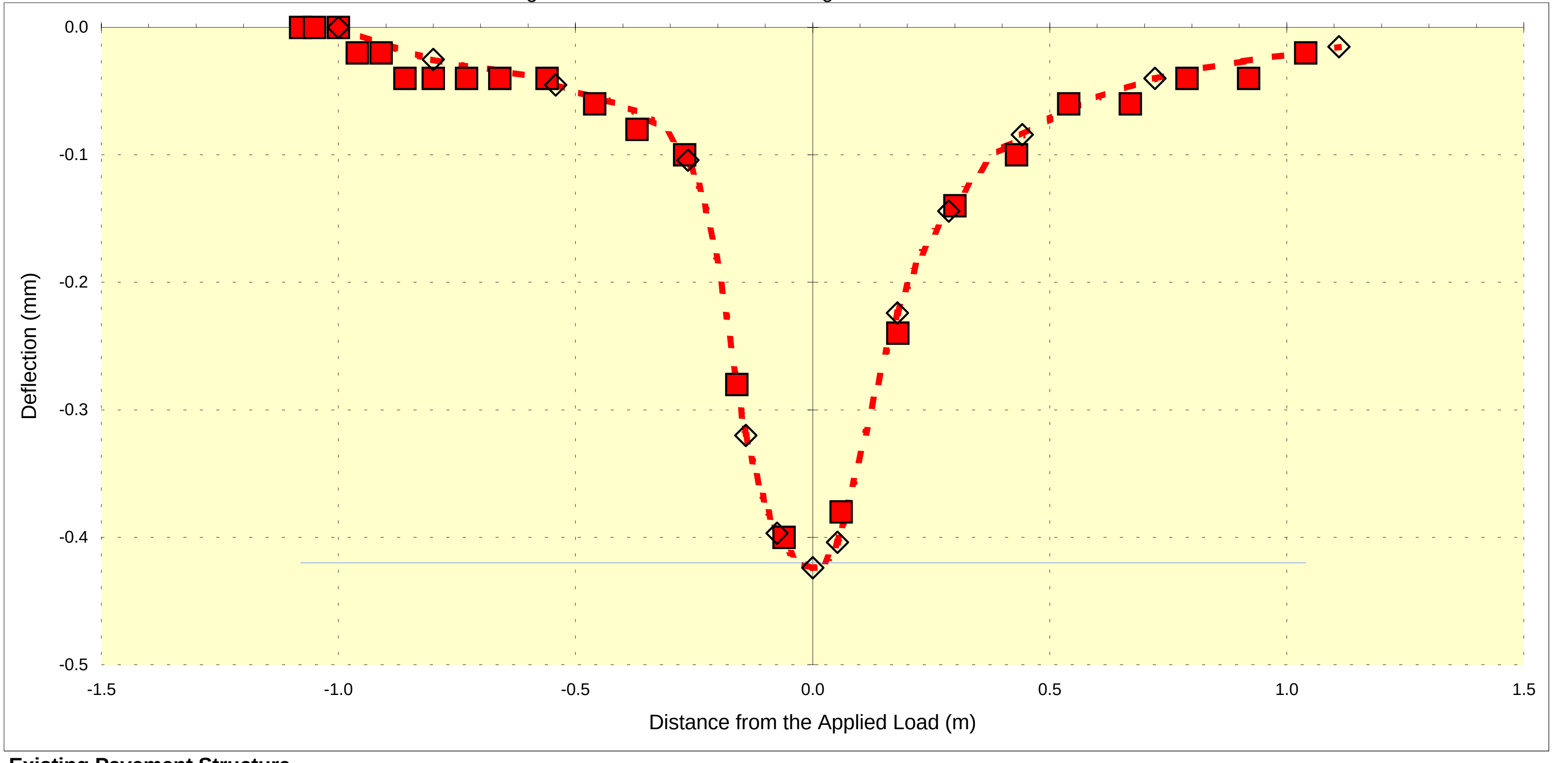
Resultant Movement	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
	Layer Thickness (mm)	270	130	1000	Infinite	Layer Thickness (mm)	270	130	1000	Infinite
0.40 mm	- Mr (MPa)	158	20	264	614	- Mr (MPa)	139	204	61	185

Roughton International

in association with **Jatula Partners**

Road Name: Madisi - Kasungu

Road Code: 7 Test Section: S.Length 3 Chainage: 31.9 Points: 24 -25



Existing Pavement Structure

Resultant	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
Movement	Layer Thickness (mm)	190	100	1000	Infinite	Layer Thickness (mm)	190	100	1000	Infinite
0.34 mm	- Mr (MPa)	49	376	153	1883	- Mr (MPa)	81	175	118	1608

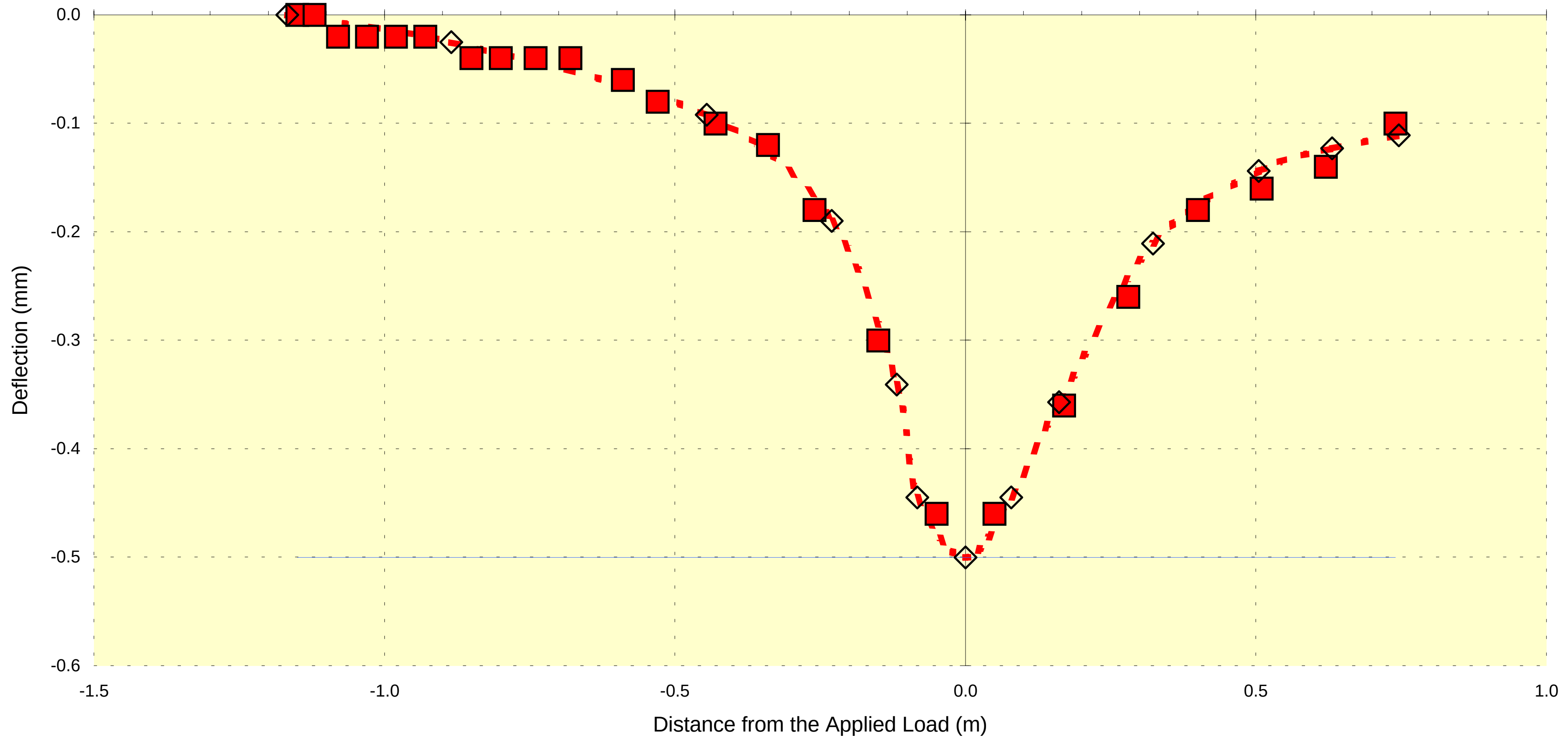
Road Maintenance and Rehabilitation Project

Deflection Bowl Test Results Road Name: Lumbadzi - Mponela

Road Code: 8 Test Section: S.Length 1 Chainage: 23.1 Points: 7 -8

Roughton International

in association with **Jatula Partners**



Existing Pavement Structure

Resultant	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
Movement	Layer Thickness (mm)	210	135	1000	Infinite	Layer Thickness (mm)	210	135	1000	Infinite
0.42 mm	- Mr (MPa)	61	201	105	1732	- Mr (MPa)	139	63	196	75

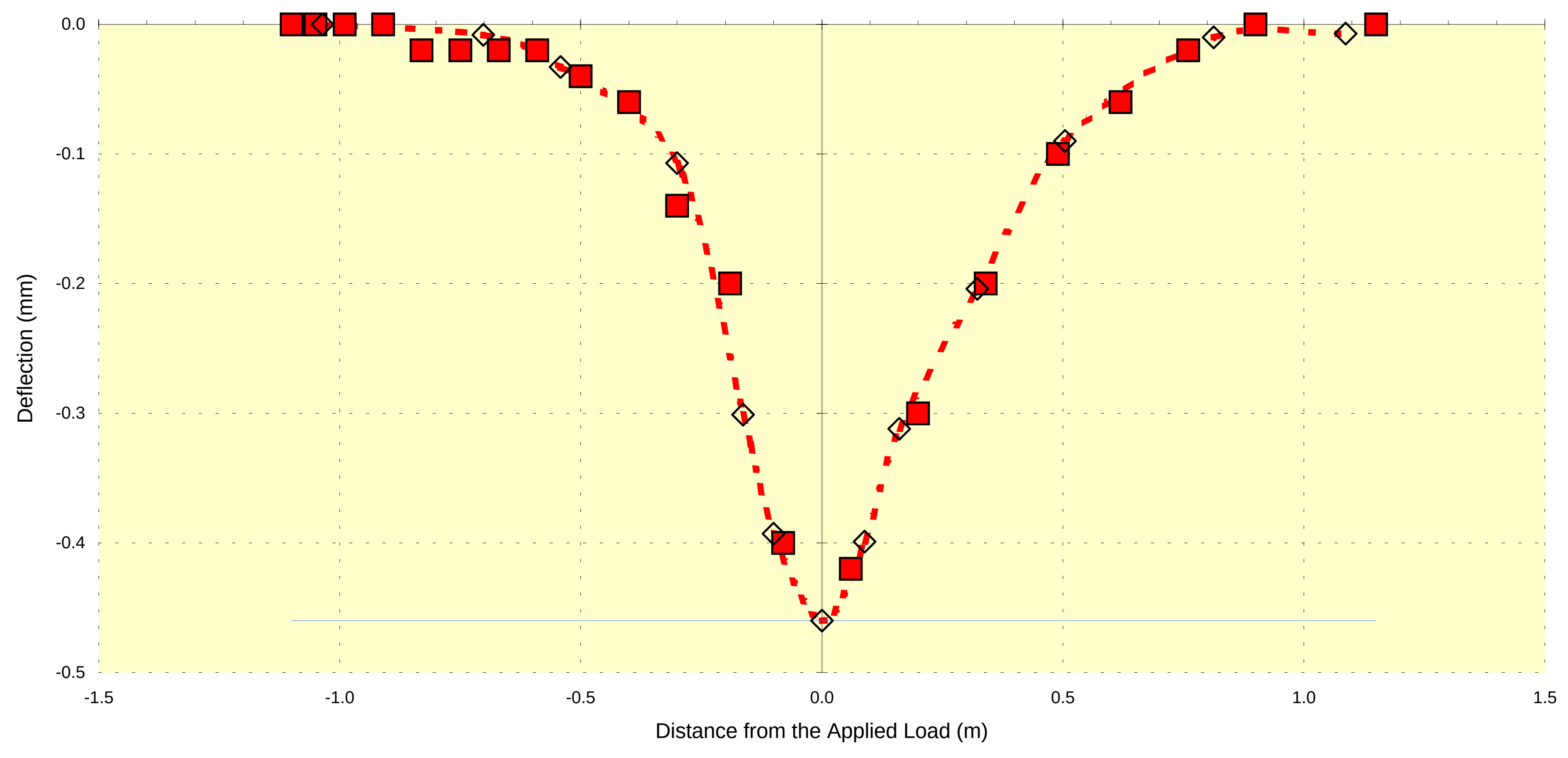
Road Maintenance and Rehabilitation Project

Deflection Bowl Test Results Road Name: Lumbadzi - Mponela

Road Code: 8 Test Section: S.Length 2 Chainage: 30.8 Points: 24 -25

Roughton International

in association with **Jatula Partners**



Existing Pavement Structure

Resultant	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
Movement	Layer Thickness (mm)	220	120	1000	Infinite	Layer Thickness (mm)	220	120	1000	Infinite
0.18 mm	- Mr (MPa)	79	63	216	1182	- Mr (MPa)	299	20	225	699

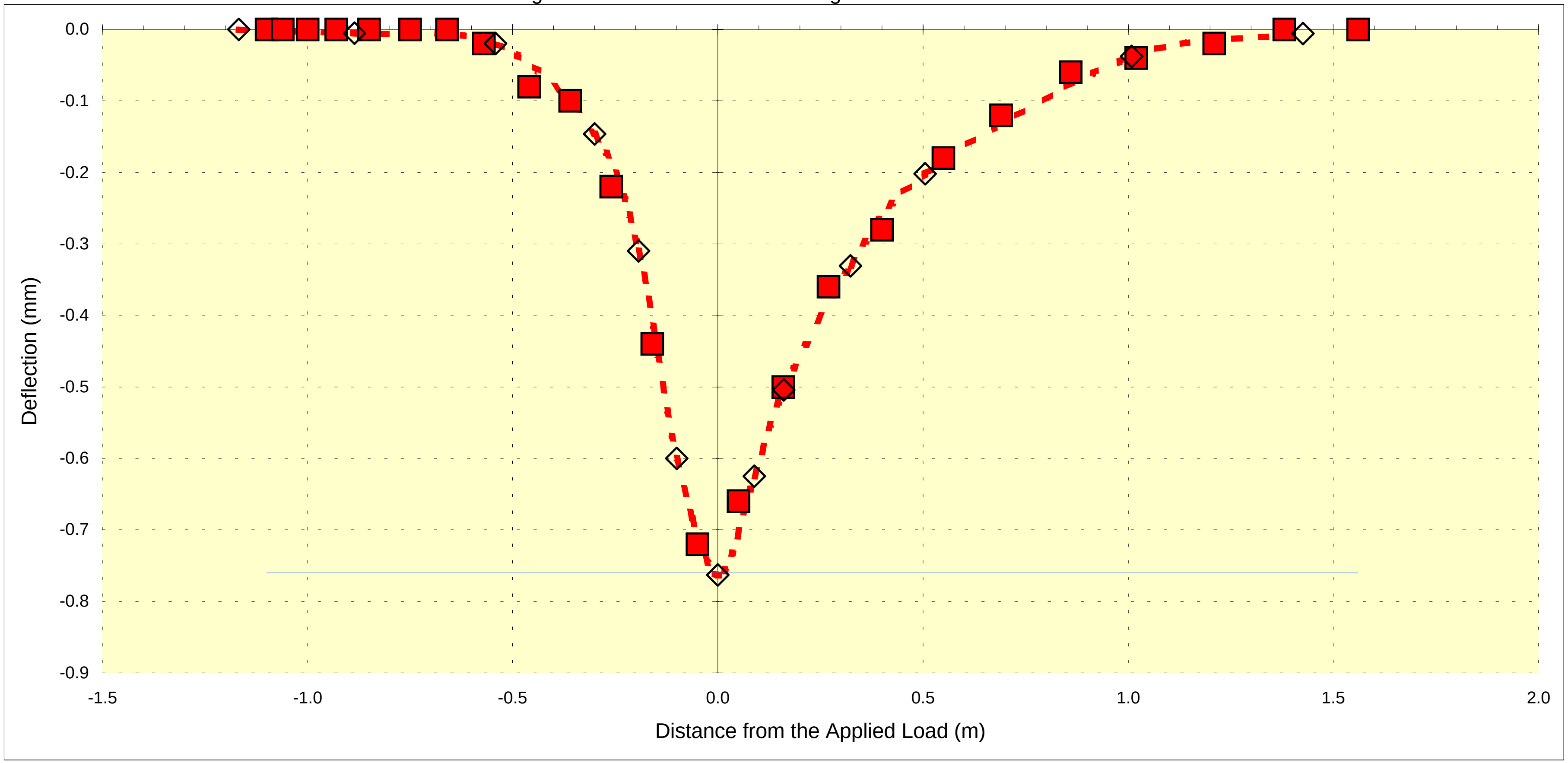
Road Maintenance and Rehabilitation Project

Roughton International

in association with **Jatula Partners**

Deflection Bowl Test Results Road Name: Bunda Turn Off - Chimbiya

Road Code: 9 Test Section: S.Length 1 Chainage: 7.7 Points: 32 -33



Existing Pavement Structure

Resultant	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
Movement	Layer Thickness (mm)	140	160	1000	Infinite	Layer Thickness (mm)	140	160	1000	Infinite
0.36 mm	- Mr (MPa)	36	23	385	977	- Mr (MPa)	40	176	44	669

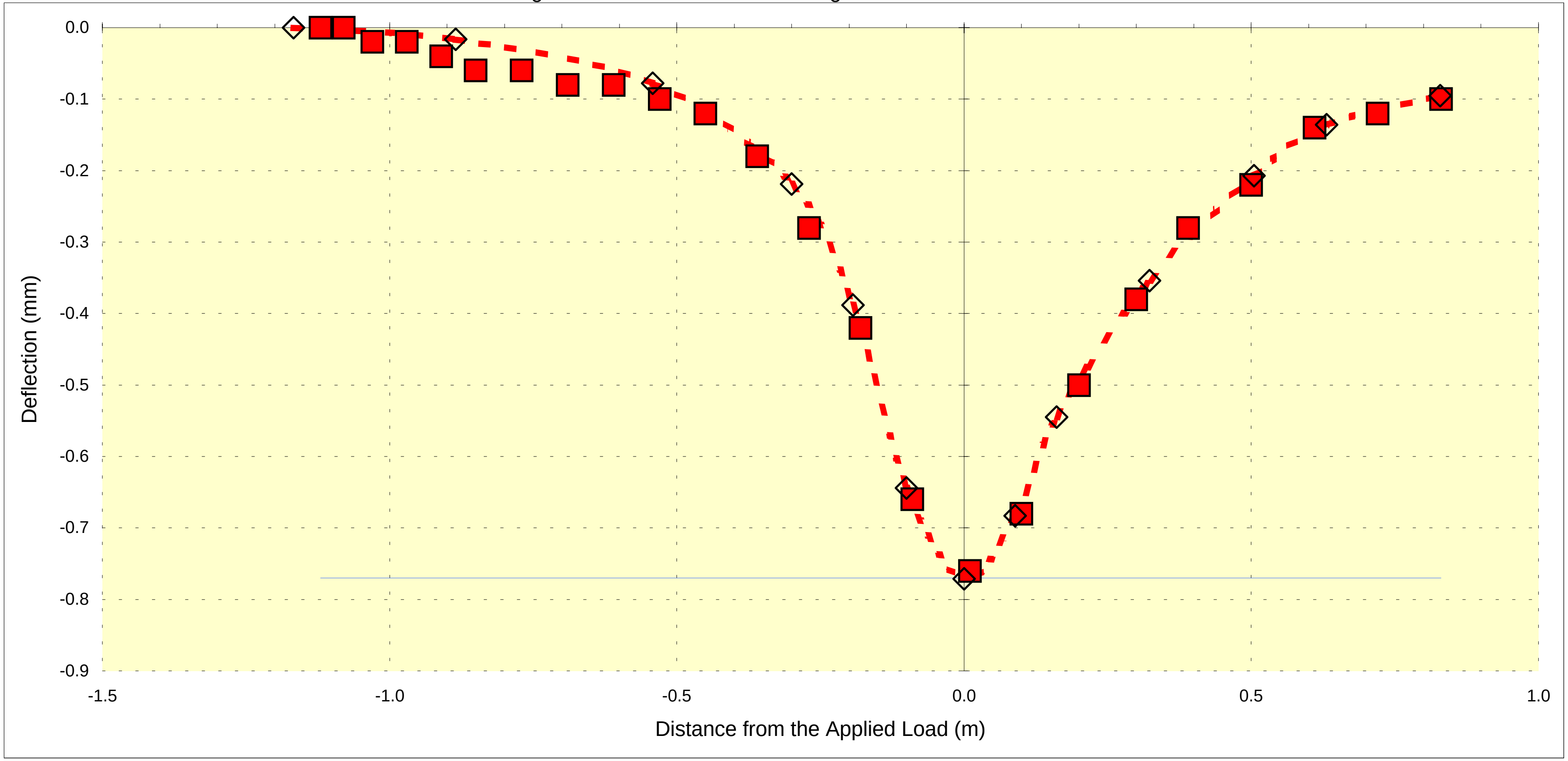
Road Maintenance and Rehabilitation Project

Roughton International

Deflection Bowl Test Results Road Name: Bunda Turn Off - Chimbiya

in association with **Jatula Partners**

Road Code: 9 Test Section: S.Length 2 Chainage: 28.6 Points: 24 -25



Existing Pavement Structure

Resultant	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
Movement	Layer Thickness (mm)	175	110	1000	Infinite	Layer Thickness (mm)	175	110	1000	Infinite
0.70 mm	- Mr (MPa)	59	40	84	1493	- Mr (MPa)	127	60	53	177

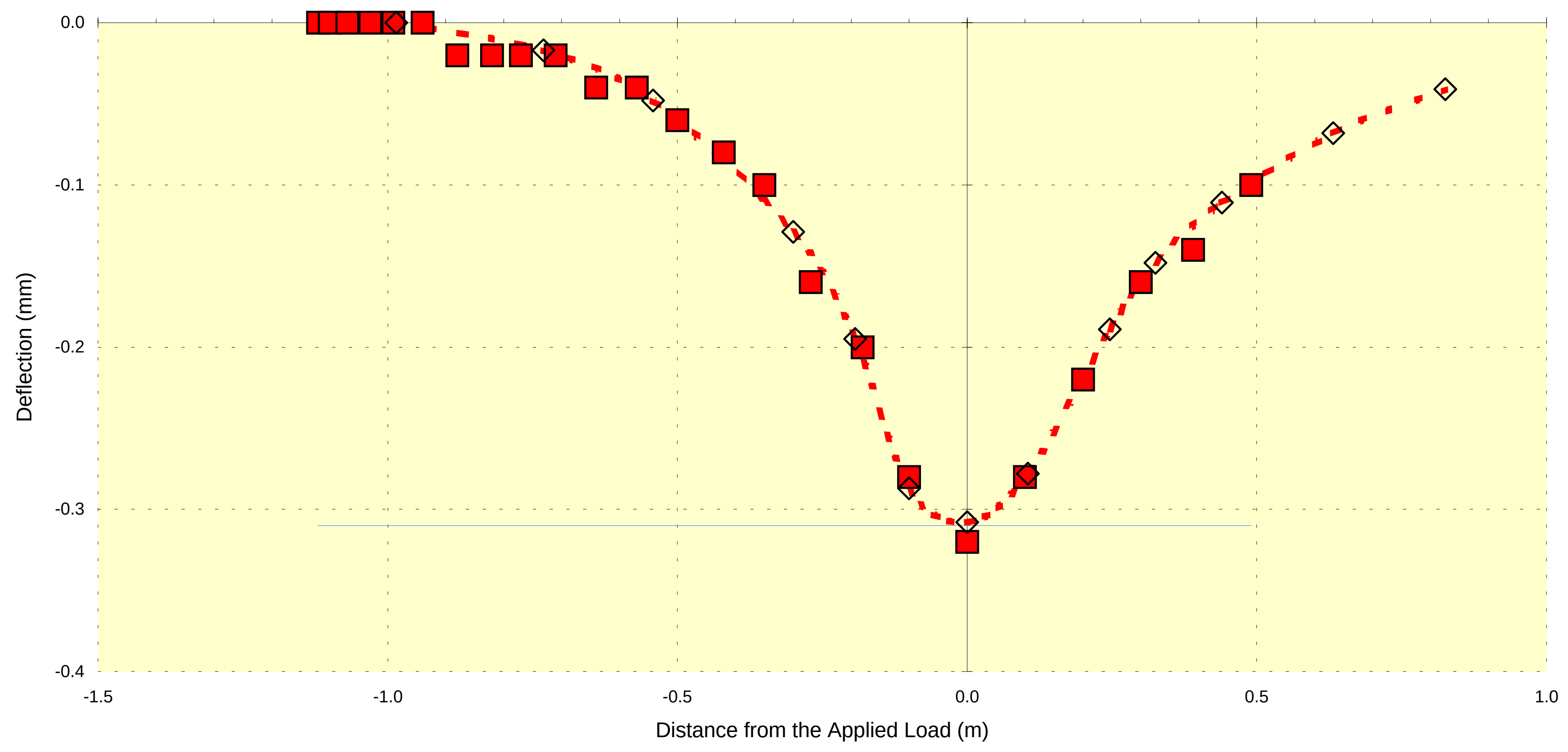
Road Maintenance and Rehabilitation Project

Deflection Bowl Test Results Road Name: Bunda Turn Off - Chimbiya

Road Code: 9 Test Section: S.Length 3 Chainage: 47.3 Points: 3 -4

Roughton International

in association with **Jatula Partners**



Existing Pavement Structure

Resultant	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
Movement	Layer Thickness (mm)	205	170	1000	Infinite	Layer Thickness (mm)	205	170	1000	Infinite
0.30 mm	- Mr (MPa)	207	230	150	5000	- Mr (MPa)	252	237	95	747

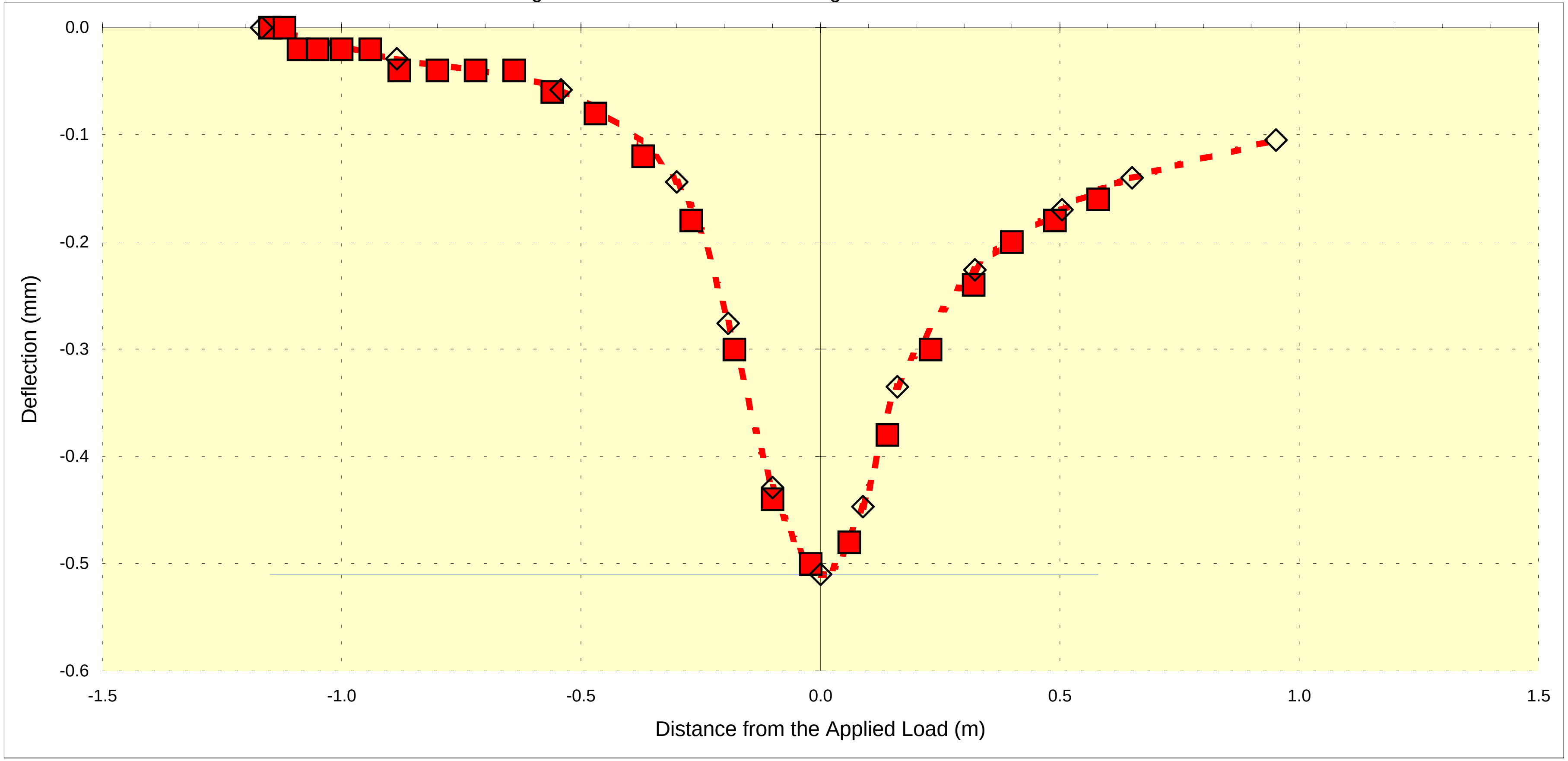
Road Maintenance and Rehabilitation Project

Roughton International

in association with **Jatula Partners**

Deflection Bowl Test Results Road Name: Dedza - Biriwiri

Road Code: 10 Test Section: S.Length 1 Chainage: 9.9 Points: 52 -53



Existing Pavement Structure

Resultant	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
Movement	Layer Thickness (mm)	180	110	1000	Infinite	Layer Thickness (mm)	180	110	1000	Infinite
0.46 mm	- Mr (MPa)	60	123	105	5000	- Mr (MPa)	76	225	122	79

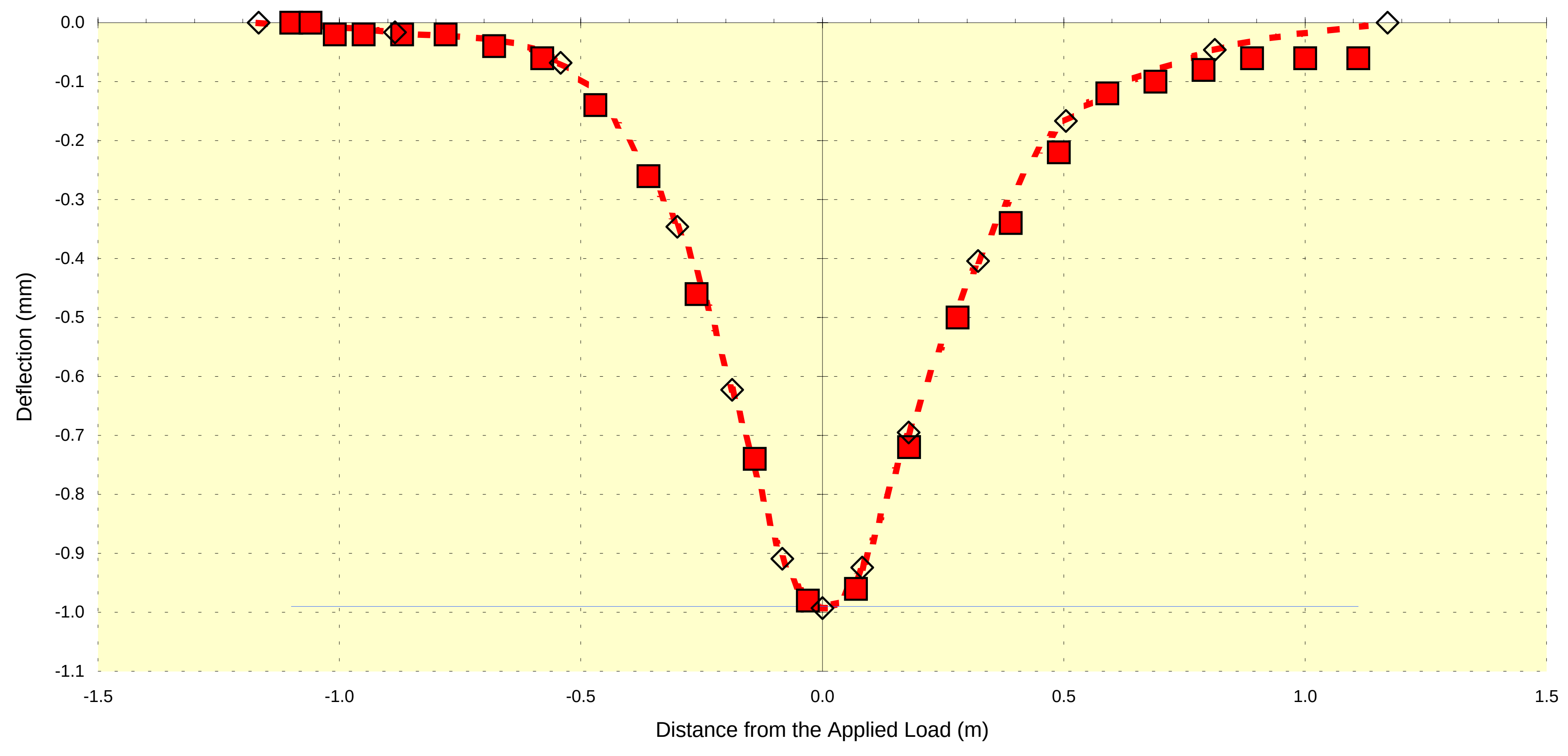
Road Maintenance and Rehabilitation Project

Roughton International

Deflection Bowl Test Results Road Name: Dedza - Biriwiri

in association with **Jatula Partners**

Road Code: 10 Test Section: S.Length 2 Chainage: 27.5 Points: 23 -24



Existing Pavement Structure

Resultant	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
Movement	Layer Thickness (mm)	135	85	1000	Infinite	Layer Thickness (mm)	135	85	1000	Infinite
0.46 mm	- Mr (MPa)	138	20	56	5000	- Mr (MPa)	253	20	45	5000

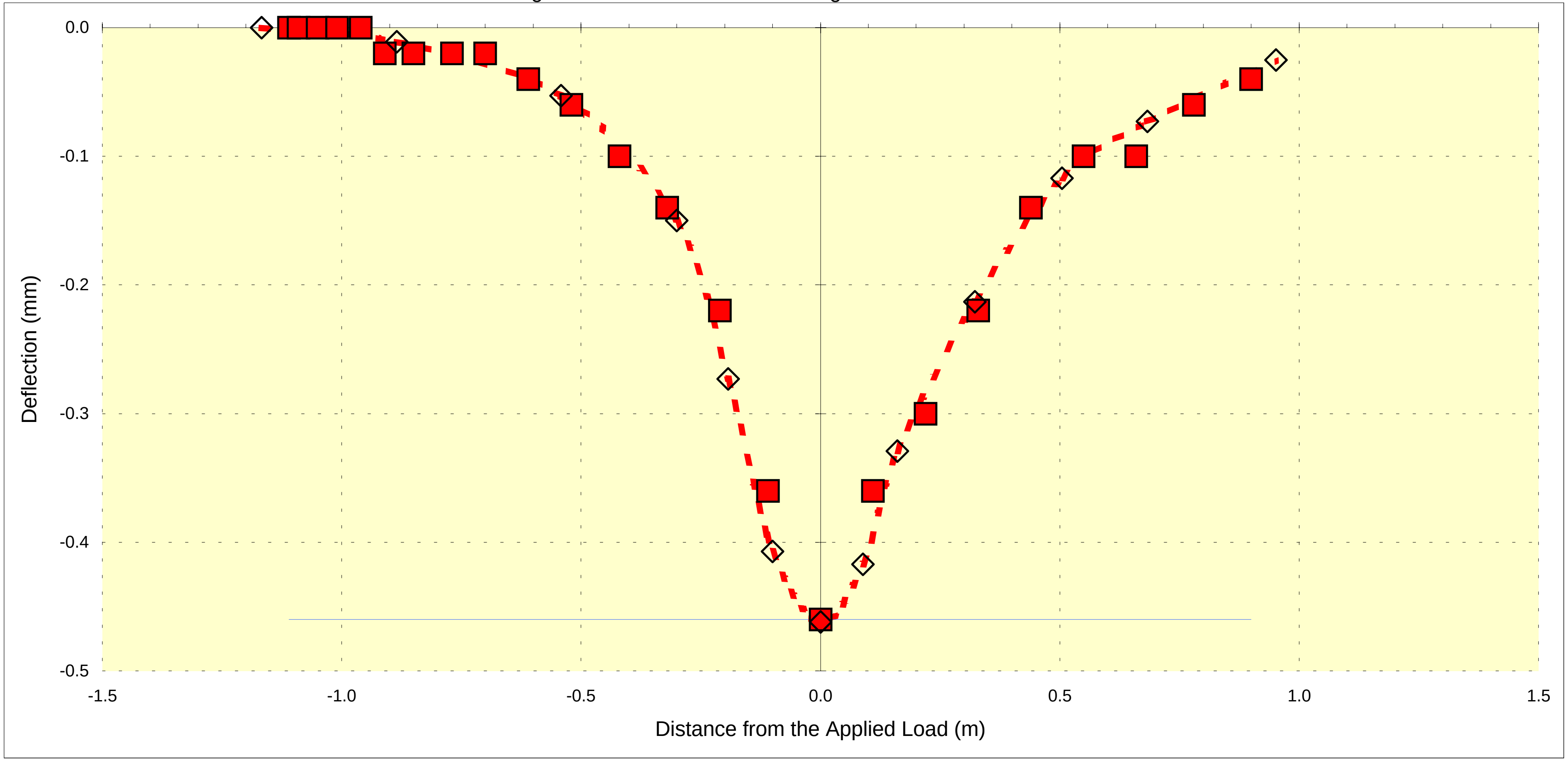
Road Maintenance and Rehabilitation Project

Deflection Bowl Test Results Road Name: Dedza - Biriwiri

Road Code: 10 Test Section: S.Length 3 Chainage: 52.7 Points: 9 -10

Roughton International

in association with **Jatula Partners**



Existing Pavement Structure

Resultant	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
Movement	Layer Thickness (mm)	110	120	1000	Infinite	Layer Thickness (mm)	110	120	1000	Infinite
0.44 mm	- Mr (MPa)	184	77	111	5000	- Mr (MPa)	372	171	72	1554

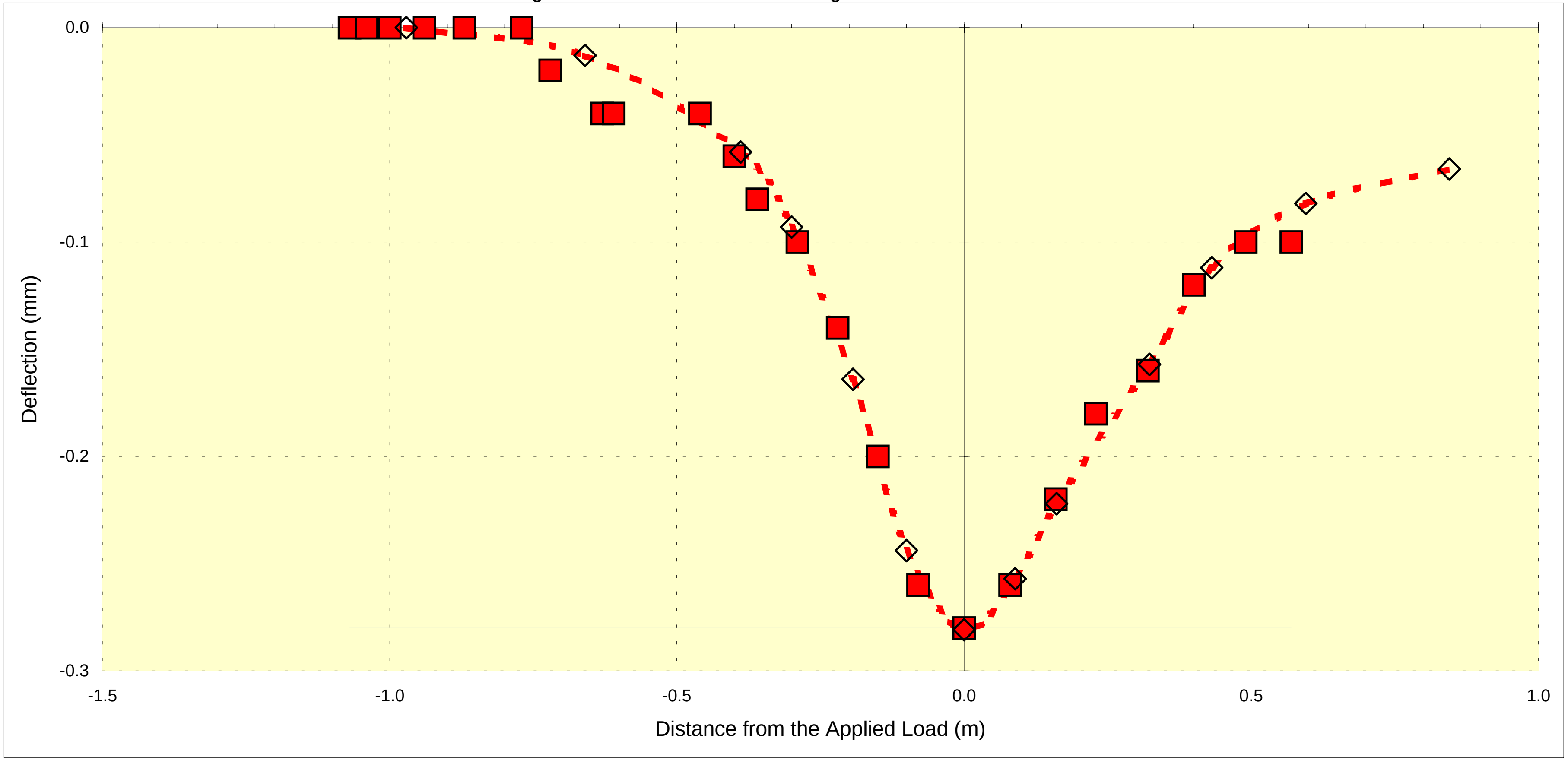
Road Maintenance and Rehabilitation Project

Deflection Bowl Test Results Road Name: Salima - Senga Bay

Roughton International

in association with **Jatula Partners**

Road Code: 11 Test Section: S.Length 1 Chainage: 5.5 Points: 5 -6



Existing Pavement Structure

Resultant	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
Movement	Layer Thickness (mm)	155	115	1000	Infinite	Layer Thickness (mm)	155	115	1000	Infinite
0.26 mm	- Mr (MPa)	321	85	208	5000	- Mr (MPa)	372	142	208	135

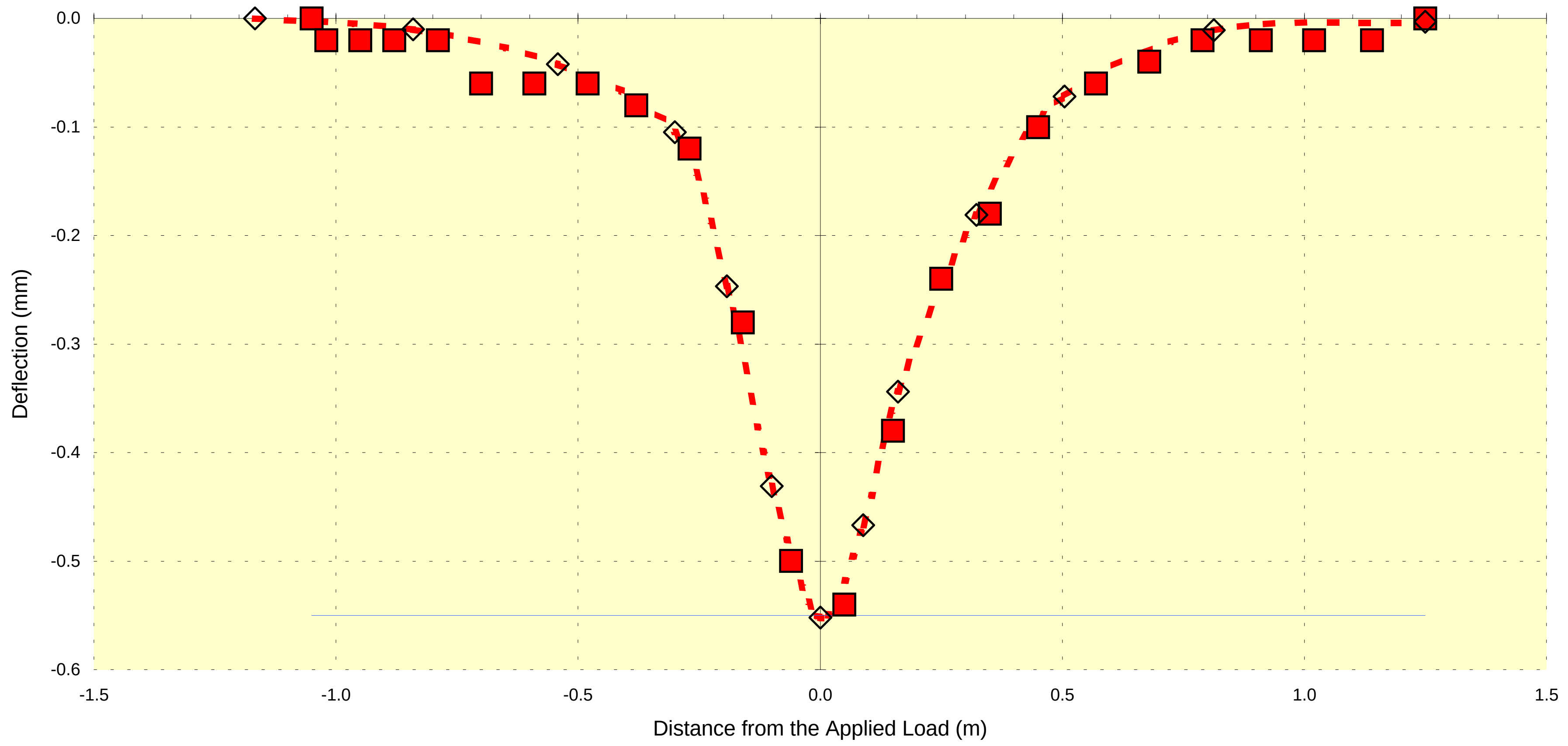
Road Maintenance and Rehabilitation Project

Deflection Bowl Test Results Road Name: Salima - Senga Bay

Road Code: 11 Test Section: S.Length 2 Chainage: 17.6 Points: 17 -18

Roughton International

in association with **Jatula Partners**



Existing Pavement Structure

Resultant	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
Movement	Layer Thickness (mm)	195	200	1000	Infinite	Layer Thickness (mm)	195	200	1000	Infinite
0.12 mm	- Mr (MPa)	43	128	143	5000	- Mr (MPa)	150	44	140	4968

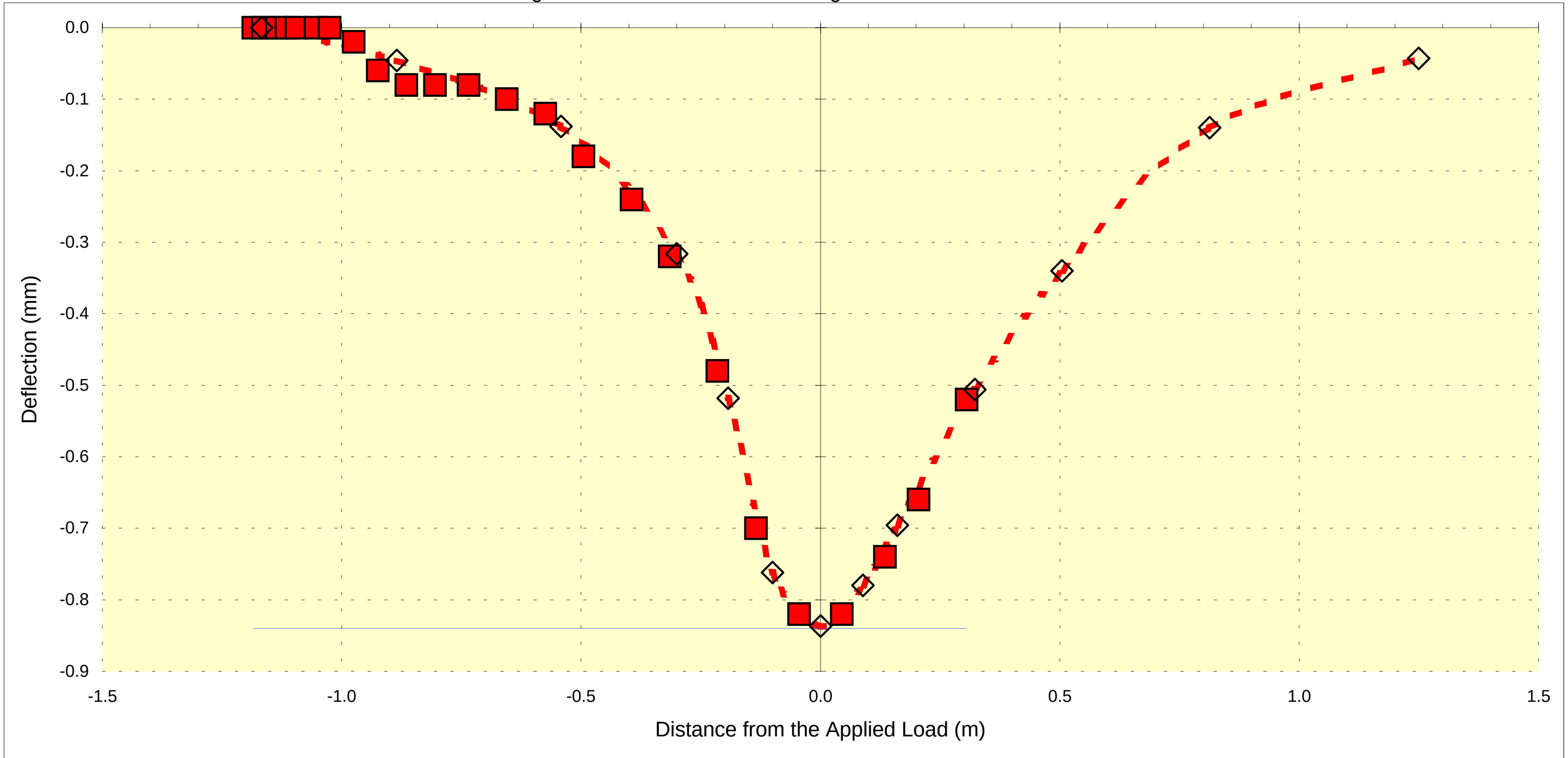
Road Maintenance and Rehabilitation Project

Deflection Bowl Test Results Road Name: Benga - Nkhotakota

Roughton International

in association with **Jatula Partners**

Road Code: 12.1 Test Section: S.Length 1 Chainage: 20.9 Points: 44 -45



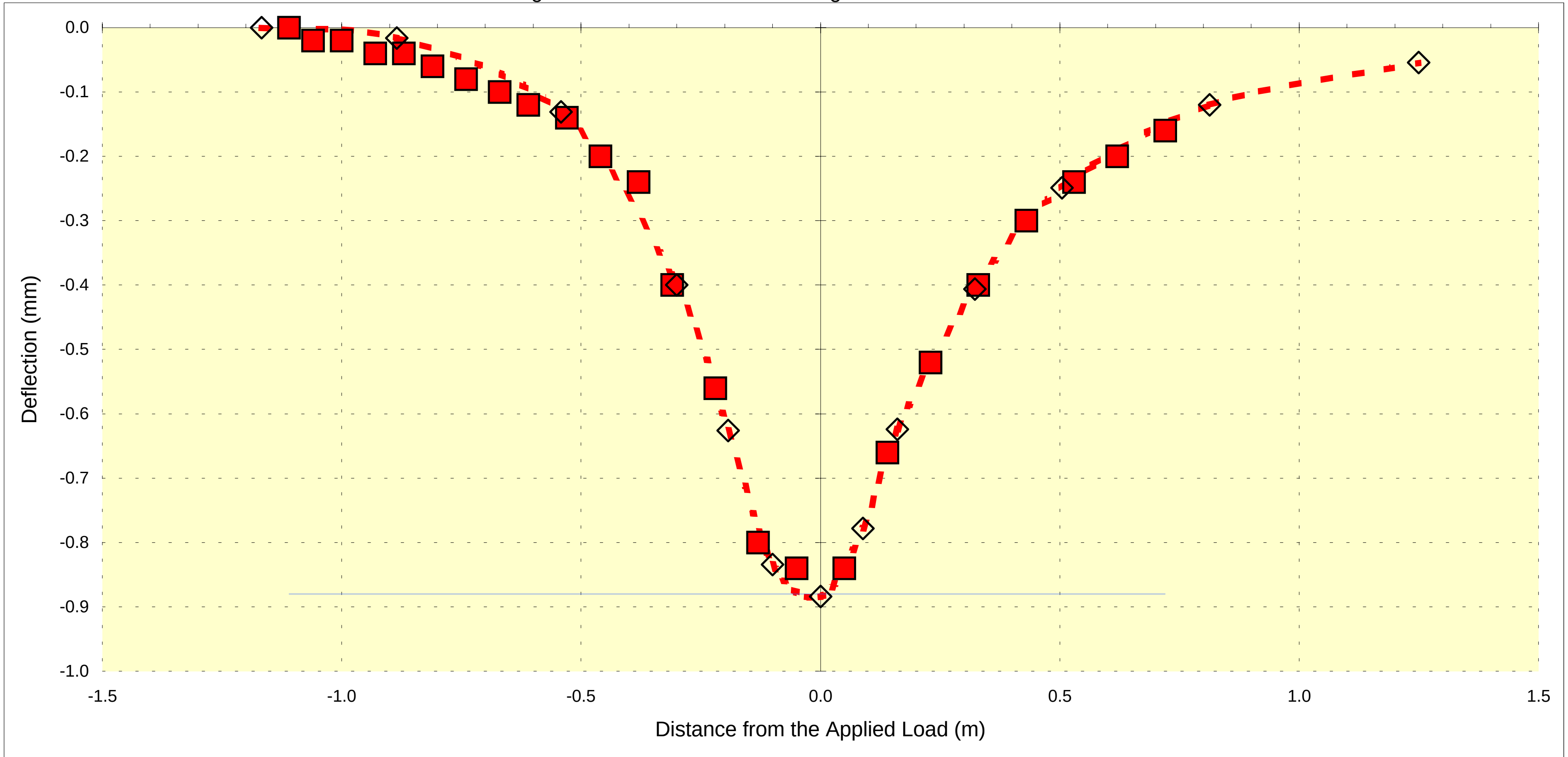
Existing Pavement Structure

Resultant	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
Movement	Layer Thickness (mm)	140	140	1000	Infinite	Layer Thickness (mm)	140	140	1000	Infinite
0.82 mm	- Mr (MPa)	81	126	70	5000	- Mr (MPa)	134	254	26	349

Road Maintenance and Rehabilitation Project | **Roughton International**

Deflection Bowl Test Results | Road Name: Benga - Nkhotakota | *in association with* **Jatula Partners**

Road Code: 12.1 | Test Section: S.Length 2 | Chainage: 20.9 | Points: 44 -45



Existing Pavement Structure

Resultant	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
Movement	Layer Thickness (mm)	140	140	1000	Infinite	Layer Thickness (mm)	140	140	1000	Infinite
0.76 mm	- Mr (MPa)	300	23	57	5000	- Mr (MPa)	76	81	46	139

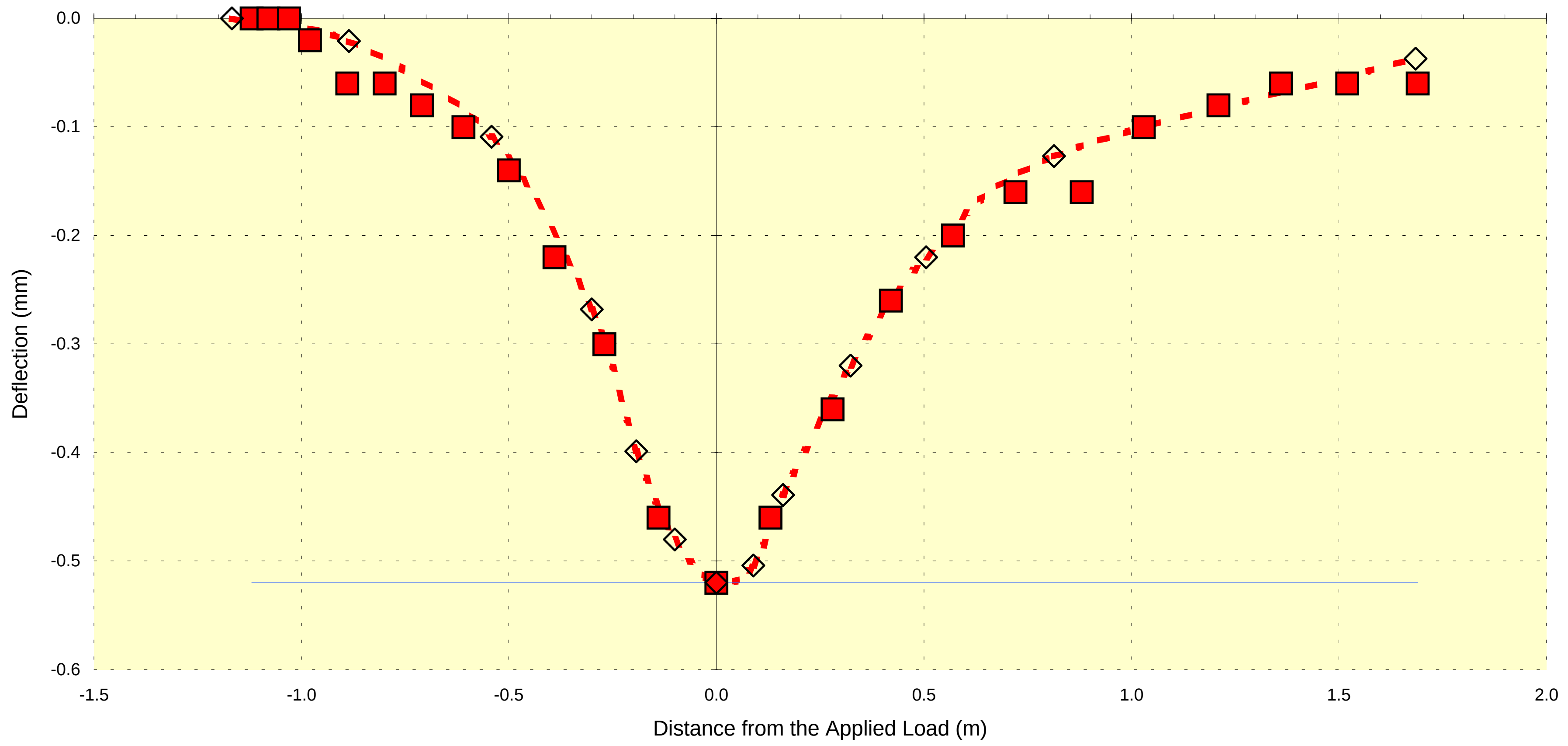
Road Maintenance and Rehabilitation Project

Deflection Bowl Test Results Road Name: Nkhotakota - Dwangwa

Road Code: 12.2 Test Section: S.Length 3 Chainage: 33.0 Points: 17 -18

Roughton International

in association with **Jatula Partners**



Existing Pavement Structure

Resultant	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
Movement	Layer Thickness (mm)	170	175	1000	Infinite	Layer Thickness (mm)	170	175	1000	Infinite
0.18 mm	- Mr (MPa)	415	50	74	5000	- Mr (MPa)	376	171	39	432

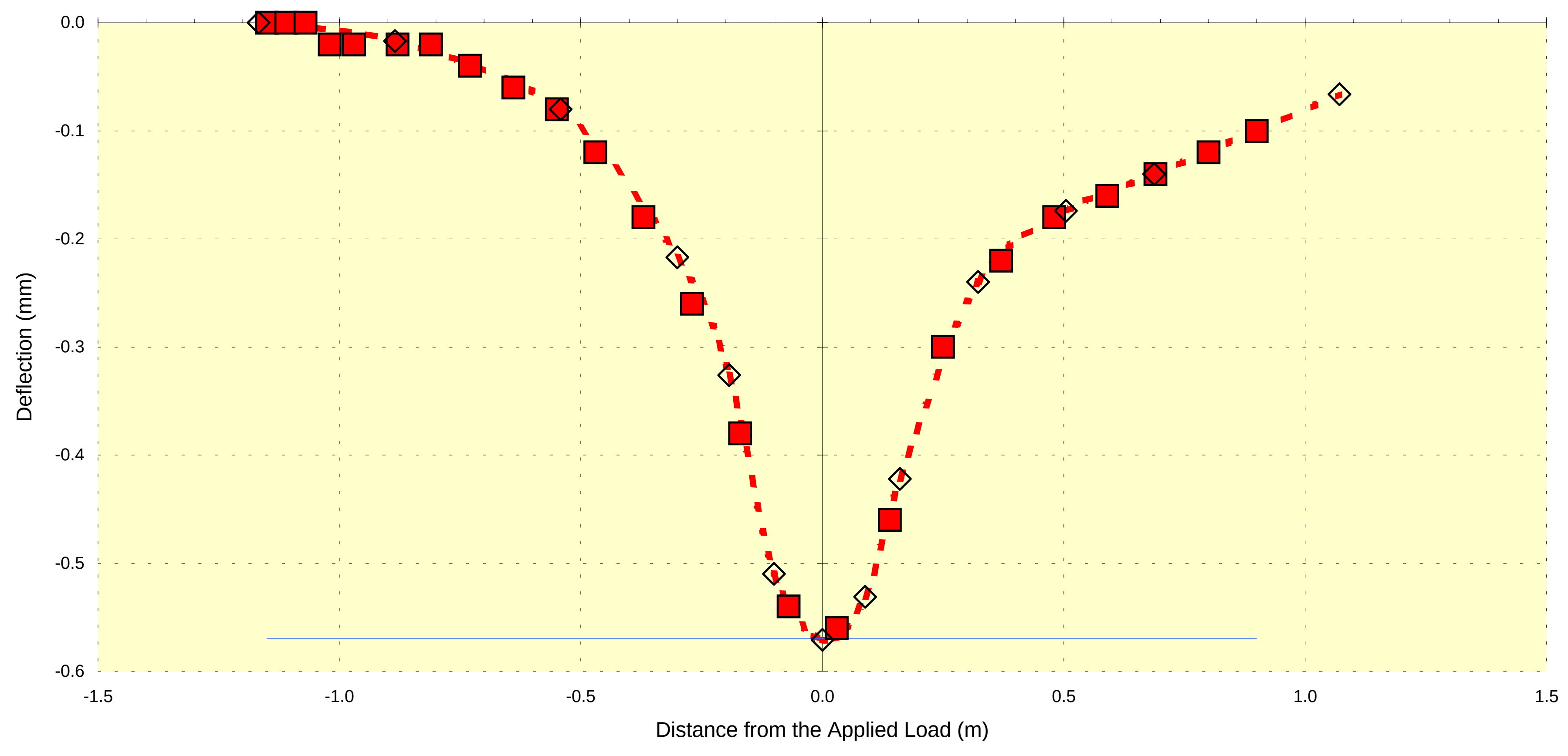
Road Maintenance and Rehabilitation Project

Roughton International

in association with **Jatula Partners**

Deflection Bowl Test Results Road Name: Nkhotakota - Dwangwa

Road Code: 12.2 Test Section: S.Length 4 Chainage: 39.6 Points: 23 -24



Existing Pavement Structure

Resultant	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
Movement	Layer Thickness (mm)	190	320	1000	Infinite	Layer Thickness (mm)	190	320	1000	Infinite
0.54 mm	- Mr (MPa)	117	68	95	5000	- Mr (MPa)	75	298	43	126

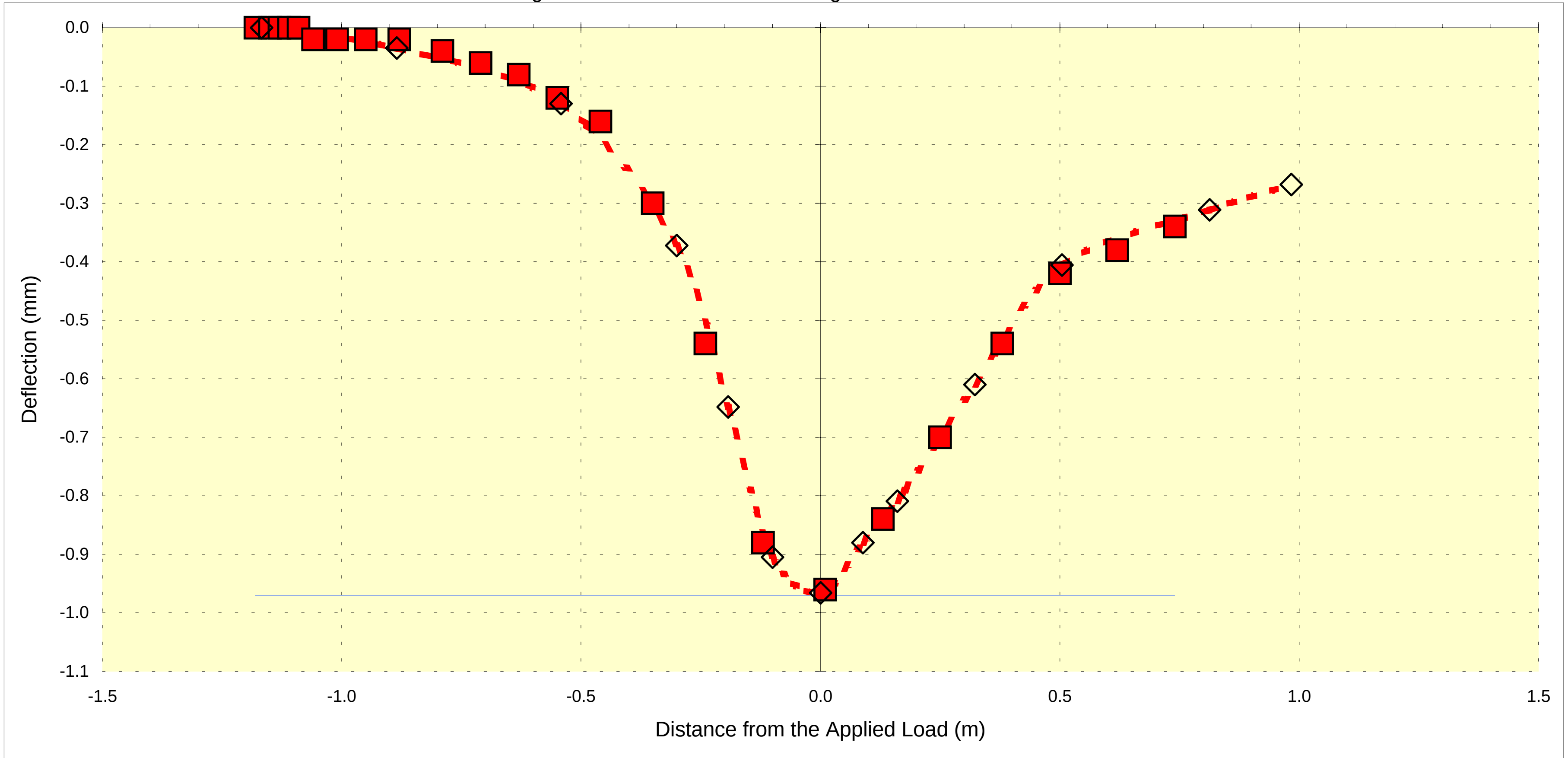
Road Maintenance and Rehabilitation Project

Deflection Bowl Test Results Road Name: Chingeni - Liwonde

Roughton International

in association with **Jatula Partners**

Road Code: 13.1 Test Section: S.Length 1 Chainage: 6.6 Points: 6 -7



Existing Pavement Structure

Resultant Movement	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
	Layer Thickness (mm)	150	170	1000	Infinite	Layer Thickness (mm)	150	170	1000	Infinite
0.94 mm	- Mr (MPa)	67	86	72	5000	- Mr (MPa)	501	20	118	23

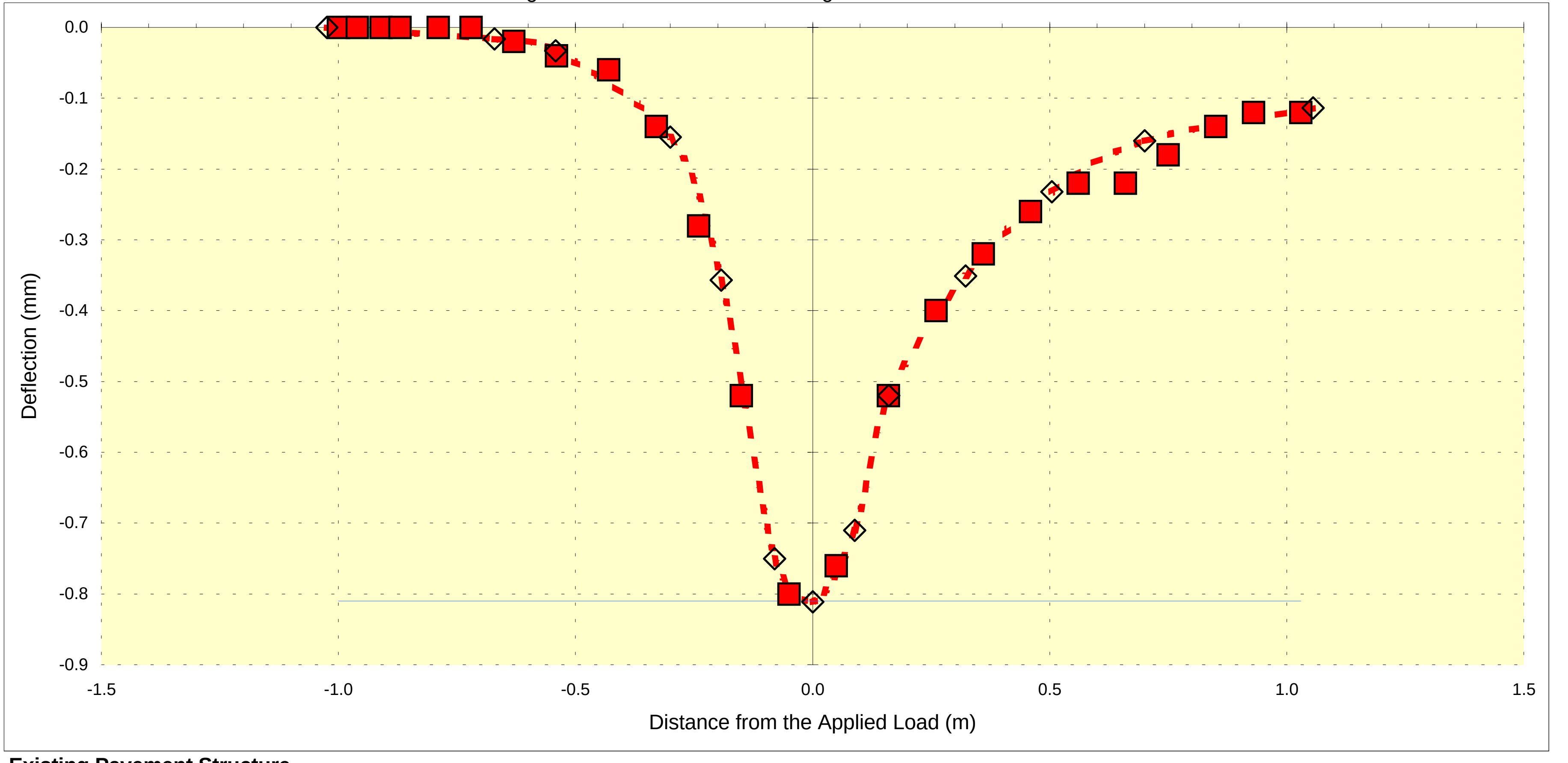
Road Maintenance and Rehabilitation Project

Deflection Bowl Test Results Road Name: Chingeni - Liwonde

Roughton International

in association with **Jatula Partners**

Road Code: 13.1 Test Section: S.Length 2 Chainage: 19.8 Points: 18 -19



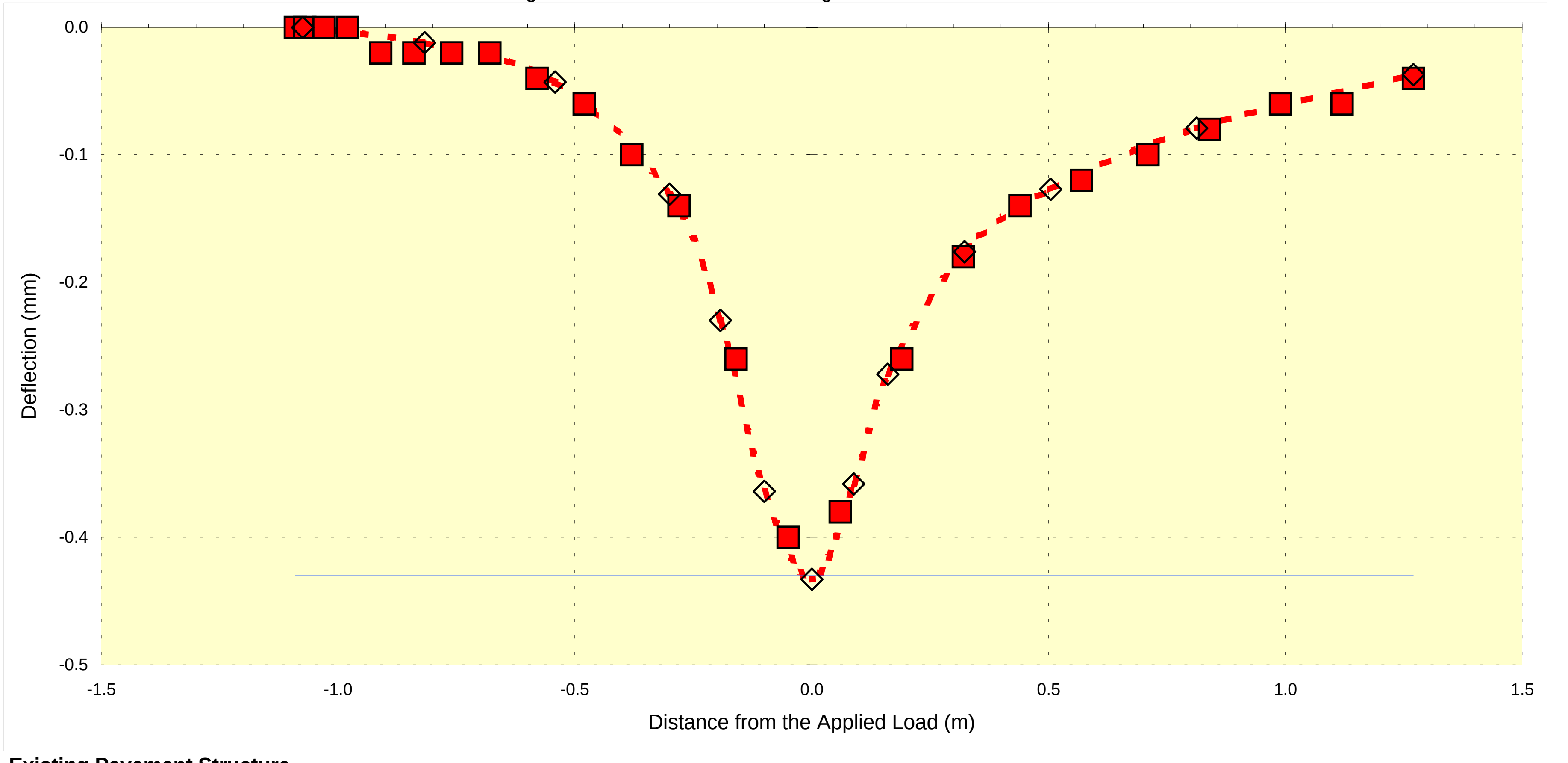
Existing Pavement Structure

Resultant	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
Movement	Layer Thickness (mm)	140	155	1000	Infinite	Layer Thickness (mm)	140	155	1000	Infinite
0.38 mm	- Mr (MPa)	21	50	162	5000	- Mr (MPa)	54	83	73	71

Road Maintenance and Rehabilitation Project
Deflection Bowl Test Results Road Name: Chingeni - Liwonde

Road Code: 13.1 Test Section: S.Length 3 Chainage: 26.4 Points: 29 -30

Roughton International
in association with **Jatula Partners**



Existing Pavement Structure

Resultant Movement	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
	Layer Thickness (mm)	165	110	1000	Infinite	Layer Thickness (mm)	165	110	1000	Infinite
0.24 mm	- Mr (MPa)	125	75	132	5000	- Mr (MPa)	63	946	104	195

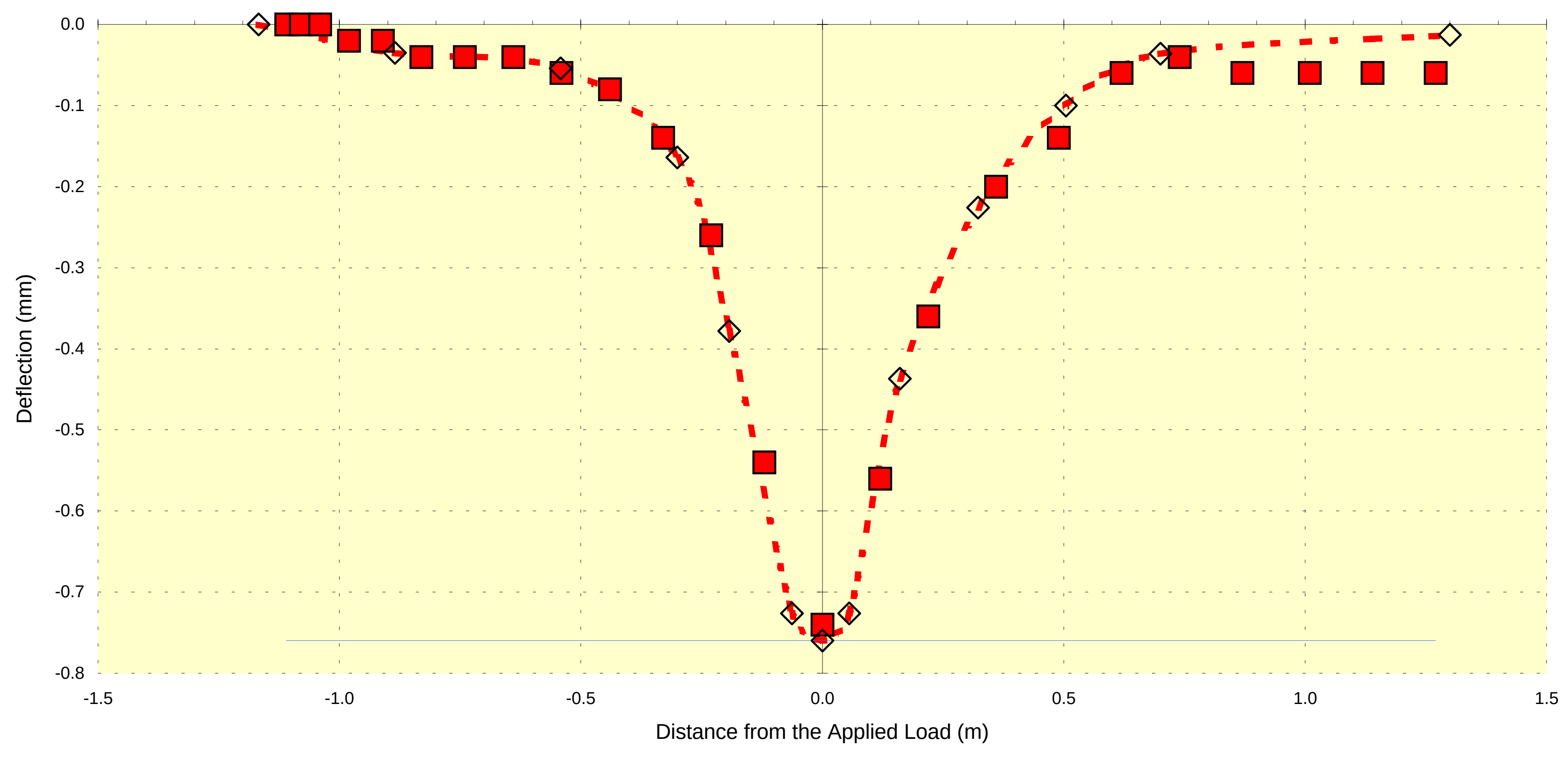
Road Maintenance and Rehabilitation Project

Deflection Bowl Test Results Road Name: Liwonde - Zomba

Roughton International

in association with **Jatula Partners**

Road Code: 13.2 Test Section: S.Length 4 Chainage: 42.9 Points: 49 -50



Existing Pavement Structure

Resultant	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
Movement	Layer Thickness (mm)	165	135	1000	Infinite	Layer Thickness (mm)	165	135	1000	Infinite
0.32 mm	- Mr (MPa)	37	52	104	5000	- Mr (MPa)	92	36	89	595

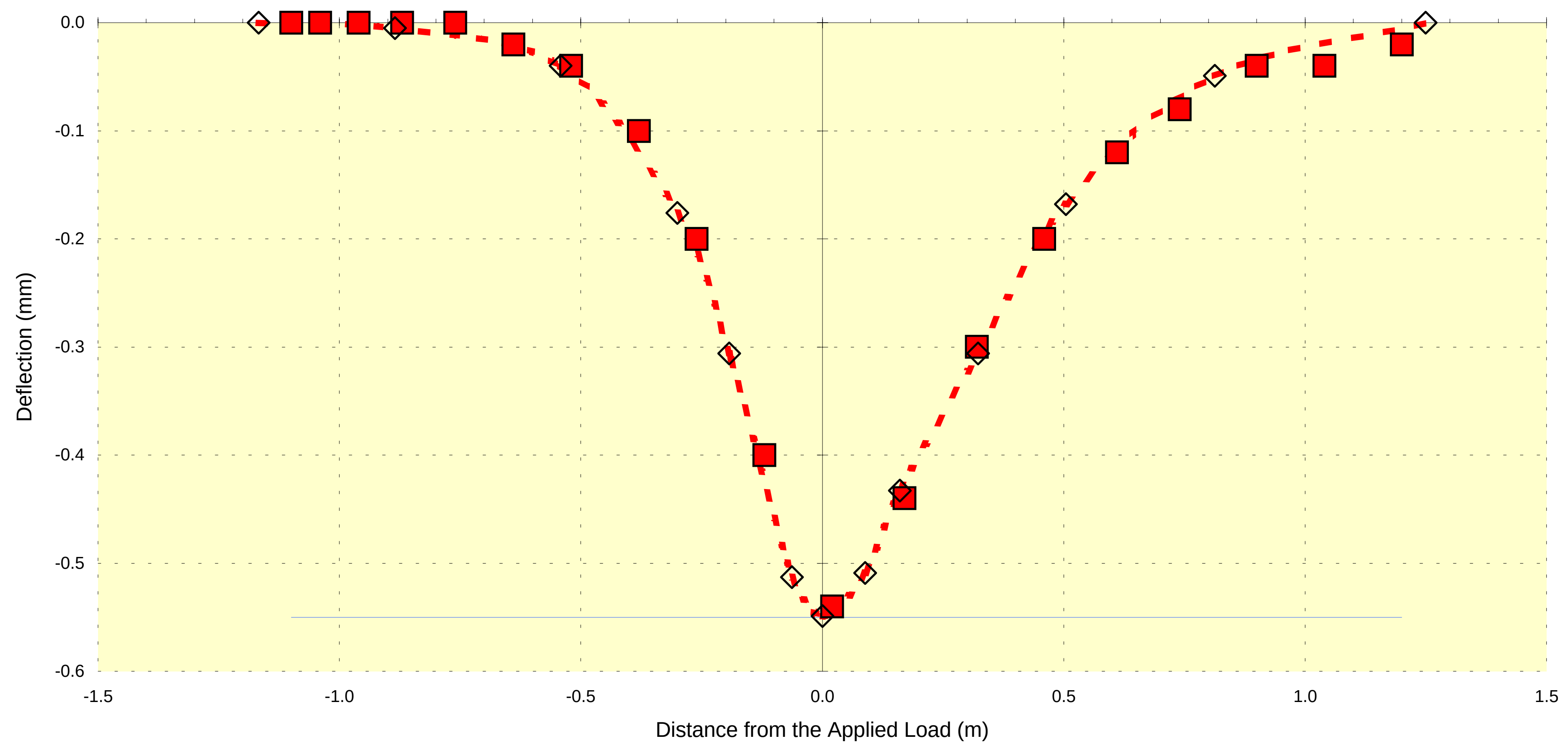
Road Maintenance and Rehabilitation Project

Deflection Bowl Test Results Road Name: Liwonde - Zomba

Road Code: 13.2 Test Section: S.Length 5 Chainage: 65.9 Points: 55 -56

Roughton International

in association with **Jatula Partners**



Existing Pavement Structure

Resultant	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
Movement	Layer Thickness (mm)	200	100	1000	Infinite	Layer Thickness (mm)	200	100	1000	Infinite
0.04 mm	- Mr (MPa)	138	24	171	5000	- Mr (MPa)	482	20	66	5000

Road Maintenance and Rehabilitation Project

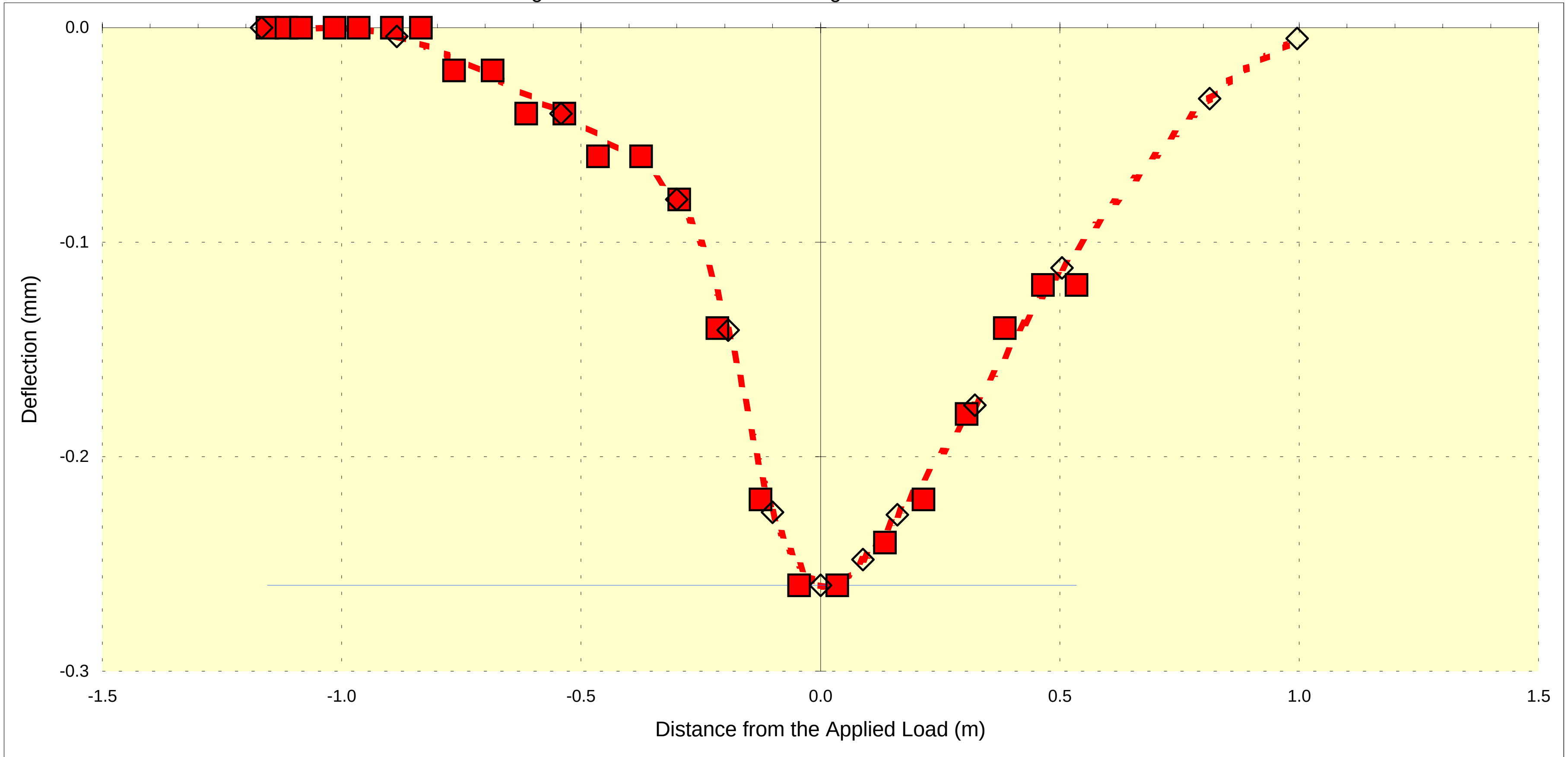
Deflection Bowl Test Results

Road Name: Liwonde - Zomba

Roughton International

in association with **Jatula Partners**

Road Code: 13.2 Test Section: S.Length 6 Chainage: 87.9 Points: 84 -85



Existing Pavement Structure

Resultant	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
Movement	Layer Thickness (mm)	150	100	1000	Infinite	Layer Thickness (mm)	150	100	1000	Infinite
0.26 mm	- Mr (MPa)	27	741	176	5000	- Mr (MPa)	571	284	96	1507

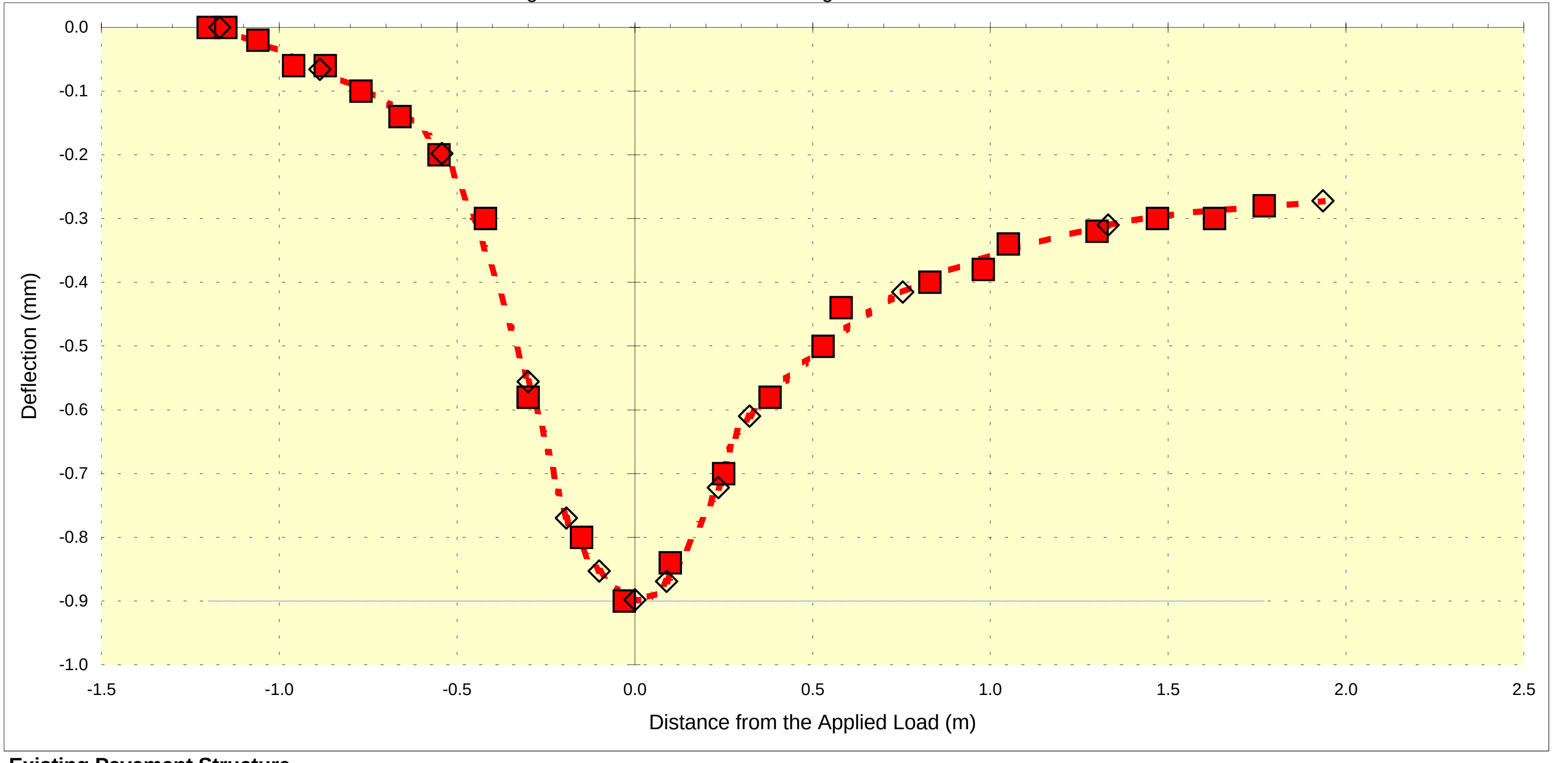
Road Maintenance and Rehabilitation Project

Deflection Bowl Test Results Road Name: Liwonde - Mangochi

Road Code: 14.1 Test Section: S.Length 1 Chainage: 4.9 Points: 0 -1

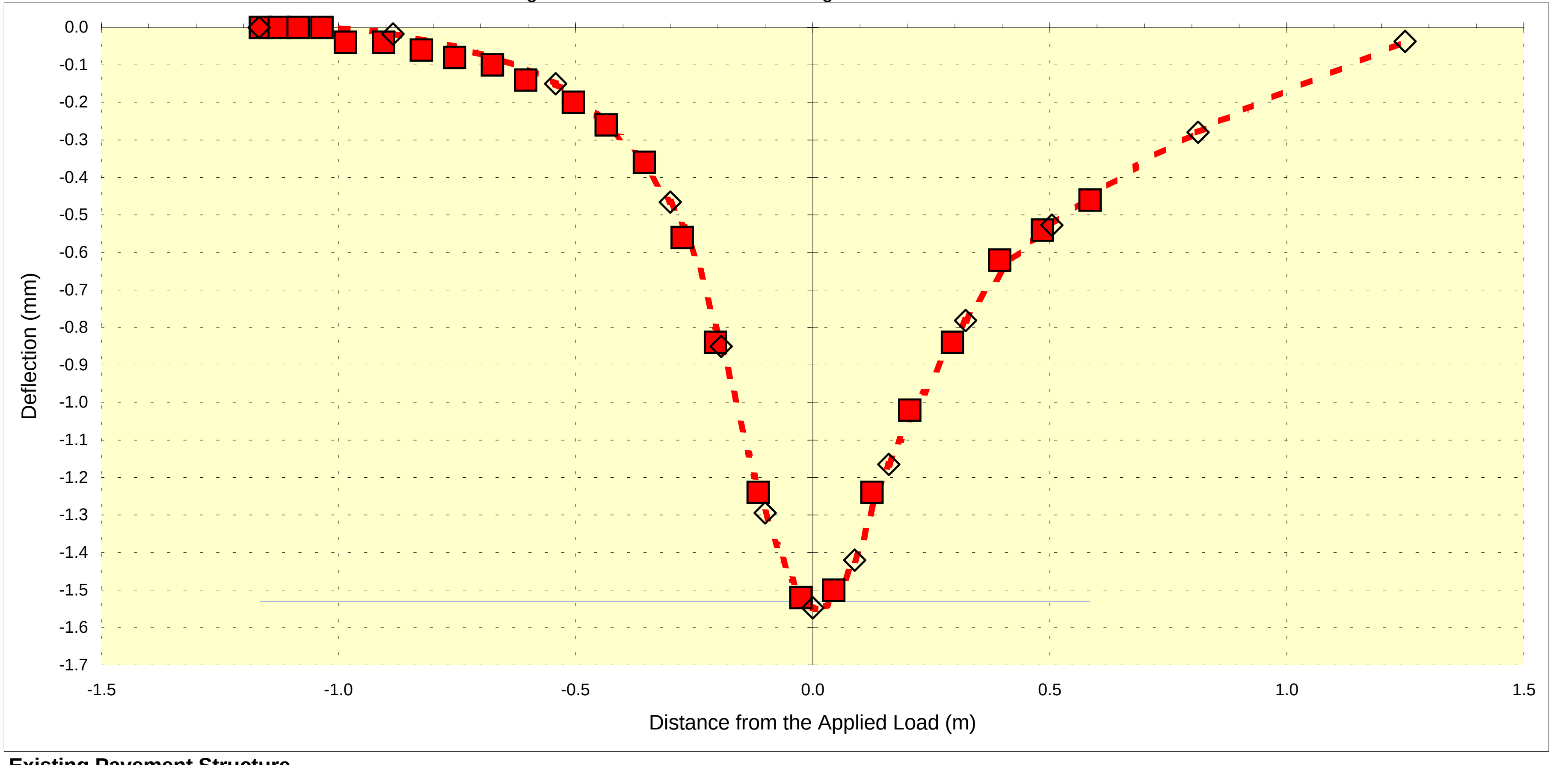
Roughton International

in association with **Jatula Partners**



Existing Pavement Structure

Resultant	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
Movement	Layer Thickness (mm)	110	150	1000	Infinite	Layer Thickness (mm)	110	150	1000	Infinite
0.36 mm	- Mr (MPa)	1497	20	35	5000	- Mr (MPa)	1876	20	153	15



Existing Pavement Structure

Resultant	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
Movement	Layer Thickness (mm)	140	60	1000	Infinite	Layer Thickness (mm)	140	60	1000	Infinite
1.46 mm	- Mr (MPa)	47	84	44	5000	- Mr (MPa)	82	153	20	243

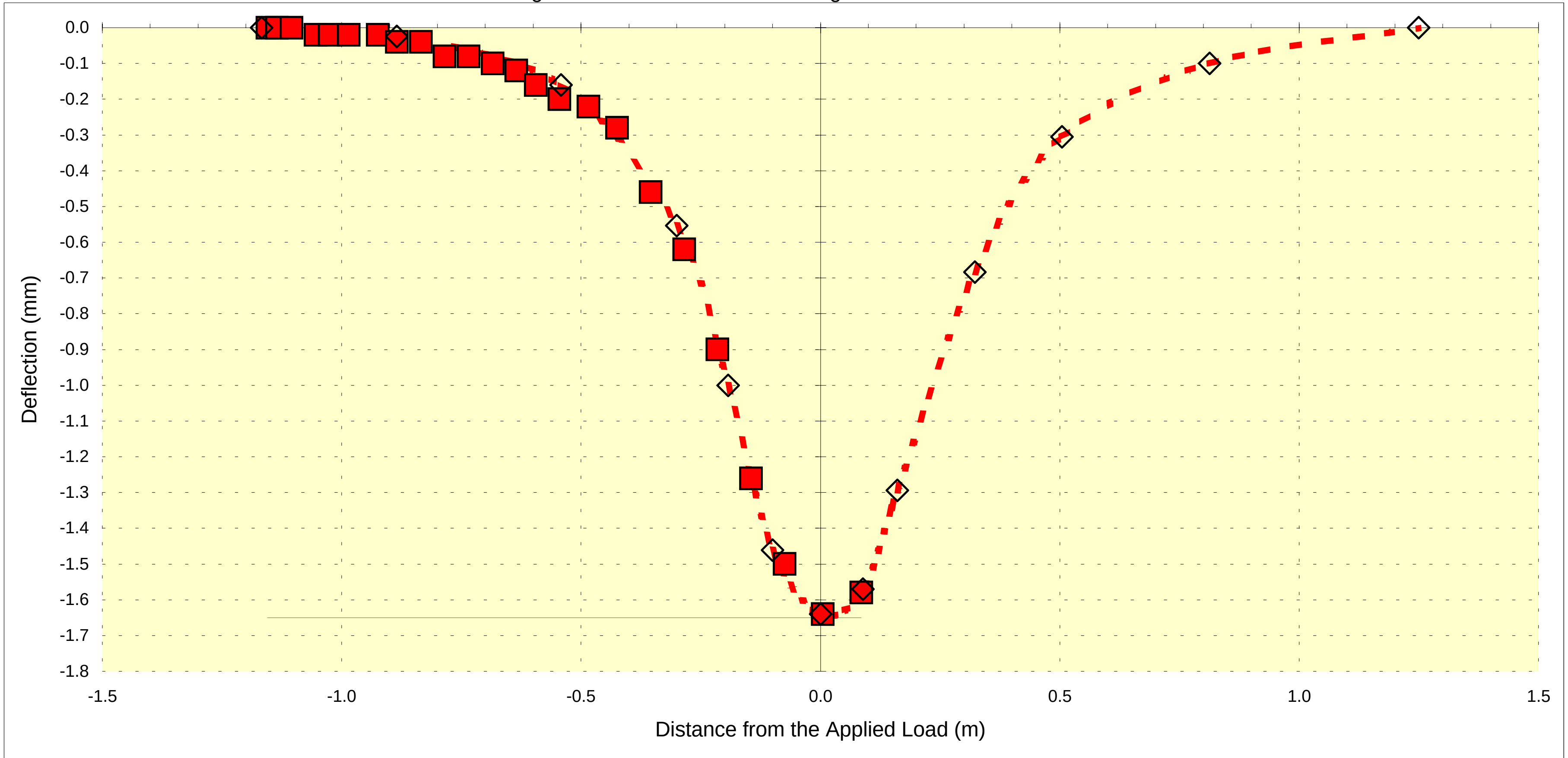
Road Maintenance and Rehabilitation Project

Deflection Bowl Test Results Road Name: Liwonde - Mangochi

Road Code: 14.1 Test Section: S.Length 3 Chainage: 44.0 Points: 32 -33

Roughton International

in association with **Jatula Partners**

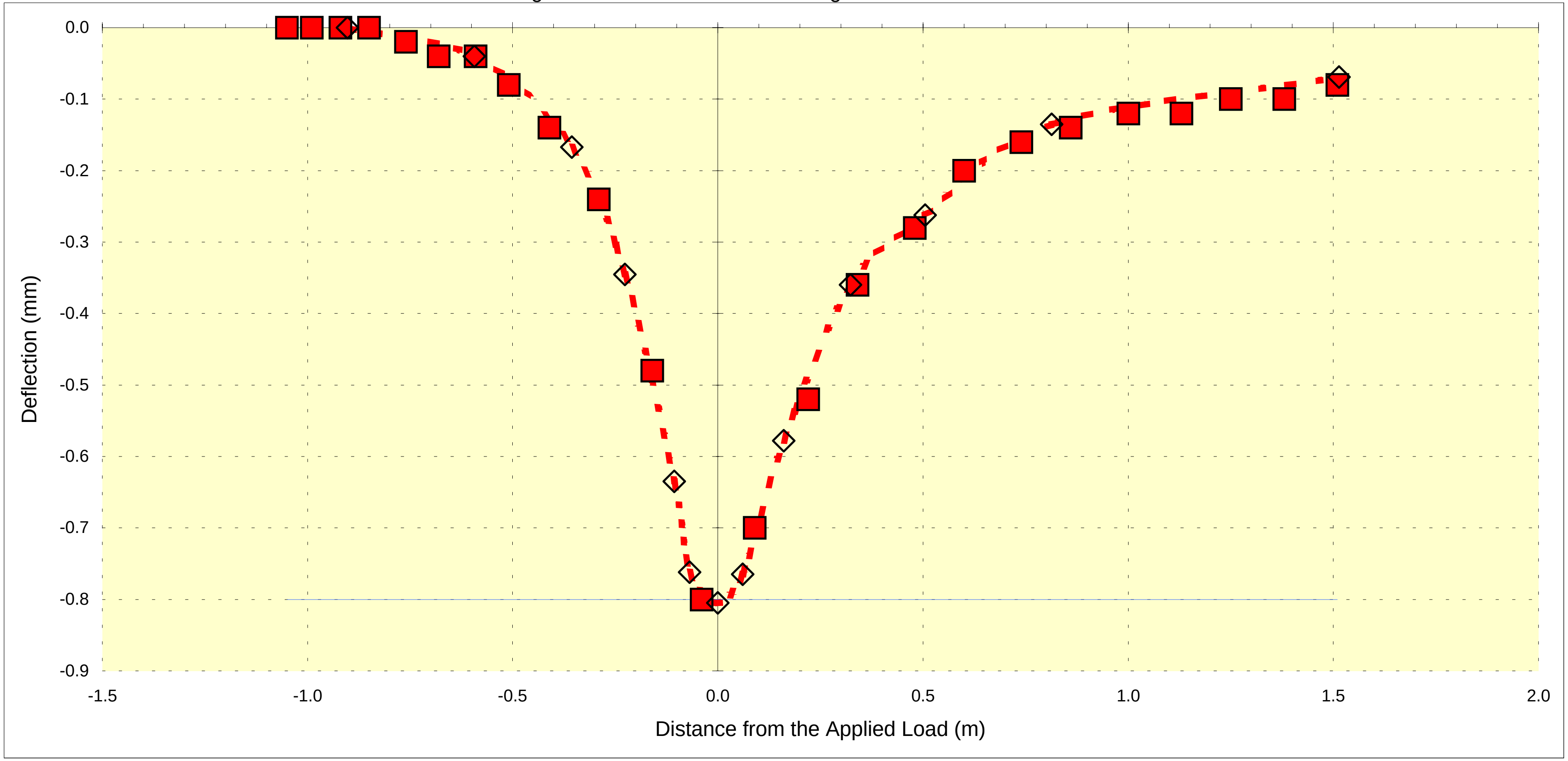


Existing Pavement Structure

Resultant Movement	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
	Layer Thickness (mm)	160	350	1000	Infinite	Layer Thickness (mm)	160	350	1000	Infinite
1.62 mm	- Mr (MPa)	45	21	52	5000	- Mr (MPa)	38	40	41	5000

Deflection Bowl Test Results Road Name: Liwonde - Mangochi

Road Code: 14.1 Test Section: S.Length 4 Chainage: 58.2 Points: 62 -63



Existing Pavement Structure

Resultant Movement	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
	Layer Thickness (mm)	150	150	1000	Infinite	Layer Thickness (mm)	150	150	1000	Infinite
0.24 mm	- Mr (MPa)	94	32	87	5000	- Mr (MPa)	32	290	54	83

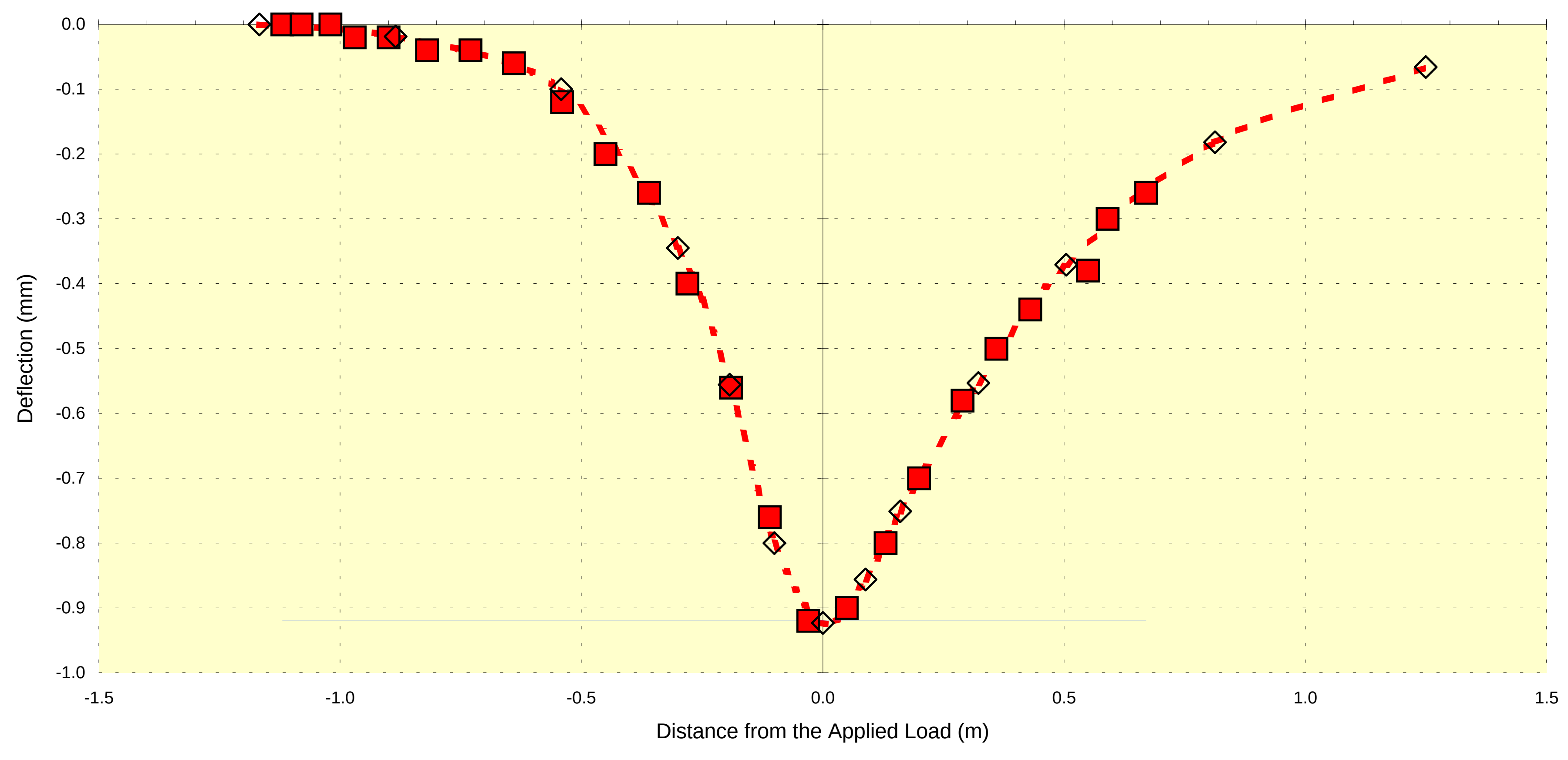
Road Maintenance and Rehabilitation Project

Roughton International

in association with **Jatula Partners**

Deflection Bowl Test Results Road Name: Mangochi - Monkey Bay

Road Code: 14.2 Test Section: S.Length 5 Chainage: 85.7 Points: 14 -15



Existing Pavement Structure

Resultant Movement	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
	Layer Thickness (mm)	210	510	1000	Infinite	Layer Thickness (mm)	210	510	1000	Infinite
0.86 mm	- Mr (MPa)	71	38	140	5000	- Mr (MPa)	226	38	24	748

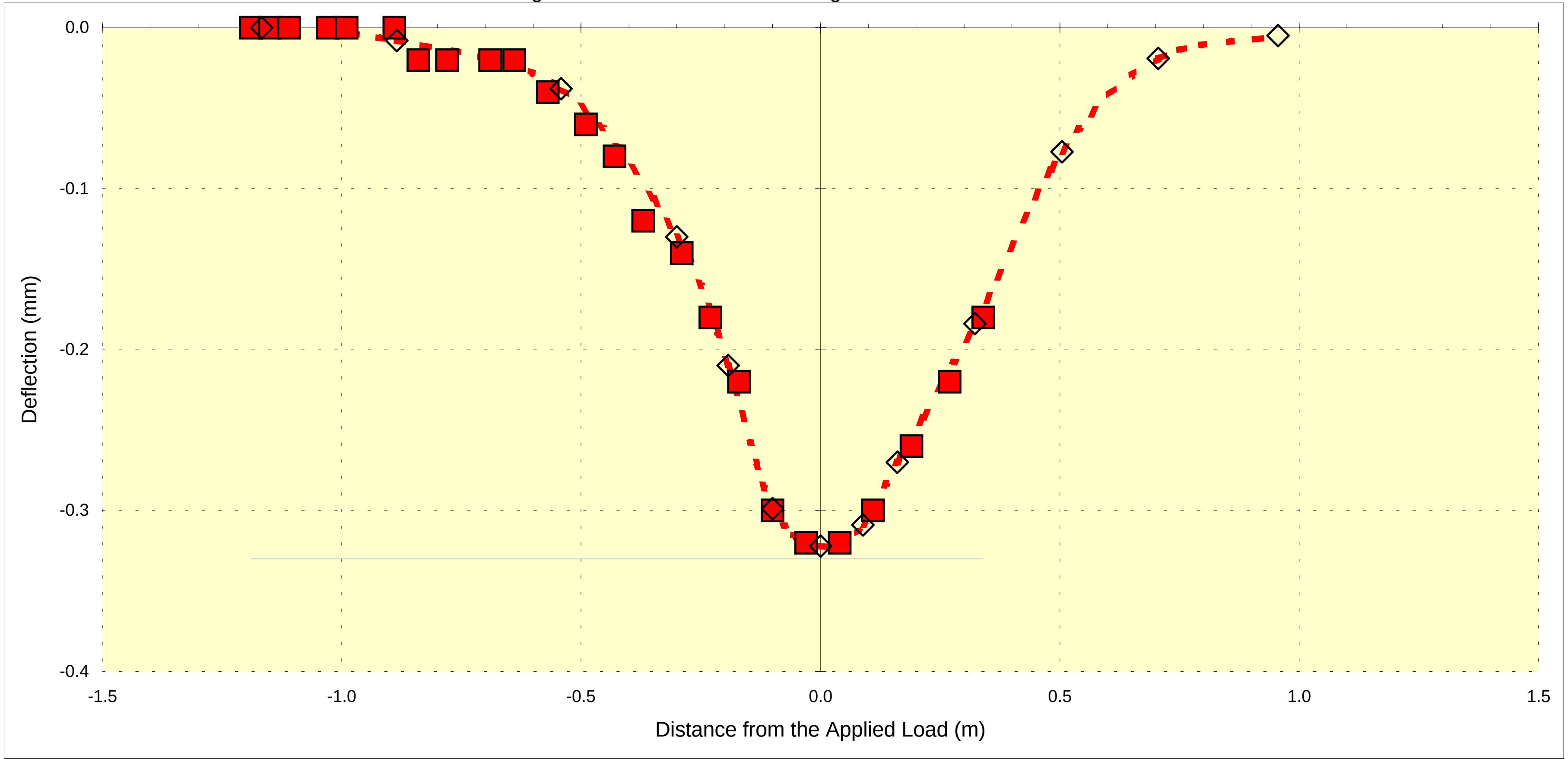
Road Maintenance and Rehabilitation Project

Roughton International

Deflection Bowl Test Results Road Name: Mangochi - Monkey Bay

in association with **Jatula Partners**

Road Code: 14.2 Test Section: S.Length 6 Chainage: 97.8 Points: 26 -27



Existing Pavement Structure

Resultant	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
Movement	Layer Thickness (mm)	130	65	1000	Infinite	Layer Thickness (mm)	130	65	1000	Infinite
0.30 mm	- Mr (MPa)	793	37	176	5000	- Mr (MPa)	2509	20	145	5000

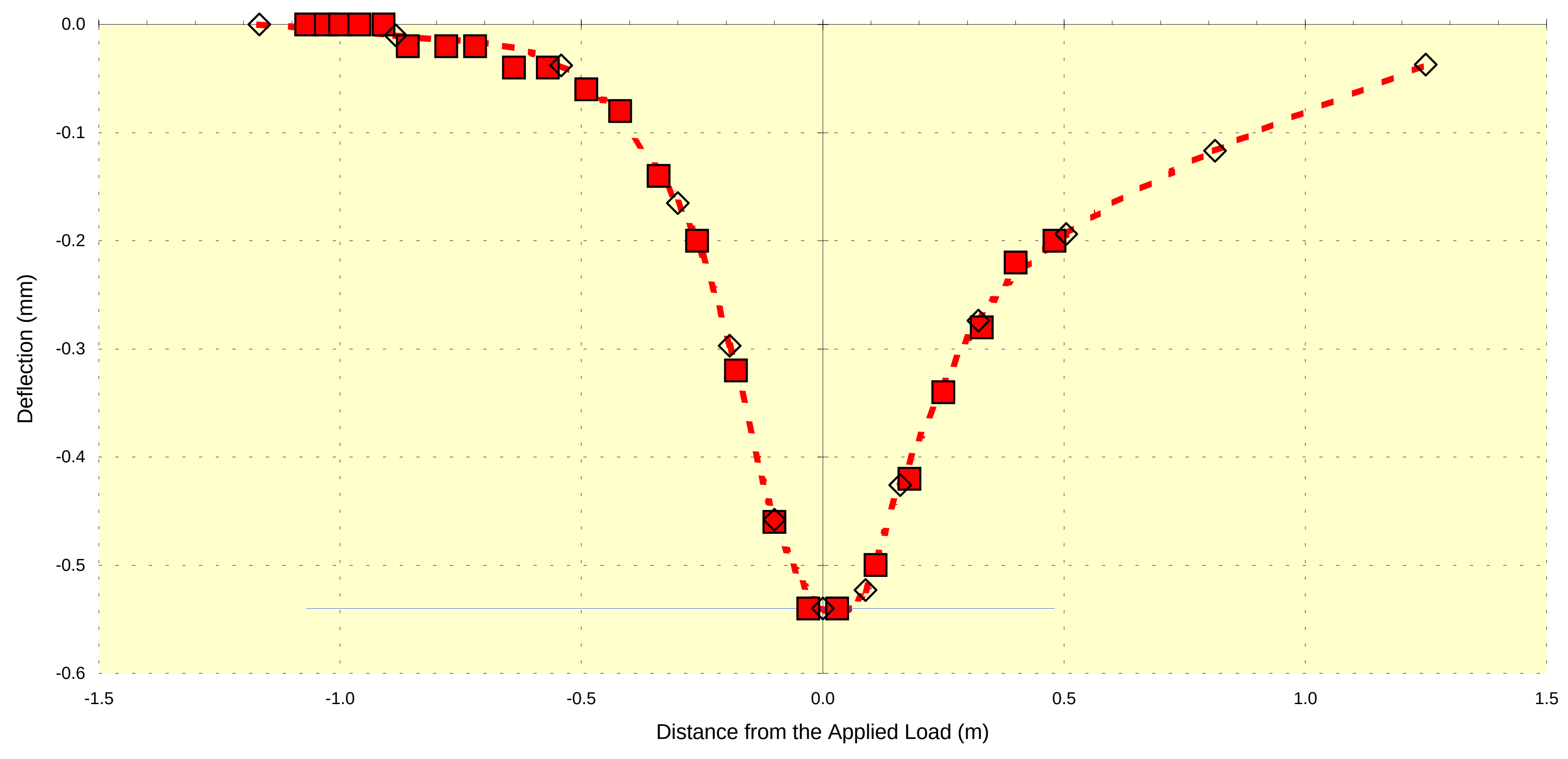
Road Maintenance and Rehabilitation Project

Roughton International

in association with **Jatula Partners**

Deflection Bowl Test Results Road Name: Mangochi - Monkey Bay

Road Code: 14.2 Test Section: S.Length 7 Chainage: 111.0 Points: 32 -33



Existing Pavement Structure

Resultant	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
Movement	Layer Thickness (mm)	200	115	1000	Infinite	Layer Thickness (mm)	200	115	1000	Infinite
0.52 mm	- Mr (MPa)	126	31	170	5000	- Mr (MPa)	145	253	53	240

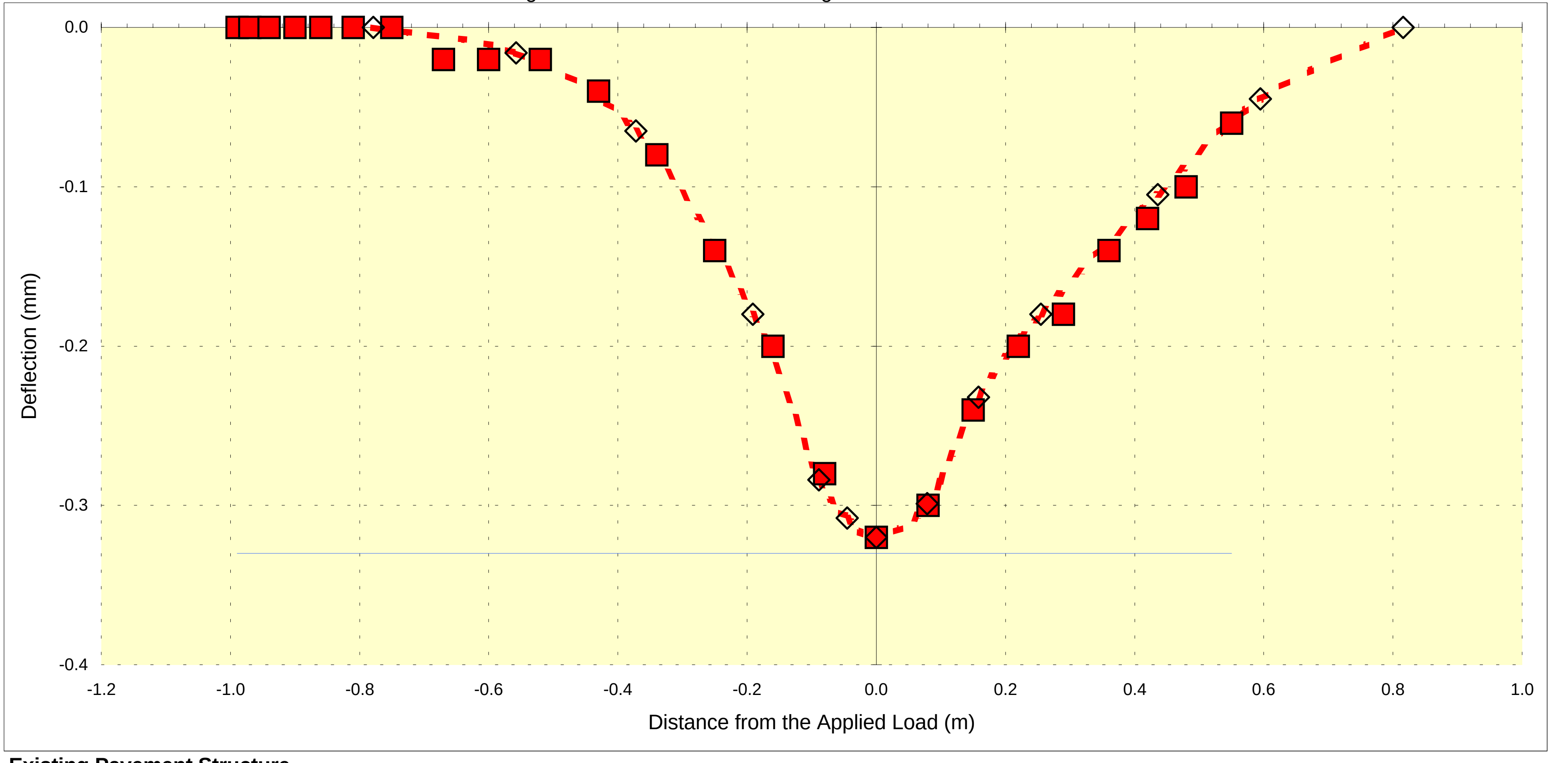
Road Maintenance and Rehabilitation Project

Roughton International

in association with **Jatula Partners**

Deflection Bowl Test Results Road Name: Mangochi - Monkey Bay

Road Code: 14.2 Test Section: S.Length 8 Chainage: 7.7 Points: 56 -57



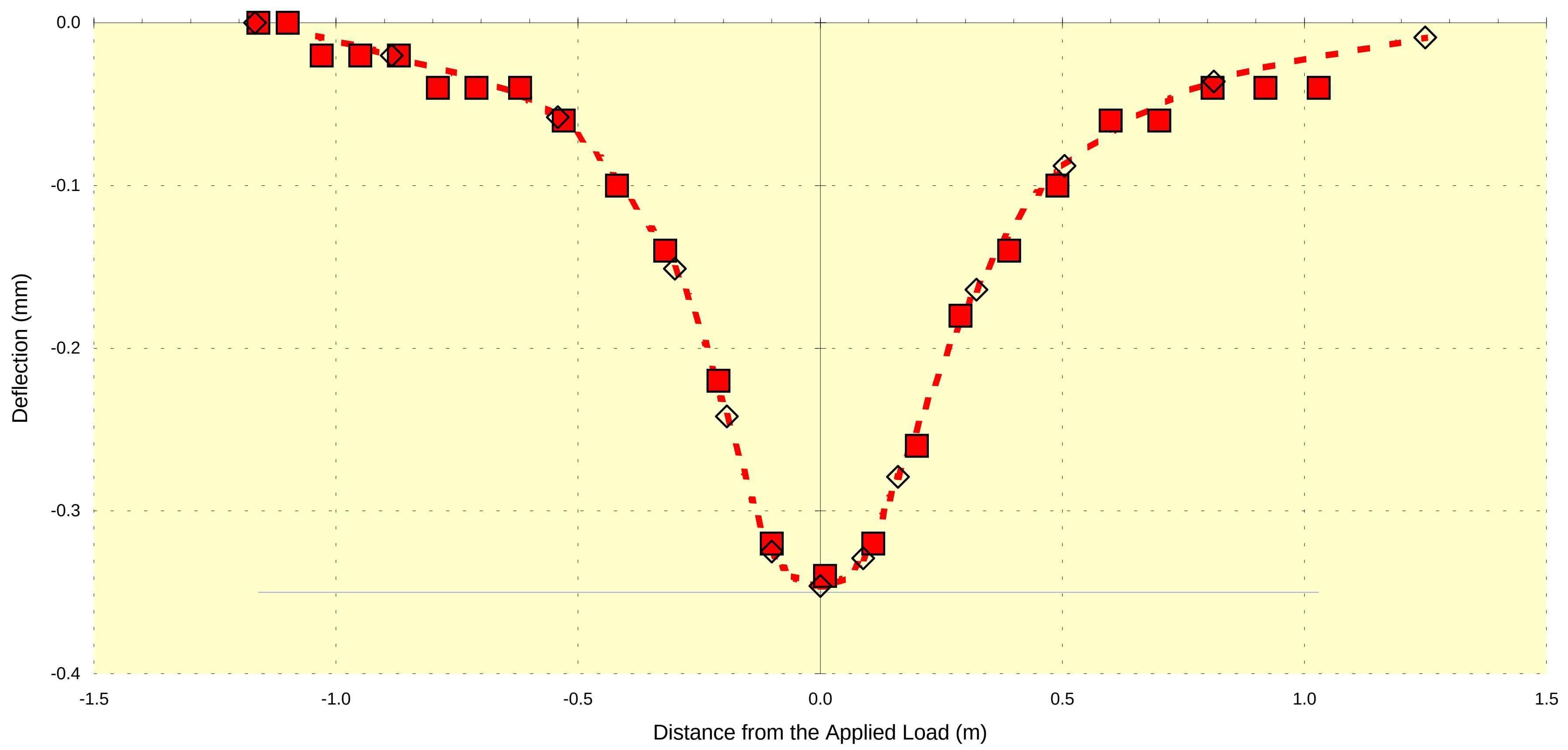
Existing Pavement Structure

Resultant	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
Movement	Layer Thickness (mm)	195	75	1000	Infinite	Layer Thickness (mm)	195	75	1000	Infinite
0.32 mm	- Mr (MPa)	275	27	348	5000	- Mr (MPa)	268	276	86	5000

Road Maintenance and Rehabilitation Project **Roughton International**

Deflection Bowl Test Results Road Name: Zomba - Blantyre *in association with* **Jatula Partners**

Road Code: 15 Test Section: S.Length 1 Chainage: 11.0 Points: 1 -2



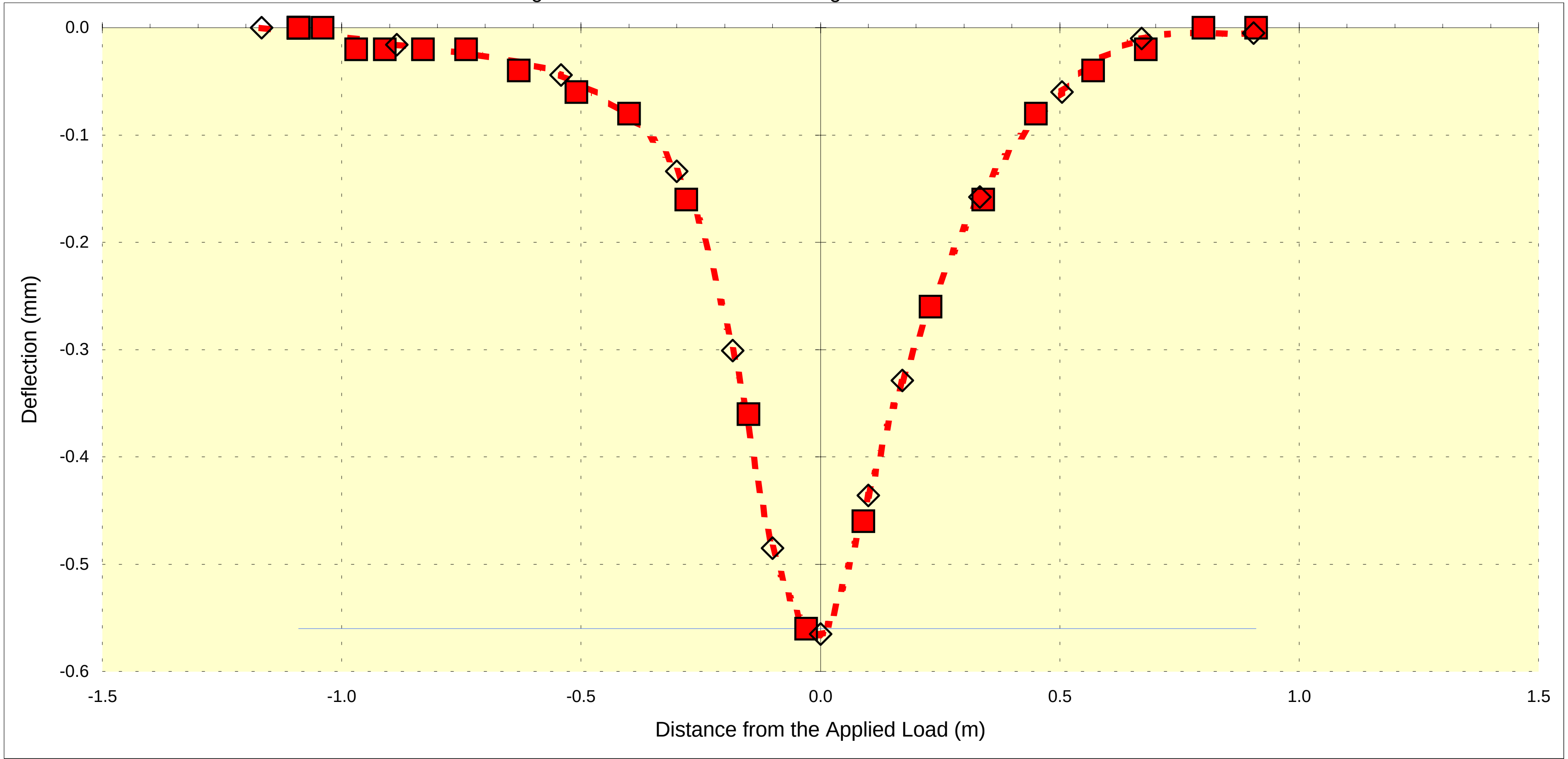
Existing Pavement Structure

Resultant	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
Movement	Layer Thickness (mm)	200	80	1000	Infinite	Layer Thickness (mm)	200	80	1000	Infinite
0.22 mm	- Mr (MPa)	273	73	118	5000	- Mr (MPa)	434	48	117	988

Road Maintenance and Rehabilitation Project **Roughton International**

Deflection Bowl Test Results Road Name: Zomba - Blantyre *in association with* **Jatula Partners**

Road Code: 15 Test Section: S.Length 2 Chainage: 16.5 Points: 12 -13



Existing Pavement Structure

Resultant	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
Movement	Layer Thickness (mm)	190	200	1000	Infinite	Layer Thickness (mm)	190	200	1000	Infinite
0.04 mm	- Mr (MPa)	48	83	136	5000	- Mr (MPa)	128	45	143	5000

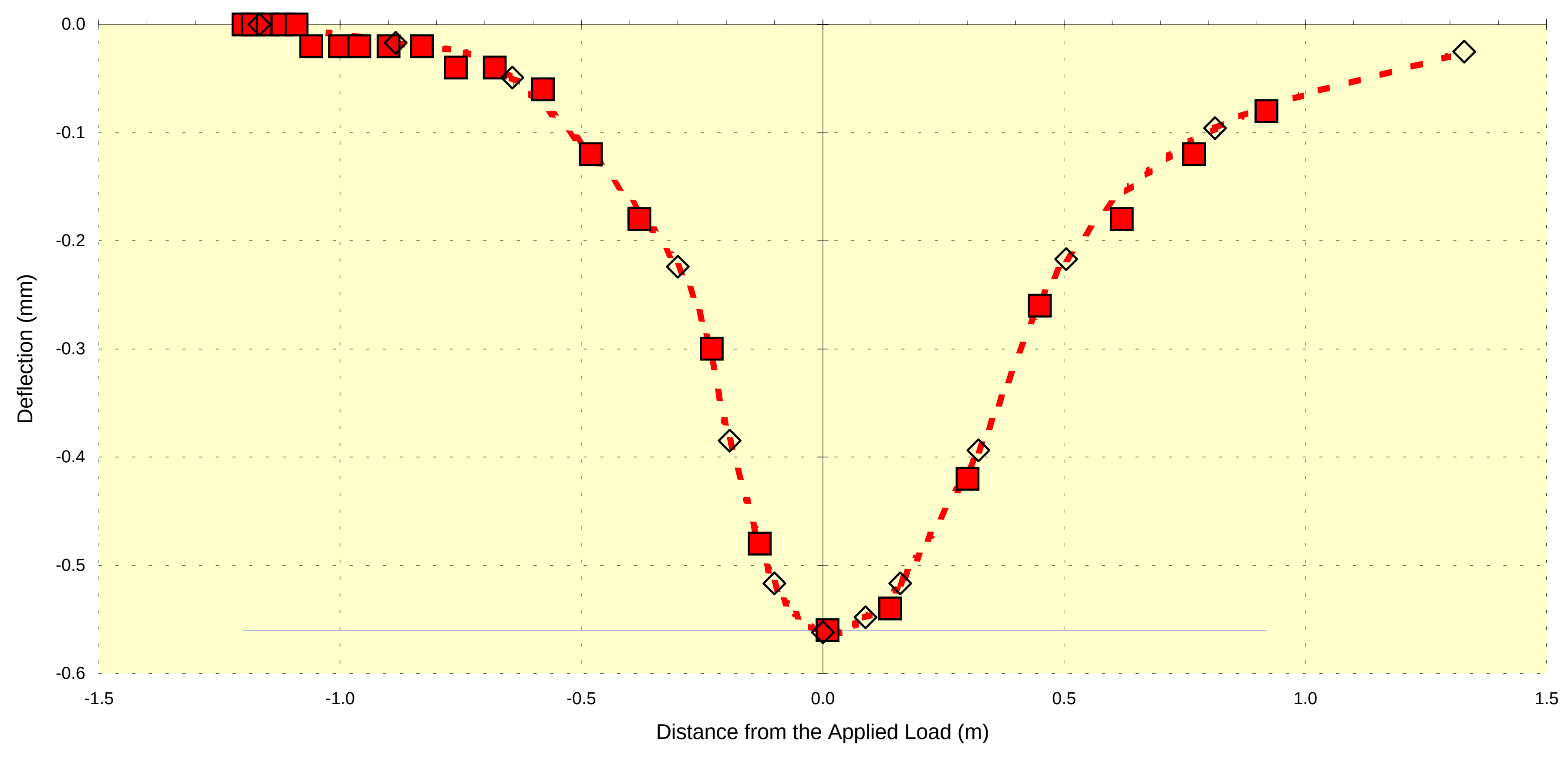
Road Maintenance and Rehabilitation Project

Roughton International

Deflection Bowl Test Results Road Name: Zomba - Blantyre

in association with **Jatula Partners**

Road Code: 15 Test Section: S.Length 3 Chainage: 24.2 Points: 24 -25



Existing Pavement Structure

Resultant	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
Movement	Layer Thickness (mm)	190	200	1000	Infinite	Layer Thickness (mm)	190	200	1000	Infinite
0.54 mm	- Mr (MPa)	156	53	96	5000	- Mr (MPa)	806	28	52	392

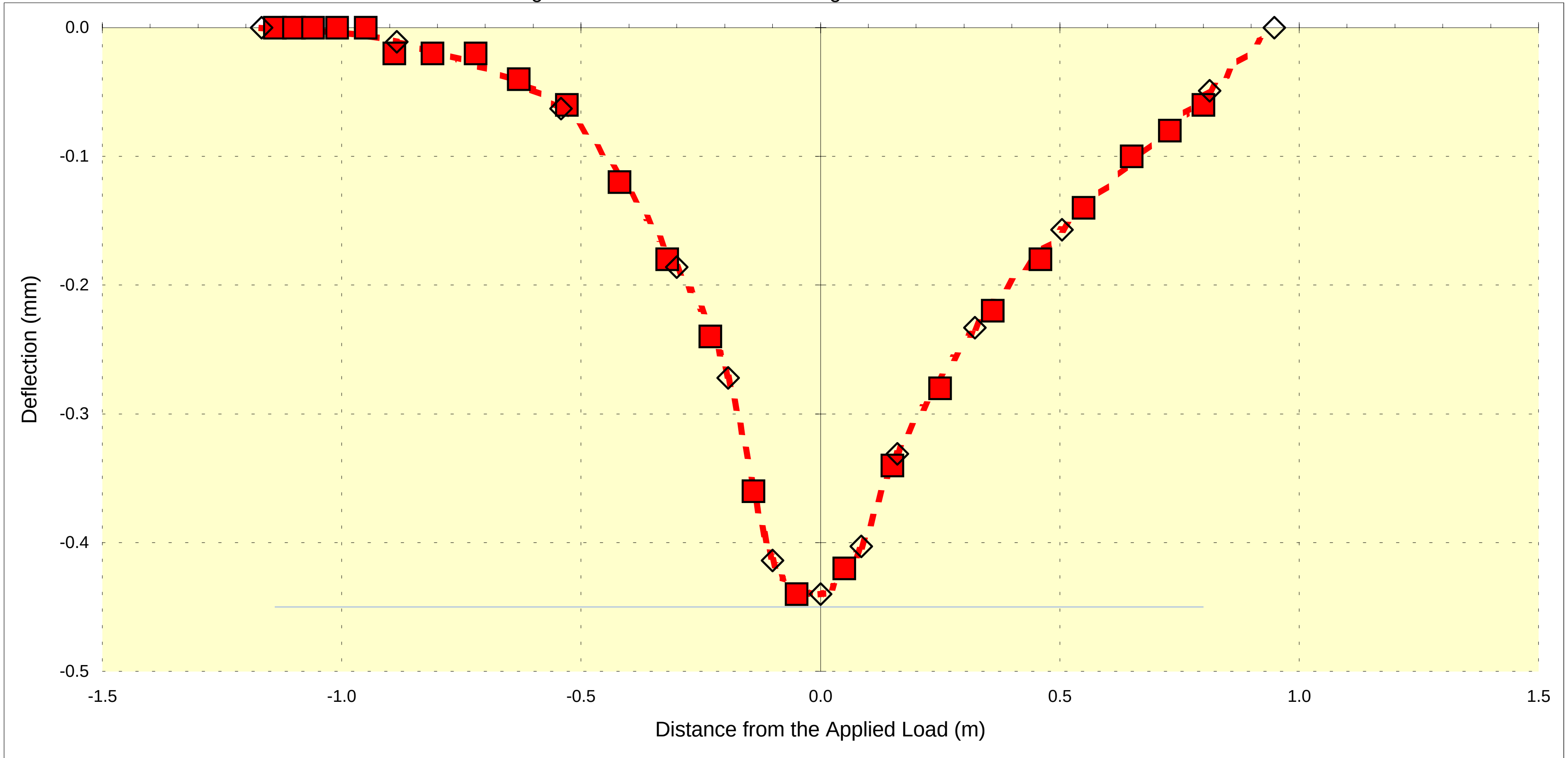
Road Maintenance and Rehabilitation Project

Deflection Bowl Test Results Road Name: Zomba - Blantyre

Road Code: 15 Test Section: S.Length 4 Chainage: 51.6 Points: 34 -35

Roughton International

in association with **Jatula Partners**



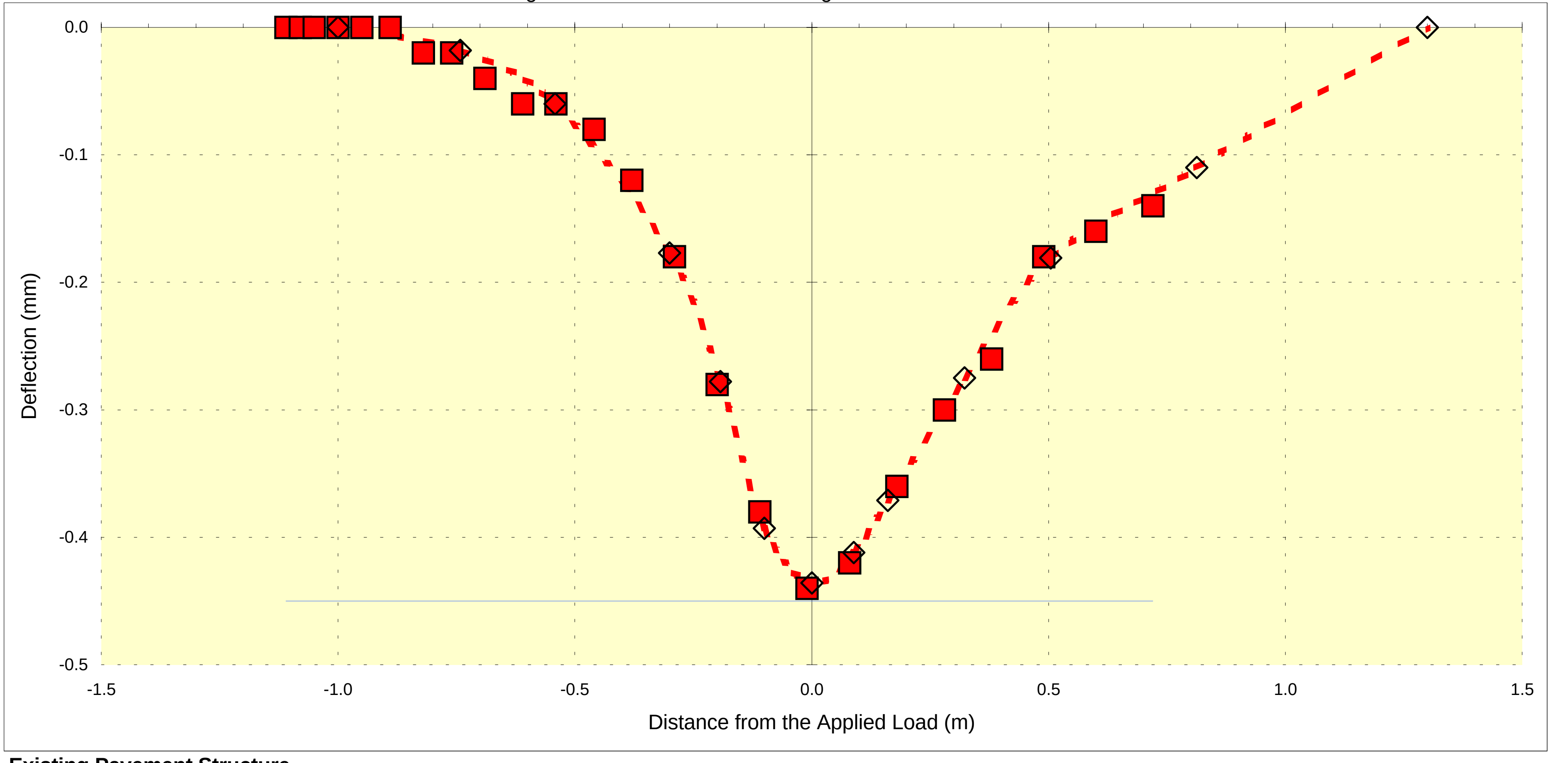
Existing Pavement Structure

Resultant	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
Movement	Layer Thickness (mm)	190	200	1000	Infinite	Layer Thickness (mm)	190	200	1000	Infinite
0.40 mm	- Mr (MPa)	248	58	128	5000	- Mr (MPa)	187	180	48	5000

Road Maintenance and Rehabilitation Project **R**<u>**oughton International**</u>

Deflection Bowl Test Results Road Name: Zomba - Blantyre *in association with* **Jatula Partners**

Road Code: 15 Test Section: S.Length 5 Chainage: 56.0 Points: 54 -55



Existing Pavement Structure

Resultant	Layer Description	Surface & Base	Subbase	Subgrade		Layer Description	Surface & Base	Subbase	Subgrade	
Movement	Layer Thickness (mm)	145	180	1000	Infinite	Layer Thickness (mm)	145	180	1000	Infinite
0.42 mm	- Mr (MPa)	319	71	114	5000	- Mr (MPa)	260	166	63	5000

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International
in association with **Jatula Partners**

Road Name: Karonga - Songwe | Road Code: 1 | Sample Length No.: S1 | Truck Axle Load - LHS: 3175 kg | Date: 27-Jul-98

Chainage (km) 3.30 to 5.30 | Sample Length Code: 11 | Width: 6.7 m | RHS: 3175 kg | Operator: RI/MOWS

Chainage (km)		Surface Condition																											
		Primary Cracking						Secondary Cracking						Pothole		Patch		Edge		Ravel		Bleed		Skid		Deform			
From	To	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Number	Av.Area (m^2)	Number	Av.Area (m^2)	Length	Av.Width (m)	Extent (%)	Degree	Extent (%)	Degree	Extent (%)	Degree	Condition	Position	Shoulder Condition	Drainage Condition
3.30	3.40	L	WP	2	20	✓														70	3	50	3	40	3			P	
3.40	3.50	L	WP	2	30	✓														70	3	60	3	50	3			P	
3.50	3.60	L	WP	4	50	✓														70	3	60	3	50	3			P	
3.60	3.70	L	WP	3	30	✓														70	3	70	2	60	2			P	
3.70	3.80	L	SH	4	50	✓										3	1	30	1.0	80	3	70	3	60	2			P	
3.80	3.90	L	SH	4	60	✓														80	3	70	3	50	2			P	
3.90	4.00	L	SH	4	60	✓														80	3							P	
4.00	4.10	L	SH	4	50	✓																						P	
4.10	4.20	L	SH	4	40	✓																						P	
4.20	4.30	L	SH	4	30	✓										2	1											P	
4.30	4.40	L	SH	4	50	✓														90	2	80	2	80	2	L	CW	G	
4.40	4.50	L	SH	4	80	✓														90	2	80	2	80	2	L	CW	G	
4.50	4.60	L	SH	4	80	✓												20	1.0	90	2	60	2	70	2	L	CW	G	
4.60	4.70	L	SH	4	80	✓														90	2	60	2	60	2	L	CW	G	
4.70	4.80	L	SH	3	80	✓												5	1.0	90	3	60	2	60	2	L	CW	G	
4.80	4.90	L	SH	2	20	✓														90	3	80	2	80	2			G	
4.90	5.00	L	SH	2	30	✓														90	3	90	3	80	2			G	
5.00	5.10	L	SH	2	30	✓														90	3	90	3	80	2			G	
5.10	5.20	L	SH	2	20	✓														90	3	90	3	80	2			G	
5.20	5.30	L	SH	2	50	✓														90	3	90	3	80	2			G	

Point Number		Peak Deflection (mm x 100)										Rad.of Curve								Rut Depth (mm)	
		LH Wheelpath				RH Wheelpath						LH Wheelpath									
		Initial	Maximum	Final	Deflection	Initial	Maximum	Final	Deflection	Max Corrected	Wheel Path	Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	LHS	RHS
0	L	2	32	1	61	0	16	-1	33	78	OWP	0	25	0	56	56	1.3	81	105	0	7
		0	30	0	60	0	16	-1	33			0	26	2	56						
1	L	1	24	0	47	2	13	2	22	59	OWP	0	10	1	147	98	2.4	92	217	6	8
		2	24	1	45	1	11	2	19			-4	25	-4	48						
2	L	2	14	1	25	2	11	0	20	34	OWP	0	15	-1	90	133	1.3	187	252	3	9
		3	16	2	27	0	10	1	19			0	8	0	175						
3	L	4	26	2	46	2	23	0	44	61	OWP	0	20	0	70	66	1.1	109	118	4	0
		2	26	2	48	2	22	1	41			3	25	2	62						
4	L	2	25	2	46	3	17	2	29	62	OWP	0	27	0	52	62	1.0	110	108	0	0
		2	27	2	50	4	20	4	32			1	20	0	72						
5	L	2	23	1	43	3	21	3	36	57	OWP	0	12	0	117	117	3.1	90	280	8	0
		2	24	1	45	3	22	4	37												
6	L	2	37	2	70	1	19	-1	38	92	OWP	1	60	-25	19	33	0.6	83	50	9	5
		2	38	1	73	2	22	3	39			1	30	-1	47						
7	L	2	22	1	41	0	21	0	42	53	IWP	0	29	0	48	42	0.3	182	51	16	5
		2	21	2	38	5	25	5	40			0	40	0	35						
8	L	2	35	2	66	1	26	0	51	89	OWP	1	35	1	41	41	0.9	78	70	15	5
			36	0	72	0	25	1	49												
9	L	2	31	1	59	5	27	6	43	76	OWP	0	27	1	53	104	4.5	62	277	16	5
		2	30	0	58	5	27	6	43			0	10	2	156						
10	L	2	39	1	75	0	26	1	51	96	OWP	0	22	0	64	60	2.3	57	132	8	7
		4	40	2	74	0	28	1	55			0	25	0	56						
11	L	0	28	-1	57	2	25	5	43	76	OWP	0	20	-1	68	68	1.8	77	142	12	8
		1	30	-1	60	2	26	2	48												
12	L	1	33	0	65	0	27	0	54	86	OWP	0	30	0	47	58	1.7	69	119	6	3
		2	35	0	68	2	29	2	54			0	20	0	70						
13	L	2	30	3	55	3	24	0	45	72	OWP	0	30	1	47	59	1.2	90	108	3	0
		2	29	0	56	3	24	0	45			0	20	0	70						
14	L	3	31	0	59	1	29	2	55	79	OWP	1	35	0	41	49	1.0	86	87	4	5
		2	32	-1	63	3	32	1	60			1	25	1	58						
15	L	3	25	1	46	2	22	3	39	59	OWP	0	32	0	44	42	0.4	144	56	7	0
		2	24	0	46	2	21	1	39			0	35	0	40						
16	L	2	28	1	53	0	21	0	42	71	OWP	0	28	0	50	54	1.0	96	93	17	7
		2	30	1	57	4	26	4	44			0	25	1	57						
17	L	2	35	1	67	1	22	0	43	88	OWP	1	22	-1	64	58	1.8	67	118	8	5
		2	36	1	69	2	26	2	48			0	27	0	52						
18	L	3	30	0	57	2	27	1	51	73	OWP	-2	27	-1	49	56	1.1	90	102	4	0
		2	30	2	56	2	26	3	47			0	22	0	64						
19	L	2	24	0	46	2	24	3	43	57	OWP	0	30	-2	45	44	0.4	147	60	9	8
		3	24	2	43	0	21	0	42			0	32	-1	43						
20	L	2	24	0	46	0	19	0	38	59	OWP	-1	22	1	64	62	0.9	117	106	10	6
		2	24	0	46	1	19	4	33			0	22	-2	61						

Road Maintenance and Rehabilitation Project - Malawi
Roughton International
Detailed Visual Condition Survey and Deflection Survey for Sample Lengths
in association with **Jatula Partners**

Road Name:	Karonga - Songwe	Road Code:	1	Sample Length No.:	S1	Truck Axle Load - LHS:	3175 kg
Chainage (km)	3.30 to 5.30	Sample Length Code:	11	Width:	6.7 m	RHS:	3175 kg

Date: 27-Jul-98
Operator: RI/MOWS

Averages and Totals

Area Cracked	6298	m^2	47.0%
Wide Cracks	6298	m^2	47.0%
Average Condition Index	5.6		
Minimum Condition Index	1.2		
Maximum Condition Index	8.9		

Area to be patched	113	m^2	0.8%
Area already patched	4	m^2	0.0%
Area Ravelled	9514	m^2	71.0%
Area patched during shoulder repair	600	m^2	4.5%

Average Deflection	δ_p	0.70	mm	
Standard Deviation	σ	0.15	mm	
Calibration Correction Factor	F_c	0.993	0.99	
Seasonal Correction Factor	F_w	1.300		
Design Deflection	δ_d	0.93	mm	
Percentile to equal the Design Deflection	96%	0.93	mm	
Predicted Design Axles	No.	3.14	$x10^6$	Axles
Residual Equivalent Standard Axles	No.	1.47	$x10^6$	ESAs

Percentile of the Road that will Require Reconstruction 4% of the road
Percentile of the Road that will not Require Strengthening d= 0.93 mm 96%

OWP	20	95%
IWP	1	5%

Average Rut Depth		6.1	mm
Standard Deviation of Rut Depth		4.5	mm
Avg.Radius of Curvature		64	m
Avg.M_r Upper Layers		126	MPa
M_r Base	80%	142	MPa
M_r Subbase	20%	70	MPa
Avg.M_r of the Foundation		101	MPa
M_r Selected Subgrade	80%	117	MPa
M_r Subgrade	20%	77	MPa

Target Deflection: 0.8 mm
Existing Base Material: CR

Crushed Rock Granular Overlay Thickness	=	110	mm
Stabilised Natural Gravel Overlay Thickness	=	110	mm
Natural Gravel Granular Overlay Thickness	=	110	mm
Asphalt Overlay Thickness	=	55	mm

Deflection for HDM model $\delta_{(80kN)} =$ 1.44 mm

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International

in association with **Jatula Partners**

Road Name: Karonga - Songwe | Road Code: 1 | Sample Length No.: S2 | Truck Axle Load - LHS: 3175 kg | Date: 27-Jul-98

Chainage (km) 23.08 to 24.08 | Sample Length Code: 12 | Width: 6.7 m | RHS: 3175 kg | Operator: RI/MOWS

Chainage (km)		Surface Condition																											
		Primary Cracking						Secondary Cracking						Pothole		Patch		Edge		Ravel		Bleed		Skid		Deform			
From	To	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Number	Av.Area (m^2)	Number	Av.Area (m^2)	Length	Av.Width (m)	Extent (%)	Degree	Extent (%)	Degree	Extent (%)	Degree	Condition	Position	Shoulder Condition	Drainage Condition
23.08	23.18	L	CW	4	10	✓														100	3	50	2	50	2			L	G
23.18	23.28	L	CW	3	15									1	1							60	2	50	2			L	G
23.28	23.38	L	CW	3	10	✓														80	3	60	2	50	2			G	G
23.38	23.48	L	CW	3	5	✓										1	28			80	3	60	2	60	2			G	G
23.48	23.58	L	CW	2	50	✓														80	3	60	2	60	2			G	G
23.58	23.68	L	CW	2	30															80	3	60	2	60	2			G	G
23.68	23.78	L	CW	3	20	✓										2	160			80	3	60	2	60	2			G	G
23.78	23.88	L	CW	3	30	✓										1	126			80	3	60	2	60	2			G	G
23.88	23.98	L	CW	3	50															80	3	60	2	60	2			L	G
23.98	24.08	L	CW	3	50															80	3	60	2	60	2			L	G

Point Number		Peak Deflection (mm x 100)										Rad.of Curve								Rut Depth (mm)	
		LH Wheelpath				RH Wheelpath						LH Wheelpath									
		Initial	Maximum	Final	Deflection	Initial	Maximum	Final	Deflection	Max Corrected	Wheel Path	Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	LHS	RHS
21	R	2	61	2	118	2	41	1	79	162	OWP	0	65	3	22	21	0.8	44	35	18	4
		2	70	5	133	1	44	5	82			-1	65	-3	21						
22	R	2	53	3	101	2	45	6	82	134	OWP	0	40	0	35	31	1.2	49	57	10	9
		3	57	5	106	2	44	3	83			0	53	3	27						
23	R	1	35	4	65	1	22	4	39	83	OWP	0	22	0	64	64	1.9	69	134	7	5
		2	35	4	64	0	22	2	42												
24	R	1	40	2	77	1	26	0	51	99	OWP	0	31	1	46	46	1.4	63	89	8	3
		2	41	4	76	2	28	3	51			0	30	0	47						
25	R	2	47	4	88	5	42	5	74	113	OWP	0	30	0	47	46	1.9	51	95	14	0
		2	47	5	87	2	39	4	72			0	31	0	45						
26	R	3	48	5	88	4	33	4	58	114	OWP	0	30	0	47	47	2.0	50	100	11	10
		2	48	5	89	2	32	3	59			1	30	0	47						
27	R	2	57	2	110	2	40	2	76	150	OWP	0	29	0	48	41	2.7	35	95	4	9
		2	60	-5	123	2	38	4	70			0	42	2	34						
28	R	2	40	2	76	1	26	1	50	98	OWP	0	44	2	33	33	0.7	76	51	3	7
		2	41	4	76	1	28	2	53												
29	R	3	62	6	115	2	20	5	33	139	OWP	2	35	1	42	37	1.8	42	77	16	4
		2	54	5	101	1	18	4	31			5	47	2	32						
30	R	3	38	5	68	2	22	2	40	88	OWP	0	30	2	48	47	1.1	75	85	9	15
		3	38	5	68	2	22	4	38			0	31	0	45						
31	R	2	32	0	62	2	15	1	27	79	OWP	0	25	0	56	58	1.5	77	114	6	5
		2	34	5	61	0	15	0	30			0	22	-2	61						

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International
in association with **Jatula Partners**

Road Name: Karonga - Songwe | Road Code: 1 | Sample Length No.: S2 | Truck Axle Load - LHS: 3175 kg | Date: 27-Jul-98

Chainage (km) 23.08 to 24.08 | Sample Length Code: 12 | Width: 6.7 m | RHS: 3175 kg | Operator: RI/MOWS

Averages and Totals

Area Cracked	1809	m^2	27.0%
Wide Cracks	838	m^2	12.5%
Average Condition Index	4.4		
Minimum Condition Index	2.1		
Maximum Condition Index	5.9		

Area to be patched	238	m^2	3.6%
Area already patched	356	m^2	5.3%
Area Ravelled	4958	m^2	74.0%
Area patched during shoulder repair	300	m^2	4.5%

Average Deflection	δ_p	1.15	mm
Standard Deviation	σ	0.28	mm
Calibration Correction Factor	F_c	0.993	0.99
Seasonal Correction Factor	F_w	1.300	
Design Deflection	δ_d	1.57	mm
Percentile to equal the Design Deflection	96%	1.57	mm
Predicted Design Axles	No.	3.14	$x10^6$ Axles
Residual Equivalent Standard Axles	No.	1.47	$x10^6$ ESAs

OWP	11	100%
IWP	0	0%

Average Rut Depth		8.0 mm
Standard Deviation of Rut Depth		4.7 mm
Avg.Radius of Curvature		42 m
Avg.M_r Upper Layers		85 MPa
M_r Base	80%	100 MPa
M_r Subbase	20%	57 MPa
Avg.M_r of the Foundation		57 MPa
M_r Selected Subgrade	80%	75 MPa
M_r Subgrade	20%	44 MPa

Percentile of the Road that will Require Reconstruction 4% of the road

Percentile of the Road that will not Require Strengthening d= 1.57 mm 96%

Target Deflection: 0.8 mm

Existing Base Material: CR

Crushed Rock Granular Overlay Thickness	=	290	mm
Stabilised Natural Gravel Overlay Thickness	=	290	mm
Natural Gravel Granular Overlay Thickness	=	290	mm
Asphalt Overlay Thickness	=	145	mm

Deflection for HDM model $\delta_{(80kN)} =$ 2.42 mm

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International

in association with **Jatula Partners**

Road Name: Karonga - Songwe | Road Code: 1 | Sample Length No.: S3 | Truck Axle Load - LHS: 3175 kg | Date: 27-Jul-98

Chainage (km) 30.77 to 32.77 | Sample Length Code: 13 | Width: 6.7 m | RHS: 3175 kg | Operator: RI/MOWS

Chainage (km)		Surface Condition																												
		Primary Cracking						Secondary Cracking						Pothole		Patch		Edge		Ravel		Bleed		Skid		Deform				
From	To	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Number	Av.Area (m^2)	Number	Av.Area (m^2)	Length	Av.Width (m)	Extent (%)	Degree	Extent (%)	Degree	Extent (%)	Degree	Condition	Position	Shoulder Condition	Drainage Condition	Point Number
																														32
30.77	30.87																			100	3	90	2	90	2			G	G	33
30.87	30.97																			100	3	90	2	90	2			G	G	34
30.97	31.07																			100	3	90	2	90	2			G	G	35
31.07	31.17															1	4			100	3	80	2	60	2			G	G	36
31.17	31.27	C	CW	2	20	✓														100	3	80	2	70	2			G	G	37
31.27	31.37																			100	3	90	2	80	2			G	G	38
31.37	31.47																			100	3	90	3	80	2			G	G	39
31.47	31.57																			100	3	90	3	80	2			G	G	40
31.57	31.67													1	1					100	3	90	3	70	2			G	G	41
31.67	31.77	C	CW	2	50	✓														100	3	90	3	70	2			G	G	42
31.77	31.87																			100	3	100	3	100	3			G	G	43
31.87	31.97																			100	3	100	3	100	3			G	G	44
31.97	32.07																			100	3	100	3	100	3			G	G	45
32.07	32.17		CW	3	40	✓														100	3	100	3	100	2			L	G	46
32.17	32.27		CW	3	30	✓														100	3	100	3	100	2			L	G	47
32.27	32.37																			100	3	100	3	100	2			G	G	48
32.37	32.47		CW	3	20	✓								4	1	2	13			100	3	100	3	100	2			L	G	49
32.47	32.57																			100	3	100	3	100	3			G	G	50
32.57	32.67																			100	3	100	3	100	3			G	G	51
32.67	32.77																			100	3	100	3	100	3			G	G	52

Point Number		Peak Deflection (mm x 100)										Rad.of Curve								Rut Depth (mm)	
		LH Wheelpath				RH Wheelpath						LH Wheelpath									
		Initial	Maximum	Final	Deflection	Initial	Maximum	Final	Deflection	Max Corrected	Wheel Path	Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	LHS	RHS
32	L	3	45	4	83	1	32	4	59	106	OWP									3	4
		3	45	5	82	3	34	7	58												
33	L	2	44	-2	88	3	34	2	63	112	OWP	0	31	-1	44	92	8.0	36	287	5	5
		2	44	1	85	1	36	3	68			0	10	0	140						
34	L	2	61	1	119	3	37	-3	74	156	OWP	0	15	1	97	118	27.3	19	519	0	3
		2	62	0	122	2	42	5	77			0	10	0	140						
35	L	0	55	-5	115	2	56	4	106	152	OWP	-2	35	-5	36	40	2.6	35	90	6	4
		0	59	-2	120	1	54	3	104			2	35	3	43						
36	L	1	68	-6	141	2	65	-5	133	183	OWP									10	7
		0	71	0	142	0	72	2	142												
37	L	0	70	1	139	2	70	7	131	179	OWP	-1	34	-2	39	39	3.6	27	99	8	6
		3	72	2	139	3	65	4	123												
38	L	1	64	1	126	3	60	4	113	163	OWP	0	40	0	35	37	2.5	33	84	0	5
		0	62	-2	126	1	58	3	112			0	36	0	39						
39	L	2	81	5	155	3	72	5	136	203	OWP	0	50	25	37	31	2.8	26	73	7	6
		3	82	1	160	1	68	-1	136			0	55	-3	25						
40	L	2	46	2	88	3	40	5	72	114	OWP	0	35	-1	39	37	1.2	57	67	6	5
		2	46	2	88	1	40	5	74			-1	40	-2	34						
41	L	1	32	3	60	3	20	-4	41	81	OWP	0	30	-3	44	39	0.6	93	60	5	6
		3	37	5	66	4	26	4	44			-2	40	-3	33						
42	L	3	27	-1	52	0	26	0	52	66	IWP									8	9
		2	26	0	50	2	27	2	50												
43	L	2	30	-2	60	3	26	1	48	79	OWP	0	30	0	47	47	0.9	87	80	5	4
		2	33	1	63	6	30	5	49			0	30	0	47						
44	L	1	34	2	65	4	26	-1	49	84	OWP	0	30	-2	45	44	0.9	82	76	7	5
		3	35	2	65	4	28	6	46			0	32	0	44						
45	L	1	25	-2	51	2	34	6	60	77	IWP	0	10	1	147	96	2.8	80	224	4	3
		1	26	1	50	2	32	2	60			2	32	0	45						
46	L	1	30	2	57	4	32	1	59	76	IWP	0	11	-5	104	87	3.0	70	205	6	4
		4	33	4	58	2	32	3	59			0	20	0	70						
47	L	2	25	-1	49	3	29	2	53	67	IWP	-1	25	1	56	52	0.7	113	84	0	4
		1	26	0	51	0	26	1	51			-1	27	-3	48						
48	L	4	26	2	46	4	27	1	49	62	IWP	0	27	0	52	84	1.7	99	172	3	0
		2	25	2	46	2	26	3	47			-1	10	-3	117						
49	L	3	21	2	37	2	27	3	49	66	IWP										
		4	24	5	39	6	32	5	53												
50	L	4	19	5	29	3	30	6	51	64	IWP	0	15	-2	88	110	1.4	154	211	0	4
		2	20	4	34	5	29	5	48			-1	10	0	133						
51	L	0	21	-2	44	3	26	1	48	67	IWP	0	20	-1	68	65	1.0	116	114	4	7
		0	23	-1	47	3	32	5	56			-2	20	-3	62						
52	L	0	21	0	42	0	20	-4	44	57	IWP	-1	7	-2	165	257	15.2	63	959	5	5
		6	27	6	42	1	21	-4	45			1	5	1	350						

Road Maintenance and Rehabilitation Project - Malawi

Roughton International

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

in association with **Jatula Partners**

Road Name: Karonga - Songwe	Road Code: 1	Sample Length No.: S3	Truck Axle Load - LHS: 3175 kg		Date: 27-Jul-98
Chainage (km) 30.77 to 32.77 Sample Length Code: 13	Width: 6.7 m		RHS: 3175 kg		Operator: RI/MOWS

Averages and Totals

Area Cracked	1072	m^2	8.0%
Wide Cracks	1072	m^2	8.0%
Average Condition Index	6.7		
Minimum Condition Index	5.3		
Maximum Condition Index	7.8		

Area to be patched	20	m^2	0.1%
Area already patched	23	m^2	0.2%
Area Ravelled	13400	m^2	100.0%
Area patched during shoulder repair	600	m^2	4.5%

Average Deflection	δ_p	1.05	mm	
Standard Deviation	σ	0.47	mm	
Calibration Correction Factor	F_c	0.993	0.99	
Seasonal Correction Factor	F_w	1.300		
Design Deflection	δ_d	1.76	mm	
Percentile to equal the Design Deflection	96%	1.86	mm	
Predicted Design Axles	No.	3.14	$x10^6$	Axles
Residual Equivalent Standard Axles	No.	1.47	$x10^6$	ESAs

OWP	12	57%
IWP	9	43%

Average Rut Depth		4.7	mm
Standard Deviation of Rut Depth		2.4	mm
Avg.Radius of Curvature		76	m
Avg.M_r Upper Layers		200	MPa
M_r Base	80%	221	MPa
M_r Subbase	20%	77	MPa
Avg.M_r of the Foundation		70	MPa
M_r Selected Subgrade	80%	98	MPa
M_r Subgrade	20%	33	MPa

Percentile of the Road that will Require Reconstruction 4% of the road

Percentile of the Road that will not Require Strengthening d= 1.86 mm 96%

Target Deflection: 0.8 mm

Existing Base Material: CR

Crushed Rock Granular Overlay Thickness	=	330	mm
Stabilised Natural Gravel Overlay Thickness	=	330	mm
Natural Gravel Granular Overlay Thickness	=	330	mm
Asphalt Overlay Thickness	=	165	mm

Deflection for HDM model $\delta_{(80kN)} =$ 2.71 mm

Road Maintenance and Rehabilitation Project - Malawi | **Roughton International**

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths | *in association with* **Jatula Partners**

Road Name: Mzuzu - Bwengu | Road Code: 2 | Sample Length No.: S1 | Truck Axle Load - LHS: 3175 kg | Date: 23-Jul-98

Chainage (km) 5.60 to 7.10 | Sample Length Code: 21 | Width: 6.7 m | RHS: 3175 kg | Operator: RI/MOWS

Point Number	Chainage (km) From	Chainage (km) To	Primary Cracking Type	Primary Cracking Position	Primary Cracking Degree	Primary Cracking Extent (%)	Primary Cracking Width >3mm	Primary Cracking Pumping	Secondary Cracking Type	Secondary Cracking Position	Secondary Cracking Degree	Secondary Cracking Extent (%)	Secondary Cracking Width >3mm	Secondary Cracking Pumping	Pothole Number	Pothole Av.Area (m^2)	Patch Number	Patch Av.Area (m^2)	Edge Length	Edge Av.Width (m)	Ravel Extent (%)	Ravel Degree	Bleed Extent (%)	Bleed Degree	Skid Extent (%)	Skid Degree	Deform Condition	Deform Position	Shoulder Condition	Drainage Condition
0																														
1	5.60	5.70																	200	0.2									P	
2	5.70	5.80																	200	0.2									P	
3	5.80	5.90													1	1	1	50	200	0.2	10	2							P	
4	5.90	6.00																	200	0.2	100	2							P	
5	6.00	6.10																	200	0.2	100	2							P	
6	6.10	6.20																	200	0.2	100	2							P	
7	6.20	6.30																	200	0.2	100	2							P	
8	6.30	6.40																	200	0.2	100	2							P	
9	6.40	6.50																	200	0.2	100	2							P	
10	6.50	6.60																	200	0.2	100	2							P	
11	6.60	6.70																	200	0.2	100	2							P	
12	6.70	6.80																	200	0.2	100	2							P	
13	6.80	6.90																	200	0.2	100	2							P	
14	6.90	7.00																3	30	200	0.2	100	2							P	
15	7.00	7.10																6	15	200	0.2									P	

Point Number		Peak Deflection (mm x 100) LH Wheelpath Initial	LH Maximum	LH Final	LH Deflection	RH Wheelpath Initial	RH Maximum	RH Final	RH Deflection	Max Corrected	Wheel Path	Rad.of Curve LH Wheelpath Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	Rut Depth (mm) LHS	Rut Depth (mm) RHS
0	L	3	29	2	53	2	16	0	30	68	OWP	2	30	0	48	48	0.7	108	76	0	5
		2	28	1	53	2	16	1	29			-1	29	0	47						
1	L	2	22	1	41	2	14	0	26	56	OWP	0	15	0	93	79	1.3	112	150	6	4
		0	22	-2	46	2	15	0	28			0	20	-3	65						
2	L	2	23	1	43	3	18	3	30	57	OWP	0	15	2	100	106	2.6	94	241	4	5
		0	23	1	45	3	18	3	30			0	14	3	112						
3	L	1	18	1	34	3	15	2	25	44	OWP	2	15	3	112	126	2.1	128	272	4	0
		2	19	2	34	2	16	3	27			2	12	2	140						
4	L	0	20	0	40	2	18	1	33	53	OWP	0	26	0	54	54	0.5	150	79	0	0
		0	21	0	42	3	19	4	31												
5	L	1	16	1	30	3	15	2	25	38	OWP	3	12	3	156	128	1.6	157	256		
		1	15	0	29	3	14	2	23			0	15	2	100						
6	L	1	20	0	39	3	20	3	34	51	OWP										
		1	21	1	40	2	21	3	37												
7	L	3	24	0	45	3	20	0	37	61	OWP	0	22	0	64	64	1.0	112	111	0	0
		1	25	0	49	1	20	0	39												
8	L	0	13	0	26	3	12	1	20	33	OWP									0	0
		0	12	-1	25	3	12	1	20												
9	L	1	15	-1	30	3	10	3	14	38	OWP									0	0
		0	14	-1	29	3	10	1	16												
10	L	1	16	1	30	3	15	2	25	40	OWP	0	15	0	93	93	0.9	172	160	0	8
		1	17	1	32	2	15	0	28												
11	L	1	17	0	33	2	20	3	35	46	IWP	1	10	2	165	165	3.9	108	420	0	0
		2	20	2	36	2	20	2	36												
12	L	2	25	4	44	2	21	2	38	56	OWP									0	0
		2	25	5	43	2	21	2	38												
13	L	2	24	2	44	3	21	3	36	56	OWP	0	20	0	70	70	1.0	120	124	3	0
		0	22	1	43	3	20	0	37												
14	L	2	23	2	42	3	20	3	34	56	OWP	0	15	2	100	100	2.2	99	218	0	0
		2	24	1	45	3	20	2	35												
15	L	4	28	1	51	2	22	1	41	67	OWP	0	10	1	147	147	7.3	61	449	0	0
		2	28	1	53	2	20	2	36												

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International
in association with **Jatula Partners**

Road Name:	Mzuzu - Bwengu	Road Code:	2	Sample Length No.:	S1	Truck Axle Load - LHS:	3175 kg
Chainage (km)	5.60 to 7.10	Sample Length Code:	21	Width:	6.7 m	RHS:	3175 kg

Date: 23-Jul-98
Operator: RI/MOWS

Averages and Totals

Area Cracked	0 m^2	0.0%
Wide Cracks	0 m^2	0.0%
Average Condition Index	3.2	
Minimum Condition Index	2.0	
Maximum Condition Index	3.9	

Area to be patched	1316 m^2	13.1%
Area already patched	173 m^2	1.7%
Area Ravelled	7437 m^2	74.0%
Area patched during shoulder repair	450 m^2	4.5%

Average Deflection	δ_p	0.51	mm	OWP 15	94%
Standard Deviation	σ	0.11	mm	IWP 1	6%
Calibration Correction Factor	F_c	0.993	0.99		
Seasonal Correction Factor	F_w	1.300			
Design Deflection	δ_d	0.67	mm		
Percentile to equal the Design Deflection	96%	0.68	mm		
Predicted Design Axles	No.	5.70	$x10^6$ Axles		
Residual Equivalent Standard Axles	No.	1.70	$x10^6$ ESAs		

Percentile of the Road that will Require Reconstruction 4% of the road

Percentile of the Road that will not Require Strengthening d= 0.68 mm 96%

Average Rut Depth		1.4 mm
Standard Deviation of Rut Depth		2.4 mm
Avg.Radius of Curvature		98 m
Avg.M_r Upper Layers		213 MPa
M_r Base	80%	269 MPa
M_r Subbase	20%	114 MPa
Avg.M_r of the Foundation		119 MPa
M_r Selected Subgrade	80%	146 MPa
M_r Subgrade	20%	101 MPa

Target Deflection: 0.8 mm

Existing Base Material: CR

Crushed Rock Granular Overlay Thickness	=	0 mm
Stabilised Natural Gravel Overlay Thickness	=	0 mm
Natural Gravel Granular Overlay Thickness	=	0 mm
Asphalt Overlay Thickness	=	0 mm

Deflection for HDM model $\delta_{(80kN)} =$ 1.03 mm

Road Maintenance and Rehabilitation Project - Malawi — **Roughton International** *in association with* **Jatula Partners**

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Road Name: Mzuzu - Bwengu | Road Code: 2 | Sample Length No.: S2 | Truck Axle Load - LHS: 3175 kg | Date: 23-Jul-98

Chainage (km) 12.09 to 14.09 | Sample Length Code: 22 | Width: 6.7 m | RHS: 3175 kg | Operator: RI/MOWS

Chainage (km)		Surface Condition: Primary Cracking						Secondary Cracking						Pothole		Patch		Edge		Ravel		Bleed		Skid		Deform			
From	To	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Number	Av.Area (m^2)	Number	Av.Area (m^2)	Length	Av.Width (m)	Extent (%)	Degree	Extent (%)	Degree	Extent (%)	Degree	Condition	Position	Shoulder Condition	Drainage Condition
12.09	12.19	C	CW	3	50	✓		L	CW	3	50	✓								100	2	100	2						
12.19	12.29	C	CW	3	50	✓		L	CW	3	50	✓								100	2	100	2						
12.29	12.39	C	CW	3	50	✓		L	CW	3	50	✓								100	2	100	2						
12.39	12.49	C	CW	3	50	✓		L	CW	3	50	✓								100	2	100	2						
12.49	12.59	C	CW	3	50	✓		L	CW	3	50	✓								100	2	100	2						
12.59	12.69																			100	2	100	2						
12.69	12.79	C	CW	4	100	✓		L	CW	4	100	✓								100	2	100	2			P	CW	P	
12.79	12.89	C	CW	4	100	✓		L	CW	4	100	✓								100	2	100	2			P	CW	P	
12.89	12.99	C	CW	4	100	✓		L	CW	4	100	✓		1	2					100	2	100	2			P	CW	P	
12.99	13.09	C	CW	4	100	✓		L	CW	4	100	✓								100	2	100	2			P	CW	P	
13.09	13.19	C	CW	4	100	✓		L	CW	4	100	✓								100	2	100	2					P	
13.19	13.29	C	CW	4	100	✓		L	CW	4	100	✓								100	2	100	2					P	
13.29	13.39	C	CW	4	100	✓		L	CW	4	100	✓								100	2	100	2					P	
13.39	13.49	C	CW	4	100	✓		L	CW	4	100	✓								100	2	100	2					P	
13.49	13.59	C	CW	4	100	✓		L	CW	4	100	✓								100	2	100	2					P	
13.59	13.69	C	CW	4	100	✓		L	CW	4	100	✓								100	2	100	2					P	
13.69	13.79	C	CW	4	100	✓		L	CW	4	100	✓								100	2	100	2					P	
13.79	13.89	C	CW	4	100	✓		L	CW	4	100	✓								100	2	100	2					P	
13.89	13.99	C	CW	4	100	✓		L	CW	4	100	✓								100	2	100	2					P	
13.99	14.09	C	CW	4	100	✓		L	CW	4	100	✓				1	300			100	2	100	2					P	

Point Number		Peak Deflection (mm x 100): LH Wheelpath Initial	Maximum	Final	Deflection	RH Wheelpath Initial	Maximum	Final	Deflection	Max Corrected	Wheel Path	Rad.of Curve LH Wheelpath: Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	Rut Depth (mm) LHS	RHS
16	L	2	24	2	44	2	29	3	53	69	IWP	0	11	1	133	125	3.8	83	317	0	0
		2	25	2	46	3	30	3	54			0	12	0	117						
17	L	3	17	2	29	2	18	1	33	42	IWP	0	8	0	175	175	3.2	133	422	0	0
		3	18	3	30	2	18	2	32												
18	L	1	36	-1	72	2	35	2	66	94	OWP									7	7
		1	37	0	73	2	36	2	68												
19	L	0	28	-2	58	1	26	1	50	76	OWP									5	0
		2	30	-1	59	1	26	1	50												
20	L	3	24	0	45	1	19	-1	38	58	OWP	0	25	1	57	57	0.7	126	91	0	0
		2	24	1	45	2	19	-1	37												
21	L	2	23	0	44	3	20	3	34	59	OWP									5	0
		1	25	1	48	2	21	2	38												
22	L	2	23	1	43	2	20	2	36	56	OWP	2	8	1	215	215	10.9	67	733	5	0
		4	25	3	43	2	20	2	36												
23	L	5	25	3	42	2	16	2	28	54	OWP	0	22	1	65	58	0.6	140	89	4	0
		5	26	5	42	1	16	2	29			0	28	0	50						
24	L	3	29	0	55	2	26	1	49	71	OWP	0	15	2	100	74	1.9	81	156	0	0
		2	29	1	55	2	27	2	50			0	30	2	48						
25	L	1	26	-1	52	2	30	0	58	75	IWP	2	30	1	49	49	0.7	115	76	8	11
		1	25	0	49	2	31	2	58			2	30	0	48						
26	L	3	38	-1	74	2	35	1	67	100	OWP									12	4
		0	39	-3	81	2	37	3	69												
27	L	1	17	-1	34	1	14	0	27	45	OWP	0	6	2	280	280	12.3	80	985	0	4
		1	18	-1	36	2	15	2	26												
28	L	2	18	0	34	3	16	2	27	45	OWP	0	9	2	175	175	4.4	105	463	4	0
		0	17	-1	35	2	16	2	28												
29	L	2	27	2	50	2	20	3	35	66	OWP	3	42	4	36	36	0.4	133	48	8	8
		5	29	1	52	3	19	3	32			0	39	1	36						
30	L	3	20	2	35	1	20	2	37	48	OWP	0	22	1	65	65	0.6	156	101	3	4
		2	21	0	40	2	19	3	33												
31	L	3	26	1	48	2	16	1	29	64	OWP	0	18	0	78	78	1.7	93	158	4	8
		2	27	1	51	1	15	1	28												
32	L	2	37	0	72	3	35	0	67	90	OWP	0	40	1	35	35	0.7	84	55	14	0
		3	35	0	67	2	35	2	66												
33	L	0	37	2	72	3	27	1	50	95	OWP	0	32	-2	42	43	1.1	69	79	19	7
		3	38	-2	75	2	28	2	52			1	32	0	44						
34	L	3	41	2	77	1	28	-1	56	103	OWP	0	40	1	35	35	0.9	68	59	7	4
		3	42	-2	83	3	30	5	52			1	41	0	35						
35	L	3	35	-1	68	2	25	3	45	89	OWP	0	24	-2	56	59	1.9	65	124	6	5
		3	35	-3	70	3	25	4	43			1	23	0	62						
36	L	5	21	-5	42	3	38	2	71	92	IWP	1	22	0	65	62	0.7	135	99	13	18
		1	22	1	42	2	38	2	72			0	23	-2	58						

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International
in association with **Jatula Partners**

Road Name: Mzuzu - Bwengu | Road Code: 2 | Sample Length No.: S2 | Truck Axle Load - LHS: 3175 kg | Date: 23-Jul-98

Chainage (km) 12.09 to 14.09 | Sample Length Code: 22 | Width: 6.7 m | RHS: 3175 kg | Operator: RI/MOWS

Averages and Totals

Area Cracked	11055	m^2	82.5%
Wide Cracks	11055	m^2	82.5%
Average Condition Index	6.6		
Minimum Condition Index	3.1		
Maximum Condition Index	16.5		

Area to be patched	152	m^2	1.1%
Area already patched	225	m^2	1.7%
Area Ravelled	13400	m^2	100.0%
Area patched during shoulder repair	600	m^2	4.5%

Average Deflection	δ_p	0.71	mm	
Standard Deviation	σ	0.20	mm	
Calibration Correction Factor	F_c	0.993	0.99	
Seasonal Correction Factor	F_w	1.300		
Design Deflection	δ_d	1.01	mm	
Percentile to equal the Design Deflection	96%	1.01	mm	
Predicted Design Axles	No.	5.70	$x10^6$	Axles
Residual Equivalent Standard Axles	No.	1.70	$x10^6$	ESAs

OWP	17	81%
IWP	4	19%

Percentile of the Road that will Require Reconstruction 4% of the road

Percentile of the Road that will not Require Strengthening d= 1.01 mm 96%

Average Rut Depth		4.9	mm
Standard Deviation of Rut Depth		5.0	mm
Avg.Radius of Curvature		83	m
Avg.M_r Upper Layers		238	MPa
M_r Base	80%	401	MPa
M_r Subbase	20%	76	MPa
Avg.M_r of the Foundation		102	MPa
M_r Selected Subgrade	80%	133	MPa
M_r Subgrade	20%	71	MPa

Target Deflection: 0.8 mm

Existing Base Material: CR

Crushed Rock Granular Overlay Thickness	=	130	mm
Stabilised Natural Gravel Overlay Thickness	=	130	mm
Natural Gravel Granular Overlay Thickness	=	130	mm
Asphalt Overlay Thickness	=	65	mm

Deflection for HDM model $\delta_{(80kN)} =$ 1.55 mm

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International
in association with **Jatula Partners**

Road Name: Mzuzu - Bwengu | Road Code: 2 | Sample Length No.: S3 | Truck Axle Load - LHS: 3175 kg | Date:

Chainage (km) 36.26 to 38.26 | Sample Length Code: 23 | Width: 6.7 m | RHS: 3175 kg | Operator: RI/MOWS

Chainage (km)		Surface Condition: Primary Cracking						Secondary Cracking						Pothole		Patch		Edge		0.0	Ravel			Bleed		Skid		Deform			
From	To	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Number	Av.Area (m^2)	Number	Av.Area (m^2)	Length	Av.Width (m)	Min Width	Extent (%)	Degree	Area	Extent (%)	Degree	Extent (%)	Degree	Condtion	Position	Shoulder Condition	Drainage Condition
36.26	36.36	C	CW	1	50	✓		L	CW	1	50	✓						100	0.3	0.3	50	2	335					P	CW		
36.36	36.46	C	CW	1	40	✓		L	CW	1	40	✓				1	294	100	0.3	0.3	50	2	335					P	CW		
36.46	36.56	C	CW	1	35	✓		L	CW	1	35	✓				2	560	100	0.3	0.3	50	2	335					P	CW		
36.56	36.66	C	CW	1	40	✓		L	CW	1	40	✓				3	38	100	0.3	0.3	50	2	335					P	CW		
36.66	36.76	C	CW	1	30	✓		L	CW	1	30	✓				2	18			0.0	50	2	335					P	CW		
36.76	36.86	C	CW	1	30	✓	✓	L	CW	1	30	✓	✓			2	28			0.0	50	2	335					P	CW		
36.86	36.96	C	CW	1	40	✓	✓	L	CW	1	40	✓	✓			1	40			0.0	50	2	335	40	2			P	CW		
36.96	37.06	C	CW	1	50	✓	✓	L	CW	1	50	✓	✓							0.0	50	2	335					P	CW		
37.06	37.16	C	CW	1	50	✓	✓	L	CW	1	50	✓	✓							0.0	50	2	335					P	CW		
37.16	37.26	C	CW	1	50	✓		L	CW	1	50	✓				1	1			0.0	60	2	402	60	3			P	CW		
37.26	37.36	C	CW	1	30	✓		L	CW	1	30	✓								0.0	100	2	670					P	CW		
37.36	37.46	C	CW	1	50	✓		L	CW	1	50	✓								0.0	100	2	670					P	CW		
37.46	37.56	C	CW	3	60	✓		L	CW	3	60	✓								0.0	100	2	670					P	CW		
37.56	37.66	C	CW	3	70	✓		L	CW	3	70	✓								0.0	100	2	670					P	CW		
37.66	37.76	C	CW	3	80	✓	✓	L	CW	3	80	✓	✓							0.0	100	3	670					P	CW	P	
37.76	37.86	C	CW	3	60	✓	✓	L	CW	3	60	✓	✓							0.0	100	3	670					P	CW	P	
37.86	37.96	C	CW	3	70	✓	✓	L	CW	3	70	✓	✓			2	2			0.0	100	4	670					P	CW	P	
37.96	38.06	C	CW	3	70	✓	✓	L	CW	3	70	✓	✓							0.0	100	4	670					P	CW	P	
38.06	38.16	C	CW	3	80	✓	✓	L	CW	3	80	✓	✓			2	3			0.0	100	4	670	100	2			P	CW	P	
38.16	38.26	C	CW	3	30	✓	✓	L	CW	3	30	✓	✓							0.0	100	4	670	100	2			P	CW	P	

Point Number		Peak Deflection (mm x 100): LH Wheelpath				RH Wheelpath				Max Corrected	Wheel Path	Rad.of Curve: LH Wheelpath								Rut Depth (mm)	
		Initial	Maximum	Final	Deflection	Initial	Maximum	Final	Deflection			Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	LHS	RHS
46	L	1	20	1	38	2	40	3	75	98	IWP	0	10	0	140	126	2.9	103	295	0	7
		2	22	2	40	2	42	5	77			5	15	0	112						
47	L	0	24	0	48	1	20	1	38	59	OWP	0	9	0	156	126	4.1	80	325	0	5
		1	23	1	44	1	19	1	36			0	15	1	97						
48	L	0	19	0	38	2	24	1	45	57	IWP	0	20	15	112	95	1.4	130	182	4	7
		1	19	1	36	2	24	2	44			3	20	1	78						
49	L	0	19	0	38	2	25	2	46	61	IWP	2	10	2	175	175	5.3	92	486	0	5
		2	20	1	37	2	26	1	49												
50	L	2	16	2	28	2	22	2	40	52	IWP	3	15	1	108	108	1.1	177	193	0	0
		2	17	2	30	2	22	2	40												
51	L	0	22	0	44	2	16	2	28	57	OWP										
		1	23	1	44	2	16	2	28												
52	L	0	19	1	37	2	17	2	30	47	OWP	2	20	3	80	80	0.9	146	138	0	0
		2	20	2	36	2	16	3	27												
53	L	0	38	1	75	2	22	2	40	99	OWP	0	10	1	147	147	16.6	34	563	10	7
		3	42	3	78	2	22	2	40				10	1	147						
54	L	1	35	1	68	3	15	3	24	85	OWP	0	20	1	72	60	1.8	70	122	7	12
		1	33	2	63	3	15	3	24			0	30	1	47						
55	L	1	18	1	34	2	14	2	24	43	OWP	0	10	0	140	226	6.9	98	675	0	3
		0	17	2	32	2	14	2	24			1	5	0	311						
56	L	0	18	0	36	2	15	1	27	48	OWP	0	20	0	70	70	0.7	153	112	0	3
		1	20	1	38	2	15	2	26												
57	L	0	14	0	28	2	15	2	26	38	OWP	1	20	1	74	74	0.5	211	107	9	6
		0	15	-1	31	2	15	2	26												
58	L	0	20	1	39	2	19	2	34	54	OWP									26	12
		2	24	2	44	2	19	2	34												
59	L	1	12	1	22	2	15	2	26	35	IWP	0	10	0	140	140	1.1	227	252	8	0
		1	12	0	23	2	15	0	28												
60	L	2	22	2	40	3	16	3	26	54	OWP									22	0
		1	23	1	44	2	16	2	28												
61	L	1	23	0	45	2	14	0	26	59	OWP									36	0
		2	25	2	46	2	14	1	25												
62	L	0	13	0	26	2	17	1	31	41	IWP									15	8
		0	14	2	26	2	17	0	32												
63	L	1	30	1	58	2	17	2	30	76	OWP	1	10	1	156	171	13.1	47	613	14	15
		1	31	1	60	2	17	2	30			1	10	4	187						
64	L	0	14	1	27	3	16	3	26	35	OWP									26	14
		1	15	1	28	3	17	3	28												
65	L	0	31	0	62	2	26	2	48	79	OWP									20	15
		0	30	0	60	2	25	2	46												
66	L	2	29	2	54	3	15	3	24	71	OWP	0	28	-3	47	47	0.7	103	77	13	5
		0	28	0	56	3	15	3	24												

Road Maintenance and Rehabilitation Project - Malawi

Roughton International

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

in association with **Jatula Partners**

Road Name: Mzuzu - Bwengu | Road Code: 2 | Sample Length No.: S3 | Truck Axle Load - LHS: 3175 kg | Date:

Chainage (km) 36.26 to 38.26 | Sample Length Code: 23 | Width: 6.7 m | RHS: 3175 kg | Operator: RI/MOWS

Averages and Totals

Area Cracked	6801	m^2	50.8%	Area to be patched	1075	m^2	8.0%	Average Deflection	δ_p	0.59	mm	OWP	15	71%	Average Rut Depth 8.3 mm
Wide Cracks	6801	m^2	50.8%	Area already patched	1253	m^2	9.3%	Standard Deviation	σ	0.19	mm	IWP	6	29%	Standard Deviation of Rut Depth 8.5 mm
				Area Ravelled	10117	m^2	75.5%	Calibration Correction Factor	F_c	0.993	0.99				
Average Condition Index	15.0			Area patched during shoulder repair	600	m^2	4.5%	Seasonal Correction Factor	F_w	1.300					Avg.Radius of Curvature 124 m
Minimum Condition Index	12.9							Design Deflection	δ_d	0.88	mm				Avg.M_r Upper Layers 296 MPa
Maximum Condition Index	19.3							Percentile to equal the Design Deflection	96%	0.98	mm				M_r Base 80% 517 MPa
								Predicted Design Axles	No.	5.70	$x10^6$ Axles				M_r Subbase 20% 118 MPa
								Residual Equivalent Standard Axles	No.	1.70	$x10^6$ ESAs				Avg.M_r of the Foundation 119 MPa
								Percentile of the Road that will Require Reconstruction	4% of the road						M_r Selected Subgrade 80% 163 MPa
								Percentile of the Road that will not Require Strengthening d= 0.98 mm	96%						M_r Subgrade 20% 76 MPa

Target Deflection: 0.8 mm

Crushed Rock Granular Overlay Thickness = 90 mm
Stabilised Natural Gravel Overlay Thickness = 90 mm
Natural Gravel Granular Overlay Thickness = 90 mm
Asphalt Overlay Thickness = 45 mm

Existing Base Material: CR

Deflection for HDM model $\delta_{(80kN)} =$ 1.35 mm

Road Maintenance and Rehabilitation Project - Malawi **Roughton International**

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths *in association with* **Jatula Partners**

Road Name: Mzuzu - Bwengu | Road Code: 2 | Sample Length No.: S4 | Truck Axle Load - LHS: 3175 kg | Date:

Chainage (km) 59.34 to 61.34 | Sample Length Code: 24 | Width: 6.7 m | RHS: 3175 kg | Operator: RI/MOWS

Point Number	Chainage (km)		Surface Condition																													
			Primary Cracking						Secondary Cracking						Pothole		Patch		Edge		Ravel		Bleed		Skid		Deform			
	From	To	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Number	Av.Area (m^2)	Number	Av.Area (m^2)	Length	Av.Width (m)	Extent (%)	Degree	Extent (%)	Degree	Extent (%)	Degree	Condition	Position	Shoulder Condition	Drainage Condition
67																														
68	59.34	59.44	C	CW	3	50	✓	✓									7	5			50	2	65	4	70	3	P	CW		
69	59.44	59.54																			40	2	65	4	70	3	P	CW		
70	59.54	59.64																			40	2	65	4	70	3	P	CW		
71	59.64	59.74																			30	2	65	4	60	4	P	CW		
72	59.74	59.84																					60	4	70	4	P	CW		
73	59.84	59.94																			70	2	50	4	60	4	P	CW		
74	59.94	60.04																			80	2	50	4	60	4	P	CW		
75	60.04	60.14																			80	2	60	4	50	4	P	CW		
76	60.14	60.24																			100	2	50	4	50	4	P	CW		
77	60.24	60.34															4	2	50	0.5	80	2	30	2	50	2	P	CW		
78	60.34	60.44																			80	2	60	3	40	3	P	CW		
79	60.44	60.54																			100	2	70	2	30	2	P	CW		
80	60.54	60.64																			100	2	50	2	20	2	P	CW		
81	60.64	60.74																			70	3	70	2	20	2	P	CW		
82	60.74	60.84																					70	2	30	2	P	CW		
83	60.84	60.94																			70	2	70	2	30	2	P	CW		
84	60.94	61.04																			70	2	70	4	80	4	P	CW		
85	61.04	61.14																			70	2	85	4	70	4	P	CW		
86	61.14	61.24															1	2			70	2	60	4	70	4	P	CW		
87	61.24	61.34															1	1			70	2	60	4	50	3	P	CW		
88	61.34	61.44																			70	2	35	4	30	3	P	CW		

Point Number		Peak Deflection (mm x 100)										Rad.of Curve								Rut Depth (mm)	
		LH Wheelpath				RH Wheelpath						LH Wheelpath									
		Initial	Maximum	Final	Deflection	Initial	Maximum	Final	Deflection	Max Corrected	Wheel Path	Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	LHS	RHS
67	R	2	15	2	26	2	18	2	32	43	IWP	2	10	1	165	152	1.7	185	307	10	3
		2	14	2	24	3	20	3	34			0	10	0	140						
68	R	1	20	0	39	2	33	0	64	83	IWP									0	7
		2	22	2	40	2	33	0	64												
69	R	0	14	1	27	3	20	3	34	45	IWP	0	20	0	70	85	0.6	206	131	8	6
		1	16	1	30	3	20	2	35			1	15	1	100						
70	R	1	16	1	30	3	23	2	41	52	IWP	2	11	1	147	147	2.4	135	331	13	4
		1	17	1	32	3	23	3	40												
71	R	0	29	0	58	3	23	2	41	76	OWP	1	18	1	82	111	5.3	59	309	17	4
		1	31	1	60	3	23	3	40			0	10	0	140						
72	R	3	23	2	41	3	22	2	39	54	OWP	0	22	1	65	61	0.7	139	95	14	0
		1	22	1	42	3	23	3	40			0	25	0	56						
73	R	2	18	2	32	2	20	2	36	46	IWP	0	20	0	70	113	1.7	135	228	0	4
		1	19	1	36	2	20	2	36			2	10	0	156						
74	R	1	21	0	41	2	19	2	34	52	OWP									13	6
		2	22	3	39	2	19	2	34			1	30	1	48						
75	R	2	25	2	46	3	19	2	33	57	OWP	3	30	0	49	42	0.4	151	56	15	0
		1	22	0	43	2	19	2	34			0	40	0	35						
76	R	0	20	1	39	2	20	2	36	48	OWP	1	20	0	72	72	0.8	148	118	0	0
		1	19	1	36	2	20	2	36												
77	R	1	23	-1	46	2	19	0	36	59	OWP	1	10	0	147	98	2.3	93	218	15	4
		0	22	-1	45	2	19	2	34			2	30	1	49						
78	R	0	32	1	63	2	39	0	76	97	IWP	0	5	1	311	187	17.4	42	725	12	0
		0	30	0	60	2	39	2	74			0	22	0	64						
79	R	0	24	-1	49	2	19	1	35	63	OWP	2	40	0	36	51	0.7	118	79	17	8
		0	24	-1	49	2	19	2	34			1	22	0	65						
80	R	1	29	0	57	2	18	2	32	72	OWP	1	35	0	41	45	0.7	104	70	16	6
		2	29	2	54	2	18	2	32			0	28	-1	49						
81	R	1	23	1	44	1	31	0	61	79	IWP	1	25	0	57	57	0.6	140	88	10	6
		1	19	-3	40	1	31	0	61												
82	R	1	32	1	62	3	41	0	79	101	IWP	4	30	3	53	43	0.8	88	72	10	6
		1	33	2	63	2	41	2	78			1	42	1	34						
83	R	1	44	1	86	3	43	0	83	112	OWP	1	9	4	215	125	15.4	30	468	15	8
		3	46	1	88	3	44	3	82			0	39	-3	35						
84	R	3	49	3	92	3	70	6	131	167	IWP	0	35	0	40	68	5.1	37	188	28	14
		3	52	3	98	4	70	9	127			0	10	-9	97						
85	R	3	49	3	92	2	49	0	96	123	IWP									18	10
		1	46	1	90	2	49	2	94												
86	R	3	45	3	84	2	44	1	85	110	IWP	1	42	-1	33	33	0.8	67	55		
		0	40	0	80	2	44	0	86												
87	R	0	32	-2	66	2	33	0	64	86	OWP									8	5
		0	34	0	68	2	32	2	60												
88	R	0	30	-2	62	2	36	1	69	89	IWP	1	45	1	32	38	0.7	89	60		
		0	35	2	68	2	36	1	69			1	32	0	44						

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International

in association with **Jatula Partners**

Road Name: Mzuzu - Bwengu | Road Code: 2 | Sample Length No.: S4 | Truck Axle Load - LHS: 3175 kg | Date:

Chainage (km) 59.34 to 61.34 | Sample Length Code: 24 | Width: 6.7 m | RHS: 3175 kg | Operator: RI/MOWS

Averages and Totals

Area Cracked	335	m^2	2.5%
Wide Cracks	335	m^2	2.5%
Average Condition Index	16.5		
Minimum Condition Index	13.6		
Maximum Condition Index	19.1		

Area to be patched	73	m^2	0.5%
Area already patched	35	m^2	0.3%
Area Ravelled	8978	m^2	67.0%
Area patched during shoulder repair	600	m^2	4.5%

Average Deflection	δ_p	0.78	mm	
Standard Deviation	σ	0.31	mm	
Calibration Correction Factor	F_c	0.993	0.99	
Seasonal Correction Factor	F_w	1.300		
Design Deflection	δ_d	1.25	mm	
Percentile to equal the Design Deflection	96%	1.28	mm	
Predicted Design Axles	No.	5.70	$x10^6$	Axles
Residual Equivalent Standard Axles	No.	1.70	$x10^6$	ESAs

Percentile of the Road that will Require Reconstruction 4% of the road

Percentile of the Road that will not Require Strengthening d= 1.28 mm 96%

OWP	10	45%
IWP	12	55%

Average Rut Depth		8.5	mm
Standard Deviation of Rut Depth		6.4	mm
Avg.Radius of Curvature		85	m
Avg.M_r Upper Layers		200	MPa
M_r Base	80%	308	MPa
M_r Subbase	20%	71	MPa
Avg.M_r of the Foundation		109	MPa
M_r Selected Subgrade	80%	145	MPa
M_r Subgrade	20%	62	MPa

Target Deflection: 0.8 mm

Existing Base Material: CR

Crushed Rock Granular Overlay Thickness	=	210	mm
Stabilised Natural Gravel Overlay Thickness	=	210	mm
Natural Gravel Granular Overlay Thickness	=	210	mm
Asphalt Overlay Thickness	=	105	mm

Deflection for HDM model $\delta_{(80kN)} =$ 1.92 mm

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International
in association with **Jatula Partners**

Road Name: Bwengu - Chiweta | Road Code: 2 | Sample Length No.: S5 | Truck Axle Load - LHS: 3175 kg | Date:

Chainage (km) 79.12 to 81.12 | Sample Length Code: 25 | Width: 6.1 m | RHS: 3175 kg | Operator: RI/MOWS

Chainage (km)		Surface Condition: Primary Cracking						Secondary Cracking						Pothole		Patch		Edge		Ravel		Bleed		Skid		Deform			
From	To	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Number	Av.Area (m^2)	Number	Av.Area (m^2)	Length	Av.Width (m)	Extent (%)	Degree	Extent (%)	Degree	Extent (%)	Degree	Condition	Position	Shoulder Condition	Drainage Condition
79.12	79.22	C	CW	4	60	✓	✓									5	80			70	2	70	3	50	2	P	CW		
79.22	79.32													8	25	6	70			70	2	60	3	30	3	P	CW		
79.32	79.42	C	CW	4	30	✓	✓							4	42					70	3	60	3	60	2	P	CW		
79.42	79.52	C	CW	4	40	✓	✓									1	1	70	0.4	70	3	60	3	50	2	P	CW		
79.52	79.62	C	CW	4	30	✓	✓											80	0.2	70	3	70	3	30	2	P	CW		
79.62	79.72	C	CW	3	85	✓	✓	L	CW	3	85	✓	✓	2	3	2	3			70	3	80	3	20	2	P	CW		
79.72	79.82	C	CW	3	60	✓	✓	L	CW	3	60	✓	✓	7	4	10	4	50	0.3	70	3	70	3	30	2	P	CW		
79.82	79.92	C	CW	3	70	✓	✓	L	CW	3	70	✓	✓	7	5	10	14	40	0.3	70	3	70	3			P	CW		
79.92	80.02	C	CW	3	80	✓	✓	L	CW	3	80	✓	✓			7	6			70	4	70	4	50	3	P	CW		
80.02	80.12	C	CW	3	55	✓	✓	L	CW	3	55	✓	✓			23	2			70	3	70	4			P	CW		
80.12	80.22	C	CW	3	60	✓	✓	L	CW	3	60	✓	✓			4	9					70	3			P	CW		
80.22	80.32	C	CW	3	60	✓	✓	L	CW	3	60	✓	✓			4	5			70	3	70	3	80	2				
80.32	80.42	C	CW	3	50	✓	✓	L	CW	3	50	✓	✓							70	3	80	3	30	2				
80.42	80.52	C	CW	3	40	✓	✓	L	CW	3	40	✓	✓			4	5	3	0.2	70	3	80	3	70	2				
80.52	80.62	C	CW	3	50	✓	✓	L	CW	3	50	✓	✓							70	3	80	3	60	2				
80.62	80.72	C	CW	3	80	✓	✓	L	CW	3	80	✓	✓	1	0	1	2	50	0.3	80	3	50	3	60	2				
80.72	80.82	C	CW	3	90	✓	✓	L	CW	3	90	✓	✓			1	4			80	3	80	3	70	2				
80.82	80.92	C	CW	3	100	✓	✓	L	CW	3	100	✓	✓			2	7	40	0.3	70	3	90	3	80	3				
80.92	81.02	C	CW	3	100	✓	✓	L	CW	3	100	✓	✓			6	5	30	0.3	80	2	55	3	60	3				
81.02	81.12	C	CW	3	100	✓	✓	L	CW	3	100	✓	✓					40	0.2	100	2	70	3	40	3				

Point Number		Peak Deflection (mm x 100): LH Wheelpath				RH Wheelpath				Max Corrected	Wheel Path	Rad.of Curve: LH Wheelpath								Rut Depth (mm)	
		Initial	Maximum	Final	Deflection	Initial	Maximum	Final	Deflection			Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	LHS	RHS
0	L	4	25	5	41	1	50	3	96	127	IWP	0	32	-1	43	43	0.3	166	56	0	4
		1	22	1	42	1	51	1	100												
1	L	0	24	-2	50	2	52	-1	103	130	IWP	3	35	3	44	41	0.4	132	57	15	8
		2	26	2	48	0	49	0	98			5	40	2	38						
2	L	4	35	4	62	0	52	0	104	136	IWP									12	7
		4	37	4	66	0	53	-1	107												
3	L	2	24	2	44	0	28	0	56	71	IWP	0	20	2	74	74	1.2	114	135	6	8
		5	27	5	44	0	27	0	54												
4	L	4	36	0	68	3	22	3	38	94	OWP	0	32	2	45	43	1.1	71	76	12	6
		4	42	3	77	0	22	0	44			0	35	0	40						
5	L	4	19	3	31	4	21	4	34	43	IWP	0	15	0	93	120	1.5	154	237	14	7
		3	18	3	30	4	20	4	32			0	10	1	147						
6	L	3	30	-1	58	2	36	-1	71	94	IWP	0	20	0	70	82	2.7	70	188	11	3
		3	32	2	59	2	38	-1	75			0	15	0	93						
7	L	2	26	0	50	0	40	-2	82	105	IWP									10	8
		2	29	4	52	3	42	1	80												
8	L	1	30	2	57	3	45	2	85	109	IWP	0	25	2	58	58	1.3	85	110	13	0
		3	32	2	59	3	45	3	84												
9	L	4	55	0	106	0	59	-6	124	163	IWP	0	50	-1	28	27	0.8	54	44	8	6
		2	52	3	99	1	62	-5	128			0	55	0	25						
10	L	4	39	2	72	1	48	-1	96	125	IWP									12	8
		2	39	4	72	0	48	-2	98												
11	L	1	29	-4	61	4	41	-4	82	106	IWP	0	39	2	37	37	0.6	99	55	9	4
		3	35	5	62	1	41	-1	82												
12	L	2	54	4	102	3	52	-1	102	130	IWP	0	45	0	31	39	1.8	45	81	5	4
		1	50	1	98	2	51	0	100			0	30	1	47						
13	L	2	39	0	76	0	50	0	100	129	IWP	0	30	0	47	58	2.3	56	129	8	4
		2	40	1	77	2	52	2	100			0	20	0	70						
14	L	3	55	-2	109	3	60	-5	122	156	IWP	0	50	0	28	28	1.1	46	50	0	6
		1	56	-2	113	4	64	4	120												
15	L	1	44	0	87	0	40	-4	84	110	OWP	1	40	0	35	32	0.8	65	52	4	3
		1	43	1	84	2	44	2	84			0	50	0	28						
16	L	1	56	-2	113	0	70	-14	154	200	IWP	0	45	-12	27	27	1.1	46	49	3	10
		3	58	0	113	0	72	-12	156												
17	L	2	41	1	79	2	52	-14	116	147	IWP	1	30	1	48	48	1.6	61	96	8	15
		4	41	4	74	1	56	0	111												
18	L	4	43	4	78	2	52	2	100	129	IWP	0	32	0	44	44	1.3	63	83	11	7
		4	43	4	78	0	50	0	100												
19	L	2	35	2	66	2	54	-2	108	136	IWP	0	25	0	56	56	1.5	74	109	12	11
		3	35	4	63	0	54	6	102												
20	L	4	33	4	58	0	50	-4	104	137	IWP									4	0
		4	34	3	61	1	54	-1	108												

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International
in association with **Jatula Partners**

Road Name:	Bwengu - Chiweta	Road Code:	2	Sample Length No.:	S5	Truck Axle Load - LHS:	3175 kg	Date:	
Chainage (km)	79.12 to 81.12	Sample Length Code:	25	Width:	6.1 m	RHS:	3175 kg	Operator:	RI/MOWS

Averages and Totals

Area Cracked	7564 m^2	62.0%	Area to be patched	1287 m^2	10.5%	Average Deflection δ_p	1.23 mm
Wide Cracks	7564 m^2	62.0%	Area already patched	916 m^2	7.5%	Standard Deviation σ	0.33 mm
			Area Ravelled	8479 m^2	69.5%	Calibration Correction Factor F_c	0.993 0.99
Average Condition Index	11.7		Area patched during shoulder repair	600 m^2	4.9%	Seasonal Correction Factor F_w	1.300
Minimum Condition Index	4.4					Design Deflection δ_d	1.72 mm
Maximum Condition Index	19.4					Percentile to equal the Design Deflection 96%	1.69 mm
						Predicted Design Axles No.	2.35 $x10^6$ Axles
						Residual Equivalent Standard Axles No.	1.07 $x10^6$ ESAs

OWP	2	10%
IWP	19	90%

Average Rut Depth		7.3 mm
Standard Deviation of Rut Depth		4.1 mm
Avg.Radius of Curvature		52 m
Avg.M_r Upper Layers		94 MPa
M_r Base	80%	125 MPa
M_r Subbase	20%	53 MPa
Avg.M_r of the Foundation		82 MPa
M_r Selected Subgrade	80%	111 MPa
M_r Subgrade	20%	54 MPa

Percentile of the Road that will Require Reconstruction 4% of the road

Percentile of the Road that will not Require Strengthening d= 1.69 mm 96%

Target Deflection: 0.9 mm

Existing Base Material: CR

Crushed Rock Granular Overlay Thickness	=	280 mm
Stabilised Natural Gravel Overlay Thickness	=	280 mm
Natural Gravel Granular Overlay Thickness	=	280 mm
Asphalt Overlay Thickness	=	140 mm

Deflection for HDM model $\delta_{(80kN)} =$ 2.65 mm

Road Maintenance and Rehabilitation Project - Malawi

Roughton International

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

in association with **Jatula Partners**

Road Name: Bwengu - Chiweta | Road Code: 2 | Sample Length No.: S6 | Truck Axle Load - LHS: 3175 kg | Date:

Chainage (km) 102.20 to 103.70 | Sample Length Code: 26 | Width: 6.1 m | RHS: 3175 kg | Operator: RI/MOWS

Chainage (km)		Surface Condition: Primary Cracking						Secondary Cracking						Pothole		Patch		Edge		Ravel		Bleed		Skid		Deform			
From	To	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Number	Av.Area (m^2)	Number	Av.Area (m^2)	Length	Av.Width (m)	Extent (%)	Degree	Extent (%)	Degree	Extent (%)	Degree	Condition	Position	Shoulder Condition	Drainage Condition
102.20	102.30	C	CW	3	20	✓	✓									3	9			50	3	50	3	60	2	P	CW		
102.30	102.40															4	12			100	3	60	3	50	2	P	CW		
102.40	102.50	C	CW	3	40	✓	✓							2	8	2	11			100	3	70	3	70	3	P	CW	P	P
102.50	102.60	C	CW	4	45	✓	✓	L	CW	4	45	✓		6	15	2	4	100	0.2	100	4	100	4	100	4	P	CW	P	P
102.60	102.70	C	CW	4	80	✓	✓	L	CW	4	80	✓		15	40	30	4	100	0.3	100	4	100	4	100	4	P	CW	P	P
102.70	102.80	C	CW	4	90	✓	✓	L	CW	4	90	✓		2	15	2	20	100	0.4	100	4	100	4	100	4	P	CW	P	P
102.80	102.90	C	CW	4	90	✓	✓	L	CW	4	90	✓				2	10			100	4	100	4	100	4	P	CW	P	P
102.90	103.00	C	CW	4	90	✓	✓	L	CW	4	90	✓		4	13	6	24			100	4	100	4	100	4	P	CW	P	P
103.00	103.10	C	CW	4	80	✓	✓	L	CW	4	80	✓		3	10	7	30			100	4	100	4	100	4	P	CW	P	P
103.10	103.20	C	CW	4	75	✓	✓	L	CW	4	75	✓		1	2					100	4			100	4	P	CW	P	P
103.20	103.30													2	4	3	20			100	3	80	3	100	3	P	CW		P
103.30	103.40													9	2	7	25			100	3	80	3	100	3	P	CW		P
103.40	103.50													11	5	8	38			100	3	85	3	100	3	P	CW		P
103.50	103.60													17	5	96	5			100	3	90	3	100	3	P	CW		P
103.60	103.70													3	9	50	10			80	3			100	3	P	CW		P

Point Number		Peak Deflection (mm x 100): LH Wheelpath				RH Wheelpath				Max Corrected	Wheel Path	Rad.of Curve: LH Wheelpath								Rut Depth (mm)	
		Initial	Maximum	Final	Deflection	Initial	Maximum	Final	Deflection			Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	LHS	RHS
21	L	2	14	1	25	4	30	4	52	66	IWP	3	20	0	76	71	0.3	277	92	13	6
		4	17	5	25	4	29	4	50			0	22	2	67						
21	L	5	21	4	33	2	28	0	54	72	IWP	1	30	0	47	49	0.3	201	62	5	6
		2	20	1	37	0	28	-2	58			1	30	4	51						
23	L	4	33	3	59	4	38	0	72	94	IWP	3	33	2	46	46	0.8	93	77	6	0
		2	31	1	59	4	41	4	74			0	30	0	47						
24	L	2	42	2	80	1	66	1	130	168	IWP									7	4
		2	44	2	84	0	66	1	131												
25	L	2	62	3	119	2	64	0	126	161	IWP									3	0
		3	62	1	120	2	63	0	124												
26	L	4	27	1	49	0	37	2	72	96	IWP	1	30	1	48	106	3.2	80	258	0	0
		4	28	3	49	3	41	3	76			1	10	2	165						
27	L	2	45	3	85	1	52	2	101	134	IWP	1	10	0	147	144	20.4	29	582	19	4
		1	46	3	88	3	56	3	106			0	10	0	140						
28	L	2	23	0	44	2	42	0	82	105	IWP	0	15	0	93	93	1.8	106	193	20	8
		1	21	0	41	0	42	3	81												
29	L	5	59	6	107	2	51	2	98	136	OWP	0	60	1	24	28	1.0	50	49	18	10
		2	55	4	104	1	49	0	97			1	45	4	33						
30	L	0	30	-1	61	1	46	0	91	114	IWP	1	31	0	46	43	0.8	92	69	7	4
		0	30	-1	61	0	43	0	86			0	60	50	40						
31	L	4	39	4	70	1	54	-4	111	145	IWP	1	55	0	26	25	0.3	97	32	13	11
		2	38	1	73	1	55	-4	113			1	60	1	24						
32	L	4	51	6	92	0	50	0	100	130	IWP	0	30	2	48	36	1.2	54	67	20	3
		5	50	3	92	0	51	0	102			0	59	1	24						
33	L	2	54	3	103	0	28	-1	57	132	OWP	3	60	2	24	24	0.7	57	38	18	7
		4	55	5	101	0	30	-1	61												
34	L	2	25	0	48	1	32	0	63	105	OWP	0	20	1	72	68	3.6	47	169	10	7
		2	59	2	114	0	31	1	61			0	20	-4	64						
35	L	4	63	4	118	0	49	0	98	141	OWP	0	30	-1	46	37	1.9	41	77	13	0
		0	49	-3	101	0	50	0	100			0	50	0	28						
36	L	5	47	6	83	1	36	1	70	92	IWP	3	62	3	24	26	0.1	246	23	0	0
		2		4	-6	1	37	0	73			0	51	0	27						

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International

in association with **Jatula Partners**

Road Name:	Bwengu - Chiweta	Road Code:	2	Sample Length No.:	S6	Truck Axle Load - LHS:	3175 kg
Date:							
Chainage (km)	102.20 to 103.70	Sample Length Code:	26	Width:	6.1 m	RHS:	3175 kg
Operator:	RI/MOWS						

Averages and Totals

Area Cracked	3721	m^2	40.7%	Area to be patched	2272 m^2	24.8%
Wide Cracks	3721	m^2	40.7%	Area already patched	1619 m^2	17.7%
				Area Ravelled	8723 m^2	95.3%
Average Condition Index	22.4			Area patched during shoulder repair	450 m^2	4.9%
Minimum Condition Index	15.5					
Maximum Condition Index	31.1					

Average Deflection	δ_p	1.18	mm	
Standard Deviation	σ	0.30	mm	
Calibration Correction Factor	F_c	0.993	0.99	
Seasonal Correction Factor	F_w	1.300		
Design Deflection	δ_d	1.63	mm	
Percentile to equal the Design Deflection	96%	1.64	mm	
Predicted Design Axles	No.	2.35	$x10^6$	Axles
Residual Equivalent Standard Axles	No.	1.07	$x10^6$	ESAs

OWP	4	25%
IWP	12	75%

Average Rut Depth		7.6 mm
Standard Deviation of Rut Depth		6.4 mm
Avg.Radius of Curvature		57 m
Avg.M_r Upper Layers		128 MPa
M_r Base	80%	179 MPa
M_r Subbase	20%	45 MPa
Avg.M_r of the Foundation		105 MPa
M_r Selected Subgrade	80%	144 MPa
M_r Subgrade	20%	49 MPa

Percentile of the Road that will Require Reconstruction 4% of the road

Percentile of the Road that will not Require Strengthening d= 1.64 mm 96%

Target Deflection: 0.9 mm

Crushed Rock Granular Overlay Thickness	=	260 mm
Stabilised Natural Gravel Overlay Thickness	=	260 mm
Natural Gravel Granular Overlay Thickness	=	260 mm
Asphalt Overlay Thickness	=	130 mm

Existing Base Material: CR

Deflection for HDM model $\delta_{(80kN)} =$ 2.52 mm

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International

in association with **Jatula Partners**

Road Name: Bwengu - Chiweta | Road Code: 2 | Sample Length No.: S7 | Truck Axle Load - LHS: 3175 kg | Date:

Chainage (km) 114.29 to 115.29 | Sample Length Code: 27 | Width: 6.1 m | RHS: 3175 kg | Operator: RI/MOWS

Chainage (km)		Surface Condition																											
		Primary Cracking						Secondary Cracking						Pothole		Patch		Edge		Ravel		Bleed		Skid		Deform			
From	To	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Number	Av.Area (m^2)	Number	Av.Area (m^2)	Length	Av.Width (m)	Extent (%)	Degree	Extent (%)	Degree	Extent (%)	Degree	Condition	Position	Shoulder Condition	Drainage Condition
114.29	114.39	C	CW	4	85	✓	✓	L	CW	4	85	✓	✓	10	24	6	13	100	0.3	100	3	60	3	50	4	P	CW		
114.39	114.49	C	CW	4	80	✓	✓	L	CW	4	80	✓	✓	3	15	11	36	100	0.4	100	3	70	4	70	4	P	CW		
114.49	114.59	C	CW	4	75	✓	✓	L	CW	4	75	✓	✓			1	500	50	0.3	100	3	90	3	90	4	P	CW		
114.59	114.69	C	CW	4	70	✓	✓	L	CW	4	70	✓	✓			1	400	100	0.3	100	3	80	3	80	3	P	CW		
114.69	114.79	C	CW	4	80	✓	✓	L	CW	4	80	✓	✓	3	6	4	75	100	0.4	100	3	90	3	80	3	P	CW		
114.79	114.89	L	CW	4	80	✓	✓	T	CW	4	80	✓	✓			2	225	70	0.4	100	3	80	4	60	4	P	CW		
114.89	114.99	L	CW	4	60	✓	✓	T	CW	4	60	✓	✓			4	35	90	0.4	100	3	90	3	90	3	P	CW		
114.99	115.09	C	CW	4	70	✓	✓	L	CW	4	70	✓	✓			5	70	60	0.3	100	3	90	3	80	3	P	CW		
115.09	115.19	C	CW	4	60	✓	✓	L	CW	4	60	✓	✓			2	4	65	0.4	100	3	80	3	70	3	P	CW		
115.19	115.29	C	CW	3	70	✓	✓	L	CW	3	70	✓	✓			3	10	50	0.3	100	3	80	3	80	3	P	CW		

Point Number		Peak Deflection (mm x 100)										Rad.of Curve								Rut Depth (mm)	
		LH Wheelpath				RH Wheelpath						LH Wheelpath									
		Initial	Maximum	Final	Deflection	Initial	Maximum	Final	Deflection	Max Corrected	Wheel Path	Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	LHS	RHS
37	L	3	42	6	75	0	52	1	103	134	IWP	0	20	1	72	72	3.5	51	178	10	15
		2	42	6	76	0	52		104												
38	L	5	32	3	56	0	50	3	97	128	IWP	3	20	2	80	69	1.6	86	138	0	7
		3	29	3	52	1	52	1	102			0	25	2	58						
39	L	1	20	0	39	0	20	-4	44	58	IWP	0	40	-4	33	40	0.3	184	48	0	0
		3	23	2	41	0	21	-4	46			1	31	0	46						
40	L	3	64	2	123	2	58	-3	117	161	OWP	2	60	0	24	24	1.0	42	41	7	8
		2	65	2	126	2	59	-3	119												
41	L	0	40	5	75	1	50	-2	101	129	IWP	0	40	3	36	40	1.0	69	70	0	0
		0	39	2	76	0	50	1	99			0	32	0	44						
42	L	3	39	6	69	4	41	4	74	93	IWP	0	35	0	40	34	0.6	89	52	6	0
		2	36	4	66	3	38	3	70			1	50	2	29						
43	L	5	42	6	73	4	70	4	132	174	IWP	1	40	0	35	34	0.7	81	54	0	0
		4	40	6	70	3	72	3	138			0	42		33						
44	L	3	38	2	71	1	30	-1	60	94	OWP	1	42	0	34	32	0.6	82	49	0	0
		3	39	1	74	0	28	0	56			0	45	0	31						
45	L	1	32	-1	64	1	35	-2	71	92	IWP	0	35	1	41	40	0.8	86	65	0	0
		3	38	6	67	0	35	-2	72			0	35	0	40						
46	L	3	41	2	77	6	30	4	50	99	OWP	0	30	0	47	35	0.8	72	58	0	0
		4	43	5	77	6	34	6	56			0	60	0	23						
47	L	1	43	-1	86	4	50	-2	98	128	IWP	2	40	2	37	32	0.9	63	55	5	6
		3	45	0	87	4	53	2	100			0	50	0	28						

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International
in association with **Jatula Partners**

Road Name:	Bwengu - Chiweta	Road Code:	2	Sample Length No.:	S7	Truck Axle Load - LHS:	3175 kg
Date:							
Chainage (km)	114.29 to 115.29	Sample Length Code:	27	Width:	6.1 m	RHS:	3175 kg
Operator:	RI/MOWS						

Averages and Totals

Area Cracked	4453	m^2	73.0%			
Wide Cracks	4453	m^2	73.0%			
Average Condition Index	21.4					
Minimum Condition Index	19.0					
Maximum Condition Index	23.6					

Area to be patched	2227	m^2	36.5%
Area already patched	1989	m^2	32.6%
Area Ravelled	6100	m^2	100.0%
Area patched during shoulder repair	300	m^2	4.9%

Average Deflection	δ_p	1.17	mm	OWP	3	27%
Standard Deviation	σ	0.34	mm	IWP	8	73%
Calibration Correction Factor	F_c	0.993	0.99			
Seasonal Correction Factor	F_w	1.300				
Design Deflection	δ_d	1.68	mm			
Percentile to equal the Design Deflection	96%	1.69	mm			
Predicted Design Axles	No.	2.35	$x10^6$ Axles			
Residual Equivalent Standard Axles	No.	1.07	$x10^6$ ESAs			

Percentile of the Road that will Require Reconstruction 4% of the road

Percentile of the Road that will not Require Strengthening d= 1.69 mm 96%

Average Rut Depth		2.9 mm
Standard Deviation of Rut Depth		4.4 mm
Avg.Radius of Curvature		41 m
Avg.M_r Upper Layers		73 MPa
M_r Base	80%	70 MPa
M_r Subbase	20%	49 MPa
Avg.M_r of the Foundation		82 MPa
M_r Selected Subgrade	80%	86 MPa
M_r Subgrade	20%	63 MPa

Target Deflection: 0.9 mm

Existing Base Material: CR

Crushed Rock Granular Overlay Thickness	=	270 mm
Stabilised Natural Gravel Overlay Thickness	=	270 mm
Natural Gravel Granular Overlay Thickness	=	270 mm
Asphalt Overlay Thickness	=	135 mm

Deflection for HDM model $\delta_{(80kN)} =$ 2.59 mm

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International
in association with **Jatula Partners**

Road Name: Jenda - Chikangawa | Road Code: 3 | Sample Length No.: S1 | Truck Axle Load - LHS: 3175 kg | Date: 21-Jul-98

Chainage (km) 10.99 to 11.99 | Sample Length Code: 31 | Width: 7.0 m | RHS: 3175 kg | Operator: RI/MOWS

Chainage (km)		Surface Condition																											
		Primary Cracking						Secondary Cracking						Pothole		Patch		Edge		Ravel		Bleed		Skid		Deform			
From	To	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Number	Av.Area (m^2)	Number	Av.Area (m^2)	Length	Av.Width (m)	Extent (%)	Degree	Extent (%)	Degree	Extent (%)	Degree	Condition	Position	Shoulder Condition	Drainage Condition
10.99	11.09																			100	2	100	2						
11.09	11.19																			100	2	100	2						
11.19	11.29																			100	2	100	2						
11.29	11.39																			100	2	100	2						
11.39	11.49																			100	2	100	2						
11.49	11.59																			100	2	100	2						
11.59	11.69																			100	2	100	2						
11.69	11.79																			100	2	100	2						
11.79	11.89																			100	2	100	2						
11.89	11.99																			100	2	100	2						

Point Number		Peak Deflection (mm x 100)										Rad.of Curve								Rut Depth (mm)	
		LH Wheelpath				RH Wheelpath						LH Wheelpath									
		Initial	Maximum	Final	Deflection	Initial	Maximum	Final	Deflection	Max Corrected	Wheel Path	Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	LHS	RHS
0	L	3	20	0	37	3	21	2	37	49	OWP									4	5
		2	21	1	39	3	19	2	33												
1	L	2	13	1	23	2	16	1	29	37	IWP									4	3
		3	15	3	24	2	16	2	28												
2	L	2	22	0	42	2	20	1	37	56	OWP	2	20	-4	67	67	0.9	123	114	3	3
		2	25	3	45	3	20	3	34												
3	L	1	20	-4	43	2	21	2	38	58	OWP	2	20	2	78	78	1.4	107	149	0	0
		3	25	0	47	3	21	2	37												
4	L	4	21	2	36	3	23	2	41	53	IWP	5	25	5	70	70	0.7	153	112	0	0
		2	22	4	38	3	23	2	41												
5	L	2	22	0	42	3	23	0	43	56	IWP	1	12	1	127	110	2.6	96	253	0	0
		0	23	2	44	2	23	1	43			1	16	1	93						
6	L	2	21	0	40	3	20	3	34	51	OWP	0	30	0	47	47	0.4	172	61	0	0
		1	20	0	39	2	20	5	33												
7	L	2	24	0	46	2	17	1	31	60	OWP	0	16	0	88	83	1.7	99	167	0	0
		1	24	0	47	3	21	1	38			0	18	0	78						
8	L	2	34	2	64	3	37	3	68	86	IWP	0	27	5	57	65	1.9	71	137	11	5
		1	32	2	61	2	35	3	65			1	20	1	74						
9	L	2	12	1	21	3	16	3	26	34	IWP	0	10	0	140	140	0.9	262	239	12	6
		1	11	1	20	3	16	3	26												
10	L	2	14	2	24	3	16	2	27	35	IWP	4	10	4	233	183	2.3	178	402	4	5
		0	13	2	24	2	16	2	28			2	12	1	133						

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International
in association with **Jatula Partners**

Road Name: Jenda - Chikangawa | Road Code: 3 | Sample Length No.: S1 | Truck Axle Load - LHS: 3175 kg | Date: 21-Jul-98

Chainage (km) 10.99 to 11.99 | Sample Length Code: 31 | Width: 7.0 m | RHS: 3175 kg | Operator: RI/MOWS

Averages and Totals

Area Cracked	0	m^2	0.0%
Wide Cracks	0	m^2	0.0%
Average Condition Index	3.1		
Minimum Condition Index	3.1		
Maximum Condition Index	3.1		

Area to be patched	0	m^2	0.0%
Area already patched	0	m^2	0.0%
Area Ravelled	7000	m^2	100.0%
Area patched during shoulder repair	300	m^2	4.3%

Average Deflection	δ_p	0.52	mm	
Standard Deviation	σ	0.15	mm	
Calibration Correction Factor	F_c	0.993	0.99	
Seasonal Correction Factor	F_w	1.300		
Design Deflection	δ_d	0.74	mm	
Percentile to equal the Design Deflection	96%	0.75	mm	
Predicted Design Axles	No.	3.03	$x10^6$	Axles
Residual Equivalent Standard Axles	No.	1.18	$x10^6$	ESAs

Percentile of the Road that will Require Reconstruction 4% of the road

Percentile of the Road that will not Require Strengthening d= 0.75 mm 96%

OWP	5	45%
IWP	6	55%

Average Rut Depth		3.0 mm
Standard Deviation of Rut Depth		3.5 mm
Avg.Radius of Curvature		99 m
Avg.M_r Upper Layers		182 MPa
M_r Base	80%	244 MPa
M_r Subbase	20%	114 MPa
Avg.M_r of the Foundation		140 MPa
M_r Selected Subgrade	80%	174 MPa
M_r Subgrade	20%	98 MPa

Target Deflection: 0.9 mm

Existing Base Material: CR

Crushed Rock Granular Overlay Thickness	=	-40 mm
Stabilised Natural Gravel Overlay Thickness	=	-40 mm
Natural Gravel Granular Overlay Thickness	=	-40 mm
Asphalt Overlay Thickness	=	-20 mm

Deflection for HDM model $\delta_{(80kN)} =$ 1.14 mm

Road Maintenance and Rehabilitation Project - Malawi
Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International
in association with **Jatula Partners**

Road Name: Jenda - Chikangawa | Road Code: 3 | Sample Length No.: S2 | Truck Axle Load - LHS: 3175 kg | Date: 21-Jul-98

Chainage (km) 25.27 to 27.27 | Sample Length Code: 32 | Width: 7.0 m | RHS: 3175 kg | Operator: RI/MOWS

Chainage (km)		Surface Condition																											
		Primary Cracking						Secondary Cracking						Pothole		Patch		Edge		Ravel		Bleed		Skid		Deform			
From	To	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Number	Av.Area (m^2)	Number	Av.Area (m^2)	Length	Av.Width (m)	Extent (%)	Degree	Extent (%)	Degree	Extent (%)	Degree	Condition	Position	Shoulder Condition	Drainage Condition
25.27	25.37	C/L	CW	4	80	✓		C/L	CW	4	80	✓								100	3					P	CW		
25.37	25.47	C/L	CW	4	80	✓		C/L	CW	4	80	✓				2	3			100	3					P	CW		
25.47	25.57	C/L	CW	4	80	✓		C/L	CW	4	80	✓				1	4			100	3					P	CW		
25.57	25.67	C/L	CW	4	80	✓		C/L	CW	4	80	✓				1	1			100	3					P	CW		
25.67	25.77	C/L	CW	4	80	✓		C/L	CW	4	80	✓								100	3					P	CW		
25.77	25.87	C/L	CW	4	80	✓		C/L	CW	4	80	✓								100	3								
25.87	25.97	C/L	CW	4	80	✓		C/L	CW	4	80	✓								100	3								
25.97	26.07	C/L	CW	4	80	✓		C/L	CW	4	80	✓		1	3	1	400			100	3					P	CW		
26.07	26.17	C/L	CW	4	80	✓		C/L	CW	4	80	✓								100	3								
26.17	26.27	C/L	CW	4	80	✓		C/L	CW	4	80	✓				1	350			100	3								
26.27	26.37	C/L	CW	4	80	✓		C/L	CW	4	80	✓								100	3								
26.37	26.47	C/L	CW	4	80	✓		C/L	CW	4	80	✓								100	3								
26.47	26.57	C/L	CW	4	80	✓		C/L	CW	4	80	✓								100	3								
26.57	26.67	C/L	CW	4	80	✓		C/L	CW	4	80	✓								100	3								
26.67	26.77	C/L	CW	4	80	✓		C/L	CW	4	80	✓								100	3								
26.77	26.87	C/L	CW	4	80	✓		C/L	CW	4	80	✓								100	3								
26.87	26.97	C/L	CW	3	70	✓		C/L	CW	3	70	✓								100	2								
26.97	27.07	C/L	CW	3	70	✓		C/L	CW	3	70	✓								100	2								
27.07	27.17	C/L	CW	3	70	✓		C/L	CW	3	70	✓								100	2								
27.17	27.27	C/L	CW	3	70	✓		C/L	CW	3	70	✓								100	2								

Point Number		Peak Deflection (mm x 100)										Rad.of Curve								Rut Depth (mm)	
		LH Wheelpath				RH Wheelpath						LH Wheelpath									
		Initial	Maximum	Final	Deflection	Initial	Maximum	Final	Deflection	Max Corrected	Wheel Path	Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	LHS	RHS
19	L	0	32	-1	65	2	29	2	54	83	OWP	0	12	0	117	128	8.6	47	409	13	8
		5	38	7	64	2	29	3	53			0	10	0	140						
20	L	2	41	0	80	2	38	3	71	105	OWP	2	20	2	78	86	5.9	42	245	15	0
		0	41	0	82	2	39	3	73			0	15	0	93						
21	L	2	29	1	55	2	24	1	45	72	OWP	0	15	0	93	93	3.2	71	225	10	0
		0	28	0	56	3	24	3	42												
22	L	0	35	0	70	0	51	4	98	128	IWP	0	15	2	100	94	5.4	48	263	7	4
		0	36	0	72	3	50	-3	100			0	16	0	88						
23	L	2	20	-2	40	4	21	2	36	52	OWP	0	20	-5	62	58	0.6	151	86	0	0
		0	20	0	40	2	18	3	31			2	30	5	53						
24	L	0	19	0	38	4	30	3	53	70	IWP	0	20	2	74	74	0.9	138	126	0	0
		1	20	-1	40	1	29	1	56												
25	L	5	18	5	26	3	37	3	68	88	IWP									4	0
		5	18	5	26	2	37	4	68												
26	L	0	11	2	20	2	22	6	36	45	IWP									0	0
		2	13	2	22	2	20	4	34												
27	L	3	38	5	68	3	22	6	35	86	OWP									8	6
		0	33	1	65	3	20	3	34												
28	L	1	38	1	74	2	24	2	44	97	OWP									0	0
		1	40	2	77	3	25	4	43												
29	L	2	32	5	57	1	40	2	77	97	IWP									60	0
		4	32	5	55	3	40	4	73												
30	L	2	41	1	79	3	18	0	33	103	OWP									4	0
		0	40	-1	81	2	21	2	38												
31	L	3	39	2	73	2	23	2	42	90	OWP									6	5
		1	34	1	66	1	21	2	39												
32	L	1	25	1	48	3	22	4	37	63	OWP									10	0
		1	26	1	50	3	21	5	34												
33	L	3	28	2	51	2	23	1	43	68	OWP									8	0
		3	30	3	54	3	25	2	45												
34	L	3	19	0	35	1	31	0	61	79	IWP									5	7
		2	20	1	37	2	32	1	61												
35	L	3	25	1	46	2	40	3	75	97	IWP									25	34
		2	25	1	47	1	39	1	76												
36	L	3	32	2	59	3	38	2	71	92	IWP									32	13
		1	32	0	63	3	39	3	72												
37	L	3	38	2	71	2	33	2	62	95	OWP									20	17
		2	40	2	76	2	32	2	60												
38	L	2	55	3	105	2	50	1	97	134	OWP									70	40
		2	52	0	102	5	55	6	99												
39	L	1	39	-1	78	4	42	3	77	103	IWP									14	9
		0	40	0	80	2	43	2	82												

Road Maintenance and Rehabilitation Project - Malawi

Roughton International

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

in association with **Jatula Partners**

Road Name:	Jenda - Chikangawa	Road Code:	3	Sample Length No.:	S2	Truck Axle Load - LHS:	3175 kg
Chainage (km)	25.27 to 27.27	Sample Length Code:	32	Width:	7.0 m	RHS:	3175 kg

Date: 21-Jul-98

Operator: RI/MOWS

Averages and Totals

Area Cracked	10920	m^2	78.0%
Wide Cracks	10920	m^2	78.0%
Average Condition Index	6.2		
Minimum Condition Index	1.7		
Maximum Condition Index	16.3		

Area to be patched	384	m^2	2.7%
Area already patched	571	m^2	4.1%
Area Ravelled	14000	m^2	100.0%
Area patched during shoulder repair	600	m^2	4.3%

Average Deflection	δ_p	0.88	mm	OWP	12	57%
Standard Deviation	σ	0.22	mm	IWP	9	43%
Calibration Correction Factor	F_c	0.993	0.99			
Seasonal Correction Factor	F_w	1.300				
Design Deflection	δ_d	1.21	mm			
Percentile to equal the Design Deflection	96%	1.29	mm			
Predicted Design Axles	No.	3.03	$x10^6$ Axles			
Residual Equivalent Standard Axles	No.	1.18	$x10^6$ ESAs			

Percentile of the Road that will Require Reconstruction 4% of the road

Percentile of the Road that will not Require Strengthening d= 1.29 mm 96%

Average Rut Depth		10.8	mm
Standard Deviation of Rut Depth		15.8	mm
Avg.Radius of Curvature		90	m
Avg.M_r Upper Layers		226	MPa
M_r Base	80%	263	MPa
M_r Subbase	20%	126	MPa
Avg.M_r of the Foundation		83	MPa
M_r Selected Subgrade	80%	138	MPa
M_r Subgrade	20%	47	MPa

Target Deflection: 0.9 mm

Existing Base Material: CR

Crushed Rock Granular Overlay Thickness	=	150	mm
Stabilised Natural Gravel Overlay Thickness	=	150	mm
Natural Gravel Granular Overlay Thickness	=	150	mm
Asphalt Overlay Thickness	=	75	mm

Deflection for HDM model $\delta_{(80kN)} =$ 1.86 mm

Road Maintenance and Rehabilitation Project - Malawi **Roughton International**
Detailed Visual Condition Survey and Deflection Survey for Sample Lengths *in association with* **Jatula Partners**

Road Name: Jenda - Chikangawa | Road Code: 3 | Sample Length No.: S3 | Truck Axle Load - LHS: 3175 kg | Date: 22-Jul-98

Chainage (km) 61.54 to 63.54 | Sample Length Code: 33 | Width: 7.0 m | RHS: 3175 kg | Operator: RI/MOWS

Chainage (km)		Surface Condition																													
		Primary Cracking						Secondary Cracking						Pothole		Patch		Edge		Ravel		Bleed		Skid		Deform			
From	To	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Number	Av.Area (m^2)	Number	Av.Area (m^2)	Length	Av.Width (m)	Extent (%)	Degree	Extent (%)	Degree	Extent (%)	Degree	Condition	Position	Shoulder Condition	Drainage Condition
61.54	61.64	C/L	CW	4	100	✓		C/L	CW	4	100	✓				3	8			100	3	60	3	100	2				
61.64	61.74	C/L	CW	4	100	✓		C/L	CW	4	100	✓				3	20			100	3	60	3	100	2				
61.74	61.84	C/L	CW	4	100	✓		C/L	CW	4	100	✓				8	32			100	3	60	3	100	2	P	CW		
61.84	61.94	C/L	CW	4	100	✓		C/L	CW	4	100	✓				6	7			100	3	60	3	100	2	P	CW		
61.94	62.04	C/L	CW	4	100	✓		C/L	CW	4	100	✓		1	2	1	4												
62.04	62.14	C/L	CW	4	100	✓		C/L	CW	4	100	✓		2	20	2	2			100	3	60	3	100	2				
62.14	62.24	C/L	CW	4	100	✓		C/L	CW	4	100	✓		5	5	1	450												
62.24	62.34	C/L	CW	3	100	✓		C/L	CW	3	100	✓		10	15	30	1			100	3	60	3	100	2	P	CW		
62.34	62.44	C/L	CW	3	100	✓		C/L	CW	3	100	✓								100	3	60	3	100	2				
62.44	62.54	C/L	CW	3	100	✓		C/L	CW	3	100	✓								100	3	60	3	100	2				
62.54	62.64	C/L	CW	3	100	✓		C/L	CW	3	100	✓								100	3	60	3	100	2				
62.64	62.74	C/L	CW	3	100	✓		C/L	CW	3	100	✓								100	3	60	3	100	2				
62.74	62.84																			100	3								
62.84	62.94																			100	3	100	3	100	2				
62.94	63.04																			100	3	100	3	100	2				
63.04	63.14																			100	3	100	3	100	2				
63.14	63.24																			100	3	100	3	100	2				
63.24	63.34																			100	3	100	3	100	2				
63.34	63.44																			100	3	100	3	100	2				
63.44	63.54																			100	3	100	3	100	2				

Point Number		Peak Deflection (mm x 100)										Rad.of Curve								Rut Depth (mm)	
		LH Wheelpath				RH Wheelpath						LH Wheelpath									
		Initial	Maximum	Final	Deflection	Initial	Maximum	Final	Deflection	Max Corrected	Wheel Path	Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	LHS	RHS
32	R	0	20	1	39	1	20	1	38	51	OWP									20	15
		1	21	1	40	2	21	2	38												
33	R	3	50	2	95	1	46	3	88	125	OWP									70	40
		3	52	3	98	1	43	3	82												
34	R	3	21	5	34	2	40	2	76	98	IWP									32	40
		4	21	4	34	5	44	7	76												
35	R	3	25	2	45	7	31	8	47	63	IWP									31	29
		3	26	3	46	1	26	0	51												
36	R	2	29	3	53	2	23	1	43	69	OWP									10	8
		2	29	2	54	1	22	0	43												
37	R	2	64	5	121	3	41	4	75	155	OWP									5	9
		2	62	3	119	2	42	2	80												
38	R	5	55	9	96	2	60	4	114	150	IWP									15	12
		1	50	3	96	2	61	1	119												
39	R	2	39	4	72	2	51	7	93	121	IWP									30	33
		4	39	5	69	3	50	3	94												
40	R	3	51	5	94	3	50	6	91	128	OWP									39	32
		2	56	6	104	2	49	2	94												
41	R	1	43	2	83	2	40	1	77	108	OWP									19	13
		1	43	1	84	3	41	3	76												
42	R	0	19	-1	39	2	12	2	20	52	OWP									13	19
		0	21	1	41	2	12	2	20												
43	R	2	22	1	41	3	21	3	36	56	OWP									12	0
		1	25	3	46	3	21	4	35												
44	R	3	19	1	34	1	12	1	22	44	OWP									6	5
		3	21	5	34	1	12	4	19												
45	R	3	25	2	45	1	22	0	43	59	OWP	0	20	5	80	72	1.2	110	132	0	6
		2	25	2	46	2	23	3	41			0	22	0	64						
46	R	2	19	0	36	2	12	1	21	45	OWP									0	0
		2	19	2	34	2	12	1	21												
47	R	2	23	2	42	2	17	1	31	55	OWP	0	20	0	70	70	1.0	124	122	7	0
		2	23	1	43	2	17	1	31												
48	R	3	23	3	40	2	15	-2	30	54	OWP	0	20	0	70	76	1.1	123	138	5	4
		0	21	-1	43	1	16	0	31			0	18	2	82						
49	R	3	22	4	37	3	12	3	18	50	OWP	0	15	0	93	85	1.2	128	156	8	4
		2	23	3	41	2	11	4	16			0	19	1	76						
50	R	3	27	2	49	2	15	-1	29	66	OWP	0	20	1	72	72	1.6	91	142	7	0
		3	32	7	54	2	15	3	25			0	19	-1	72						
51	R	1	33	0	65	3	31	3	56	86	OWP	0	28	2	52	65	2.2	64	141	8	7
		3	39	6	69	2	32	2	60			0	18	0	78						
52	R	2	25	1	47	2	21	1	39	61	OWP										
		1	25	1	48	2	20	3	35												

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International
in association with **Jatula Partners**

Road Name: Jenda - Chikangawa | Road Code: 3 | Sample Length No.: S3 | Truck Axle Load - LHS: 3175 kg | Date: 22-Jul-98

Chainage (km) 61.54 to 63.54 | Sample Length Code: 33 | Width: 7.0 m | RHS: 3175 kg | Operator: RI/MOWS

Averages and Totals

Area Cracked	8400	m^2	60.0%
Wide Cracks	8400	m^2	60.0%
Average Condition Index	7.2		
Minimum Condition Index	0.4		
Maximum Condition Index	18.7		

Area to be patched	652	m^2	4.7%
Area already patched	653	m^2	4.7%
Area Ravelled	12600	m^2	90.0%
Area patched during shoulder repair	600	m^2	4.3%

Average Deflection	δ_p	0.81	mm	
Standard Deviation	σ	0.36	mm	
Calibration Correction Factor	F_c	0.993	0.99	
Seasonal Correction Factor	F_w	1.300		
Design Deflection	δ_d	1.35	mm	
Percentile to equal the Design Deflection	96%	1.51	mm	
Predicted Design Axles	No.	3.03	$x10^6$	Axles
Residual Equivalent Standard Axles	No.	1.18	$x10^6$	ESAs

Percentile of the Road that will Require Reconstruction 4% of the road

Percentile of the Road that will not Require Strengthening d= 1.51 mm 96%

OWP	17	81%
IWP	4	19%

Average Rut Depth		15.3	mm
Standard Deviation of Rut Depth		15.2	mm
Avg.Radius of Curvature		73	m
Avg.M_r Upper Layers		139	MPa
M_r Base	80%	142	MPa
M_r Subbase	20%	132	MPa
Avg.M_r of the Foundation		107	MPa
M_r Selected Subgrade	80%	124	MPa
M_r Subgrade	20%	91	MPa

Target Deflection: 0.9 mm

Existing Base Material: CR

Crushed Rock Granular Overlay Thickness	=	190	mm
Stabilised Natural Gravel Overlay Thickness	=	190	mm
Natural Gravel Granular Overlay Thickness	=	190	mm
Asphalt Overlay Thickness	=	95	mm

Deflection for HDM model $\delta_{(80kN)} =$ 2.08 mm

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International
in association with **Jatula Partners**

Road Name: Jenda - Chikangawa | Road Code: 3 | Sample Length No.: S4 | Truck Axle Load - LHS: 3175 kg | Date: 22-Jul-98

Chainage (km) 69.23 to 71.23 | Sample Length Code: 34 | Width: 7.0 m | RHS: 3175 kg | Operator: RI/MOWS

Chainage (km)		Surface Condition																											
		Primary Cracking						Secondary Cracking						Pothole		Patch		Edge		Ravel		Bleed		Skid		Deform			
From	To	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Number	Av.Area (m^2)	Number	Av.Area (m^2)	Length	Av.Width (m)	Extent (%)	Degree	Extent (%)	Degree	Extent (%)	Degree	Condition	Position	Shoulder Condition	Drainage Condition
69.23	69.33																	200	0.1	100	2	100	2					P	
69.33	69.43																	200	0.1	100	2	100	2					P	
69.43	69.53																	200	0.1	100	2	100	2					P	
69.53	69.63																	200	0.1	100	2	100	2					P	
69.63	69.73																	200	0.1	100	2	100	2					P	
69.73	69.83																	200	0.1	100	2	100	2					P	
69.83	69.93																	200	0.1	100	2	100	2					P	
69.93	70.03																	200	0.1	100	2	100	2					P	
70.03	70.13																	200	0.1	100	2	100	2					P	
70.13	70.23																	200	0.1	100	2	100	2					P	
70.23	70.33																	200	0.1	100	2	100	2					P	
70.33	70.43																	200	0.1	100	2	100	2					P	
70.43	70.53																	200	0.1	100	2	100	2					P	
70.53	70.63																	200	0.1	100	2	100	2					P	
70.63	70.73																	200	0.1	100	2	100	2					P	
70.73	70.83																	200	0.1	100	2	100	2					P	
70.83	70.93																	200	0.1	100	2	100	2					P	
70.93	71.03																	200	0.1	100	2	100	2					P	
71.03	71.13																	200	0.1	100	2	100	2					P	
71.13	71.23																	200	0.1	100	2	100	2					P	

Chainage (km)		Point Number		Peak Deflection (mm x 100)										Rad.of Curve								Rut Depth (mm)	
				LH Wheelpath				RH Wheelpath						LH Wheelpath									
From	To			Initial	Maximum	Final	Deflection	Initial	Maximum	Final	Deflection	Max Corrected	Wheel Path	Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	LHS	RHS
		53	L	2	19	1	35	2	17	0	32	46	OWP									5	4
				3	20	1	36	2	16	0	30												
69.23	69.33	54	L	2	20	2	36	3	17	0	31	48	OWP	0	20	-2	67	69	0.7	154	110	4	3
				1	20	1	38	2	17	0	32			0	20	1	72						
69.33	69.43	55	L	0	16	-1	33	3	12	-1	22	42	OWP	1	14	0	104	102	1.2	153	189	5	3
				1	17	1	32	1	12	-1	24			0	14	0	100						
69.43	69.53	56	L	1	13	0	25	3	11	1	18	35	OWP	0	12	0	117	117	1.1	189	210	0	0
				0	14	-1	29	3	11	0	19												
69.53	69.63	57	L	1	14	0	27	3	14	0	25	37	OWP	1	10	0	147	147	2.0	154	315	4	3
				1	16	1	30	3	15	1	26			1	10	0	147						
69.63	69.73	58	L	2	15	0	28	2	14	0	26	37	OWP	0	10	0	140	140	1.8	158	290	0	0
				3	17	2	29	3	15	1	26												
69.73	69.83	59	L	0	15	-1	31	2	16	0	30	40	OWP									4	0
				1	16	0	31	3	16	1	28												
69.83	69.93	60	L	2	15	1	27	3	13	1	22	35	OWP									3	0
				2	16	2	28	2	13	0	24												
69.93	70.03	61	L	1	21	1	40	3	16	0	29	52	OWP									7	0
				5	25	5	40	2	17	-1	33												
70.03	70.13	62	L	4	20	2	34	3	19	1	34	45	IWP	2	10	3	187	187	5.1	101	513	3	4
				3	20	2	35	2	18	-1	35												
70.13	70.23	63	L	2	15	-3	31	3	21	0	39	51	IWP									4	5
				5	22	4	35	3	22	1	40												
70.23	70.33	64	L	2	16	0	30	3	16	0	29	41	IWP									4	5
				5	20	5	30	3	19	1	34												
70.33	70.43	65	L	3	21	1	38	3	17	0	31	48	OWP	0	25	2	58	58	0.5	169	84	9	0
				2	20	2	36	3	17	0	31												
70.43	70.53	66	L	1	20	0	39	2	20	0	38	50	OWP	0	11	2	140	95	1.6	120	190	6	5
				2	21	1	39	2	21	1	39			0	30	5	51						
70.53	70.63	67	L	2	23	-1	45	2	21	0	40	59	OWP	0	20	1	72	72	1.2	110	132	8	9
				1	24	1	46	2	23	4	40												
70.63	70.73	68	L	3	33	3	60	3	29	3	52	77	OWP	0	15	3	104	83	2.9	67	196	10	6
				2	32	2	60	3	30	2	55			0	20	-5	62						
70.73	70.83	69	L	4	28	2	50	3	24	1	44	65	OWP	0	11	1	133	133	5.4	69	374	7	0
				3	28	3	50	3	26	1	48												
70.83	70.93	70	L	0	20	0	40	3	24	0	45	59	IWP	0	20	-5	62	62	0.7	145	98	4	5
				3	23	3	40	2	24	0	46												
70.93	71.03	71	L	1	20	0	39	2	15	1	27	51	OWP	0	10	1	147	135	3.4	98	330	0	0
				2	22	2	40	2	16	0	30			0	12	1	122						
71.03	71.13	72	L	0	23	-1	47	3	25	0	47	65	IWP	0	10	1	147	132	4.9	73	359	10	5
				0	24	-1	49	2	25	-5	53			0	12	0	117						
71.13	71.23	73	L	0	19	0	38	3	13	1	22	50	OWP	0	15	2	100	100	1.7	117	204		
				1	21	1	40	3	13	1	22												

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International

in association with **Jatula Partners**

Road Name:	Jenda - Chikangawa	Road Code:	3	Sample Length No.:	S4	Truck Axle Load - LHS:	3175 kg
Date:	22-Jul-98						
Chainage (km)	69.23 to 71.23	Sample Length Code:	34	Width:	7.0 m	RHS:	3175 kg
Operator:	RI/MOWS						

Averages and Totals

Area Cracked	0 m^2	0.0%	Area to be patched	800 m^2	5.7%	Average Deflection δ_p	0.49 mm
Wide Cracks	0 m^2	0.0%	Area already patched	0 m^2	0.0%	Standard Deviation σ	0.11 mm
			Area Ravelled	14000 m^2	100.0%	Calibration Correction Factor F_c	0.993 0.99
Average Condition Index	4.7		Area patched during shoulder repair	600 m^2	4.3%	Seasonal Correction Factor F_w	1.300
Minimum Condition Index	4.7					Design Deflection δ_d	0.66 mm
Maximum Condition Index	4.7					Percentile to equal the Design Deflection 96%	0.67 mm
						Predicted Design Axles No.	3.03 $x10^6$ Axles
						Residual Equivalent Standard Axles No.	1.18 $x10^6$ ESAs

OWP	16	76%
IWP	5	24%

Average Rut Depth		3.9 mm
Standard Deviation of Rut Depth		3.0 mm
Avg.Radius of Curvature		109 m
Avg.M_r Upper Layers		240 MPa
M_r Base	80%	336 MPa
M_r Subbase	20%	128 MPa
Avg.M_r of the Foundation		125 MPa
M_r Selected Subgrade	80%	155 MPa
M_r Subgrade	20%	93 MPa

Percentile of the Road that will Require Reconstruction 4% of the road

Percentile of the Road that will not Require Strengthening d= 0.67 mm 96%

Target Deflection: 0.9 mm

Existing Base Material: CR

Crushed Rock Granular Overlay Thickness	=	-80 mm
Stabilised Natural Gravel Overlay Thickness	=	-80 mm
Natural Gravel Granular Overlay Thickness	=	-80 mm
Asphalt Overlay Thickness	=	-40 mm

Deflection for HDM model $\delta_{(80kN)} =$ 1.01 mm

Road Maintenance and Rehabilitation Project - Malawi

Roughton International

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

in association with **Jatula Partners**

Road Name: Mzuzu - Nkhata Bay | Road Code: 4 | Sample Length No.: S1 | Truck Axle Load - LHS: 3175 kg | Date: 23-Jul-98

Chainage (km) 8.24 to 9.74 | Sample Length Code: 41 | Width: 6.0 m | RHS: 3175 kg | Operator: RI/MOWS

Chainage (km)		Surface Condition																													
		Primary Cracking						Secondary Cracking						Pothole		Patch		Edge		Ravel		Bleed		Skid		Deform					
From	To	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Number	Av.Area (m^2)	Number	Av.Area (m^2)	Length	Av.Width (m)	Extent (%)	Degree	Extent (%)	Degree	Extent (%)	Degree	Condition	Position	Shoulder Condition	Drainage Condition	Point Number	
																														0	L
8.24	8.34															3	10					100	2					P	P	1	L
8.34	8.44															3	15					100	2					P	P	2	L
8.44	8.54	B	CW	2	100	✓		B	CW	2	100	✓				8	9					100	2					P	P	3	L
8.54	8.64	B	CW	2	100	✓		B	CW	2	100	✓				4	13					100	2					P	P	4	L
8.64	8.74															8	11					100	2					P	P	5	L
8.74	8.84	C/T	WP	3	100	✓		C/T	WP	3	100	✓				9	15			50	2	100	2					P	P	6	L
8.84	8.94	C/T	WP	3	100	✓		C/T	WP	3	100	✓				8	10					100	2			P	CW	P	P	7	L
8.94	9.04													1	1	2	300					100	2					P	P	8	L
9.04	9.14	B	CW	2	100	✓		B	CW	2	100	✓				8	2					100	2			P	CW	P	P	9	L
9.14	9.24	B	CW	2	100	✓		B	CW	2	100	✓				3	15					100	2			P	CW	P	P	10	L
9.24	9.34	B	CW	2	100	✓		B	CW	2	100	✓										100	2			P	CW	P	P	11	L
9.34	9.44	B	CW	2	100	✓		B	CW	2	100	✓										100	2			P	CW	P	P	12	L
9.44	9.54																					100	2			P	CW	P	P	13	L
9.54	9.64																					100	2					P	P	14	L
9.64	9.74															1	15			100	2	100	2					P	P	15	L

Point Number		Peak Deflection (mm x 100)										Rad.of Curve								Rut Depth (mm)	
		LH Wheelpath				RH Wheelpath						LH Wheelpath									
		Initial	Maximum	Final	Deflection	Initial	Maximum	Final	Deflection	Max Corrected	Wheel Path	Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	LHS	RHS
0	L	1	30	0	59	5	24	5	38	77	OWP									7	0
		1	30	-1	60	0	20	0	40												
1	L	1	34	0	67	1	21	0	41	88	OWP									0	0
		1	35	0	69	2	24	1	45												
2	L	2	31	-1	61	3	35	4	63	83	IWP	1	21	2	72	69	2.1	71	149	0	0
		2	32	0	62	0	33	0	66			0	21	0	67						
3	L	3	29	2	53	0	26	0	52	68	OWP	0	19	1	76	78	2.0	84	164	0	0
		0	27	1	53	2	28	2	52			1	19	2	80						
4	L	4	22	1	39	1	20	1	38	52	OWP	0	21	0	67	69	0.9	134	116	0	5
		3	23	1	42	0	19	1	37			0	19	-1	72						
5	L	4	32	1	59	1	25	1	48	79	OWP	1	24	2	62	61	1.6	76	121	0	0
		0	32	0	64	4	29	5	49			3	26	2	60						
6	L	1	56	0	111	0	80	0	160	208	IWP	0	48	0	29	26	0.9	48	44		
		4	59	0	114	1	82	0	163			1	64	0	22						
7	L	4	14	3	21	1	12	1	22	32	IWP	1	13	1	117	117	0.8	250	189	0	11
		0	12	0	24	1	14	0	27			0	12	0	117						
8	L	2	26	0	50	3	28	2	51	65	OWP	0	16	2	93	90	2.4	84	202	6	7
		4	27	0	50	0	24	2	46			2	18	2	88						
9	L	2	26	2	48	2	38	3	71	89	IWP	4	17	3	104	88	2.1	91	188	0	0
		3	26	1	48	1	33	-2	67			1	19	-2	72						
10	L	3	29	3	52	1	37	3	70	92	IWP	2	21	3	76	71	1.5	94	139	9	5
		1	25	0	49	1	38	3	72			3	24	3	67						
11	L	4	18	3	29	0	12	0	24	38	OWP	0	10	0	140	124	1.5	160	243	0	0
		3	18	3	30	0	13	-2	28			2	13	-2	108						
12	L	5	22	4	35	0	14	0	28	45	OWP	0	20	0	70	74	0.7	162	118	0	4
		3	20	2	35	0	15	1	29			1	19	1	78						
13	L	3	24	2	43	5	22	3	36	54	OWP	1	13	3	127	115	2.7	99	266	0	7
		2	21	0	40	4	20	1	35			0	14	1	104						
14	L	2	40	1	77	6	31	1	55	99	OWP	0	32	1	44	48	1.5	62	94	9	0
		2	39	0	76	5	30	2	53			1	29	2	51						
15	L	2	16	1	29	4	18	6	26	39	OWP	0	20	2	74	74	0.5	200	109	9	34
		3	19	3	32	4	18	6	26			0	19	0	74						

Road Maintenance and Rehabilitation Project - Malawi | **Roughton International**
Detailed Visual Condition Survey and Deflection Survey for Sample Lengths | *in association with* **Jatula Partners**

Road Name: Mzuzu - Nkhata Bay | Road Code: 4 | Sample Length No.: S1 | Truck Axle Load - LHS: 3175 kg | Date: 23-Jul-98

Chainage (km) 8.24 to 9.74 | Sample Length Code: 41 | Width: 6.0 m | RHS: 3175 kg | Operator: RI/MOWS

Averages and Totals

Area Cracked	4800 m^2	53.3%	Area to be patched	590 m^2	6.6%	Average Deflection δ_p	0.76	mm	OWP 11	69%	Average Rut Depth 3.8 mm
Wide Cracks	4800 m^2	53.3%	Area already patched	884 m^2	9.8%	Standard Deviation σ	0.41	mm	IWP 5	31%	Standard Deviation of Rut Depth 6.8 mm
			Area Ravelled	900 m^2	10.0%	Calibration Correction Factor F_c	0.993	0.99			
Average Condition Index	8.1		Area patched during shoulder repair	450 m^2	5.0%	Seasonal Correction Factor F_w	1.300				Avg.Radius of Curvature 79 m
Minimum Condition Index	2.8					Design Deflection δ_d	1.38	mm			Avg.M_r Upper Layers 153 MPa
Maximum Condition Index	15.3					Percentile to equal the Design Deflection 96%	1.40	mm			M_r Base 80% 194 MPa
						Predicted Design Axles No.	1.63	$x10^6$ Axles			M_r Subbase 20% 113 MPa
						Residual Equivalent Standard Axles No.	0.63	$x10^6$ ESAs			Avg.M_r of the Foundation 115 MPa
						Percentile of the Road that will Require Reconstruction	4% of the road				M_r Selected Subgrade 80% 161 MPa
						Percentile of the Road that will not Require Strengthening d= 1.40 mm	96%				M_r Subgrade 20% 74 MPa

Target Deflection: 1.1 mm

Crushed Rock Granular Overlay Thickness	=	100 mm
Stabilised Natural Gravel Overlay Thickness	=	100 mm
Natural Gravel Granular Overlay Thickness	=	100 mm
Asphalt Overlay Thickness	=	50 mm

Existing Base Material: GN

Deflection for HDM model $\delta_{(80kN)} =$ 2.12 mm

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International

in association with **Jatula Partners**

Road Name: Mzuzu - Nkhata Bay | Road Code: 4 | Sample Length No.: S2 | Truck Axle Load - LHS: 3175 kg | Date: 24-Jul-98

Chainage (km) 21.43 to 22.93 | Sample Length Code: 42 | Width: 6.0 m | RHS: 3175 kg | Operator: RI/MOWS

Chainage (km)		Surface Condition: Primary Cracking						Secondary Cracking						Pothole		Patch		Edge		Ravel		Bleed		Skid		Deform			
From	To	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Number	Av.Area (m^2)	Number	Av.Area (m^2)	Length	Av.Width (m)	Extent (%)	Degree	Extent (%)	Degree	Extent (%)	Degree	Condition	Position	Shoulder Condition	Drainage Condition
21.43	21.53	C	CW	3	50	✓	✓							2	1	3	23			70	3	30	2			P	CW		F
21.53	21.63	C	CW	3	50	✓	✓									6	6			70	3	70	2			P	CW		F
21.63	21.73	C	CW	3	50	✓	✓									4	18			70	3	50	2			P	CW		F
21.73	21.83	C	CW	3	40	✓	✓									3	33	2	0.5	70	2	60	3			P	CW		F
21.83	21.93	C	CW	3	50	✓	✓									5	100	7	0.3	70	2	3	2			P	CW		P
21.93	22.03	C	CW	3	30	✓	✓									10	50			60	3	30	2			P	CW		F
22.03	22.13	C	CW	3	40	✓	✓									5	80			70	2	50	2			P	CW		F
22.13	22.23	C	CW	3	40	✓	✓							1	1	7	43			70	3	70	2			P	CW		F
22.23	22.33	C	CW	3	50	✓	✓									4	125			70	3	70	2			P	CW		F
22.33	22.43	C	CW	3	30	✓	✓									8	24					50	3			P	CW		F
22.43	22.53	C	CW	3	30	✓	✓									7	86			50	3	30	2			P	CW		F
22.53	22.63	C	CW	3	20	✓	✓									4	25	60	0.2	50	2	10	2			P	CW		P
22.63	22.73	C	CW	3	40	✓	✓									7	7			60	3	5	2			P	CW		F
22.73	22.83	C	CW	3	50	✓	✓													2	3	6	2			P	CW		P
22.83	22.93	C	CW	4	60	✓	✓													80	3		2			P	CW		P

Point Number		Peak Deflection (mm x 100): LH Wheelpath Initial	Maximum	Final	Deflection	RH Wheelpath Initial	Maximum	Final	Deflection	Max Corrected	Wheel Path	Rad. of Curve: LH Wheelpath Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	Rut Depth (mm) LHS	RHS
16	L	1	41	2	79	1	28	1	54	103	OWP	2	35	2	42	39	1.1	65	69	12	0
		2	42	2	80	4	32	5	55			0	40	0	35						
17	L	1	31	1	60	3	33	3	60	79	IWP	2	40	2	37	37	0.5	101	54	5	5
		1	32	2	61	1	32	1	62												
18	L	5	55	1	104	3	31	5	54	137	OWP	0	40	0	35	37	1.8	43	76	7	5
		4	59	6	108	3	29	4	51			3	40	5	39						
19	L	2	30	0	58	1	14	2	25	77	OWP									8	6
		1	32	1	62	0	13	0	26												
20	L	3	41	5	74	2	22	5	37	98	OWP	0	30	0	47	47	1.4	63	90	9	4
		2	40	0	78	2	22	4	38												
21	L	2	29	3	53	2	30	3	55	71	IWP	0	12	3	133	97	3.1	75	232	12	7
		4	30	4	52	4	30	1	55			0	25	4	61						
22	L	2	55	12	96	0	44	5	83	123	OWP	0	30	0	47	51	2.8	43	120	10	7
		3	49	1	94	0	42	2	82			0	25	0	56						
23	L	4	32	2	58	1	21	0	41	76	OWP	0	22	2	67	54	1.1	86	99	7	10
		1	31	1	60	1	20	0	39			2	40	11	42						
24	L	1	41	4	77	4	31	4	54	99	OWP	0	25	1	57	57	2.3	56	125	8	10
		2	42	5	77	4	31	4	54												
25	L	1	60	2	117	5	35	5	60	162	OWP									0	5
		2	68	0	134	4	36	4	64												
26	L	1	41	2	79	3	38	3	70	105	OWP									18	0
		2	43	1	83	3	38	6	67												
27	L	1	39	3	74	3	10	4	13	97	OWP									5	6
		0	39	1	77	2	10	3	15												
28	L	2	39	3	73	2	34	4	62	97	OWP									18	15
		2	41	3	77	2	34	4	62												
29	L	2	46	7	83	2	40	5	73	110	OWP									7	10
		2	45	1	87	2	41	3	77												
30	L	1	100	6	193	1	31	3	58	248	OWP									7	12
		0	96	0	192	2	30	2	56												
31	L	0	110	0	220	2	130	4	254	328	IWP									8	8
		0	110	2	218	2	130	4	254												

Road Maintenance and Rehabilitation Project - Malawi
Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International
in association with **Jatula Partners**

Road Name: Mzuzu - Nkhata Bay | Road Code: 4 | Sample Length No.: S2 | Truck Axle Load - LHS: 3175 kg | Date: 24-Jul-98

Chainage (km) 21.43 to 22.93 | Sample Length Code: 42 | Width: 6.0 m | RHS: 3175 kg | Operator: RI/MOWS

Averages and Totals

Area Cracked	3780 m^2	42.0%	Area to be patched	1743 m^2	19.4%	Average Deflection δ_p	1.26 mm	OWP	13	81%	Average Rut Depth 7.8 mm
Wide Cracks	3780 m^2	42.0%	Area already patched	2565 m^2	28.5%	Standard Deviation σ	0.69 mm	IWP	3	19%	Standard Deviation of Rut Depth 4.3 mm
			Area Ravelled	5172 m^2	57.5%	Calibration Correction Factor F_c	0.993 0.99				
Average Condition Index	15.1		Area patched during shoulder repair	450 m^2	5.0%	Seasonal Correction Factor F_w	1.300				Avg.Radius of Curvature 54 m
Minimum Condition Index	12.4					Design Deflection δ_d	2.29 mm				Avg.M_r Upper Layers 108 MPa
Maximum Condition Index	17.2					Percentile to equal the Design Deflection 96%	2.79 mm				M_r Base 80% 123 MPa
						Predicted Design Axles No.	1.63 $x10^6$ Axles				M_r Subbase 20% 72 MPa
						Residual Equivalent Standard Axles No.	0.63 $x10^6$ ESAs				Avg.M_r of the Foundation 66 MPa
						Percentile of the Road that will Require Reconstruction	4% of the road				M_r Selected Subgrade 80% 82 MPa
						Percentile of the Road that will not Require Strengthening d= 2.79 mm	96%				M_r Subgrade 20% 48 MPa

Target Deflection: 1.1 mm

Existing Base Material: GN

Crushed Rock Granular Overlay Thickness	=	290 mm
Stabilised Natural Gravel Overlay Thickness	=	290 mm
Natural Gravel Granular Overlay Thickness	=	290 mm
Asphalt Overlay Thickness	=	145 mm

Deflection for HDM model $\delta_{(80kN)} =$ 3.53 mm

Road Maintenance and Rehabilitation Project - Malawi **Roughton International**

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths *in association with* **Jatula Partners**

Road Name: Mzuzu - Nkhata Bay | Road Code: 4 | Sample Length No.: S3 | Truck Axle Load - LHS: 3175 kg | Date: 24-Jul-98

Chainage (km) 42.31 to 43.81 | Sample Length Code: 43 | Width: 6.0 m | RHS: 3175 kg | Operator: RI/MOWS

Chainage (km)		Surface Condition: Primary Cracking						Secondary Cracking						Pothole		Patch		Edge		Ravel		Bleed		Skid		Deform			
From	To	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Number	Av.Area (m^2)	Number	Av.Area (m^2)	Length	Av.Width (m)	Extent (%)	Degree	Extent (%)	Degree	Extent (%)	Degree	Condition	Position	Shoulder Condition	Drainage Condition
42.31	42.41	C	CW	4	60	✓	✓							9	6	7	21	50	0.5	70	3	50	2			P	CW		F
42.41	42.51	C	CW	4	60	✓	✓							7	11	8	69	70	0.1	70	3	50	2			P	CW		F
42.51	42.61	C	CW	4	70	✓	✓									1	20	80	0.1			70	3			P	CW		P
42.61	42.71	C	CW	4	65	✓	✓							11	3	9	6	80	0.1	70	3	70	3			P	CW		P
42.71	42.81	C	CW	4	50	✓	✓									5	12			70	3					P	CW		P
42.81	42.91	C	CW	4	50	✓	✓													70	3					P	CW		F
42.91	43.01	C	CW	4	50	✓	✓									8	50			70	3					P	CW		F
43.01	43.11	C	CW	4	50	✓	✓									9	67			40	3					P	CW		P
43.11	43.21	C	CW	4	80	✓	✓									16	31			70	3					P	CW		F
43.21	43.31	C	CW	4	80	✓	✓									4	10			70	3					P	CW		F
43.31	43.41	C	CW	4	60	✓	✓									8	44			70	3								F
43.41	43.51	B	CW	3	20	✓	✓									3	34			50	2	30	3			P	CW		F
43.51	43.61	B	CW	3	30	✓	✓									11	36			35	3	70	3			P	CW		F
43.61	43.71	B	CW	3	80	✓	✓									5	40			20	3	40	3			P	CW		F
43.71	43.81	C	CW	4	80	✓	✓									4	88			40	3	30	2			P	CW		F
43.81	43.91	C	CW	4	80	✓	✓													40	3	55	2			P	CW		F

Point Number		Peak Deflection (mm x 100): LH Wheelpath				RH Wheelpath				Max Corrected	Wheel Path	Rad.of Curve: LH Wheelpath								Rut Depth (mm)	
		Initial	Maximum	Final	Deflection	Initial	Maximum	Final	Deflection			Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	LHS	RHS
32	R	0	41	0	82	2	55	4	104	134	IWP	0	10	0	140	117	11.4	35	402	12	
		1	41	1	80	2	54	3	103			0	15	0	93						
33	R	1	25	1	48	2	33	4	60	77	IWP	0	10	0	140	140	5.9	68	402	6	6
		0	26	1	51	2	33	4	60												
34	R	1	28	2	53	2	42	4	78	104	IWP									10	0
		0	27	0	54	2	45	5	83												
35	R	0	36	1	71	1	35	2	67	94	OWP									9	0
		0	37	0	74	1	33	2	63												
36	R	0	49	-2	100	0	50	4	96	128	OWP									7	0
		0	50	1	99	2	50	5	93												
37	R	1	59	-1	118	2	65	1	127	162	IWP	0	30	0	47	43	3.2	33	105	12	6
		0	60	-1	121	2	63	0	124			0	35	0	40						
38	R	0	31	2	60	1	48	2	93	119	IWP	0	20	2	74	84	3.1	64	201	8	5
		1	32	0	63	1	48	3	92			0	16	2	93						
39	R	0	34	-4	72	2	60	2	116	150	IWP	0	26	2	56	49	1.4	65	94	0	0
		0	37	-1	75	2	61	3	117			2	36	2	41						
40	R	0	42	1	83	2	50	1	97	125	IWP									0	8
		0	43	0	86	2	50	1	97												
41	R	2	87	6	166	1	44	1	86	217	OWP									5	4
		0	85	0	170	2	45	2	86												
42	R	0	68	0	136	2	51	2	98	177	OWP	0	40	5	37	35	2.7	30	81	5	6
		1	70	1	138	1	52	0	103			0	45	5	33						
43	R	3	75	5	142				0	188	OWP										
		0	73	-3	149	0	71	2	140			0	38	2	38						
44	R	0	75	-5	155	1	69	0	137	165	OWP	0	52	2	27	34	2.2	34	73		
		3	53	2	101	1	59	-1	118			5	40	5	40						
45	R	2	56	2	108	2	60	2	116	128	OWP	0	40	0	35	46	2.4	43	101		
		0	45	0	90	2	40	3	75			0	25	0	56						
46	R	0	45	0	90	2	40	2	76	123	OWP	0	40	0	35	38	1.4	50	73		
		2	52	2	100	5	40	5	70			0	35	0	40						
47	R	1	52	1	102	2	39	2	74	176	OWP	0	50	0	28	28	1.7	34	57		
		1	84	-3	170	2	63	4	120			0	50	2	29						
48	R	0	86	-6	178	2	64	3	123	230	OWP	0	49	0	29	29	3.1	22	68		

Road Maintenance and Rehabilitation Project - Malawi
Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International
in association with **Jatula Partners**

Road Name:	Mzuzu - Nkhata Bay	Road Code:	4	Sample Length No.:	S3	Truck Axle Load - LHS:	3175 kg	Date:	24-Jul-98
Chainage (km)	42.31 to 43.81	Sample Length Code:	43	Width:	6.0 m	RHS:	3175 kg	Operator:	RI/MOWS

Averages and Totals

Area Cracked	5790	m^2	64.3%
Wide Cracks	5790	m^2	64.3%
Average Condition Index	14.7		
Minimum Condition Index	3.7		
Maximum Condition Index	18.1		

Area to be patched	2211	m^2	24.6%
Area already patched	2831	m^2	31.5%
Area Ravelled	5130	m^2	57.0%
Area patched during shoulder repair	450	m^2	5.0%

Average Deflection	δ_p	1.47	mm	OWP	10	59%
Standard Deviation	σ	0.42	mm	IWP	7	41%
Calibration Correction Factor	F_c	0.993	0.99			
Seasonal Correction Factor	F_w	1.300				
Design Deflection	δ_d	2.10	mm			
Percentile to equal the Design Deflection	96%	2.21	mm			
Predicted Design Axles	No.	1.63	$x10^6$ Axles			
Residual Equivalent Standard Axles	No.	0.63	$x10^6$ ESAs			

Percentile of the Road that will Require Reconstruction 4% of the road

Percentile of the Road that will not Require Strengthening d= 2.21 mm 96%

Average Rut Depth		5.3 mm
Standard Deviation of Rut Depth		4.6 mm
Avg.Radius of Curvature		55 m
Avg.M_r Upper Layers		151 MPa
M_r Base	80%	201 MPa
M_r Subbase	20%	73 MPa
Avg.M_r of the Foundation		43 MPa
M_r Selected Subgrade	80%	64 MPa
M_r Subgrade	20%	33 MPa

Target Deflection: 1.1 mm

Existing Base Material: GN

Crushed Rock Granular Overlay Thickness	=	260 mm
Stabilised Natural Gravel Overlay Thickness	=	260 mm
Natural Gravel Granular Overlay Thickness	=	260 mm
Asphalt Overlay Thickness	=	130 mm

Deflection for HDM model $\delta_{(80kN)} =$ 3.23 mm

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International
in association with **Jatula Partners**

Road Name: Bwengu - Rumphi | Road Code: 5 | Sample Length No.: S1 | Truck Axle Load - LHS: 3175 kg | Date:

Chainage (km) 3.30 to 4.30 | Sample Length Code: 51 | Width: 5.5 m | RHS: 3175 kg | Operator: RI/MOWS

Chainage (km)		Surface Condition																											
		Primary Cracking						Secondary Cracking						Pothole		Patch		Edge		Ravel		Bleed		Skid		Deform			
From	To	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Number	Av.Area (m^2)	Number	Av.Area (m^2)	Length	Av.Width (m)	Extent (%)	Degree	Extent (%)	Degree	Extent (%)	Degree	Condtion	Position	Shoulder Condition	Drainage Condition
3.30	3.40	L	CW	3	40	✓										1	15	50	0.2	20	2								P
3.40	3.50																	100	0.3	60	2	30	2						P
3.50	3.60																	100	0.3	100	2	30	2						P
3.60	3.70	L	CW	3	30	✓												100	0.2	100	2	10	2						P
3.70	3.80	L	CW	3	50	✓								6	4	40	5	100	0.3	100	3	100	2						P
3.80	3.90	C	CW	3	30			L	CW	3	30					2	3	100	0.3	100	3	100	3						P
3.90	4.00	C	CW	3	20	✓		L	CW	3	20	✓		3	5	4	15	100	0.3	100	3	100	2						P
4.00	4.10	L	CW	3	60	✓								1	0	5	9	100	0.3	100	3	100	2						P
4.10	4.20															11	14	100	0.3	100	3	100	2						P
4.20	4.30													2	5	4	22	100	0.5	100	3	100	2						P

From	To	Point Number		Peak Deflection (mm x 100) LH Wheelpath Initial	Maximum	Final	Deflection	RH Wheelpath Initial	Maximum	Final	Deflection	Max Corrected	Wheel Path	Rad.of Curve LH Wheelpath Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	Rut Depth (mm) LHS	RHS
		0	L	2	19	2	34	2	31	0	60	75	IWP									27	0
				1	18	1	34	2	30	2	56												
3.30	3.40	1	L	1	24	4	43	1	38	1	74	97	IWP									17	4
				2	25	2	46	1	39	1	76												
3.40	3.50	2	L	1	22	1	42	2	21	1	39	53	OWP									10	8
				5	25	5	40	1	20	1	38												
3.50	3.60	3	L	2	27	4	48	0	25	0	50	66	IWP	1	30	0	47	46	0.5	127	67	0	0
				1	25	0	49	0	26	-1	53			0	32	1	44						
3.60	3.70	4	L	0	25	4	46	0	8	-2	18	57	OWP									0	0
				5	26	4	43	0	10	-1	21												
3.70	3.80	5	L	2	19	2	34	3	21	2	37	52	IWP									20	3
				3	22	3	38	0	23	2	44												
3.80	3.90	6	L	2	15	2	26	0	20	2	38	50	IWP	0	40	0	35	35	0.1	348	31	0	0
				2	15	-1	29	0	19	-1	39												
3.90	4.00	7	L	2	14	2	24	2	16	0	30	37	IWP	0	20	0	70	70	0.3	317	85	8	5
				1	12	1	22	4	18	4	28												
4.00	4.10	8	L	3	42	2	79	0	22	-1	45	102	OWP	1	1	0	2800	2800	####	7	####	0	6
				2	41	1	79	0	21	-1	43												
4.10	4.20	9	L	2	10	4	14	4	14	4	20	25	IWP	0	25	4	61	100	0.2	591	110	0	5
				2	9	3	13	2	10	0	18			0	10	0	140						
4.20	4.30	10	L	2	17	2	30	3	21	3	36	49	IWP	0	10	1	147	110	1.4	151	210	5	5
				5	21	3	34	0	20	0	40			0	20	1	72						

Road Maintenance and Rehabilitation Project - Malawi
Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International
in association with **Jatula Partners**

Road Name: Bwengu - Rumphi | Road Code: 5 | Sample Length No.: S1 | Truck Axle Load - LHS: 3175 kg | Date:

Chainage (km) 3.30 to 4.30 | Sample Length Code: 51 | Width: 5.5 m | RHS: 3175 kg | Operator: RI/MOWS

Averages and Totals

Area Cracked	1265	m^2	23.0%	Area to be patched	933	m^2	17.0%	Average Deflection	δ_p	0.60	mm	OWP	3	27%	Average Rut Depth	5.6	mm
Wide Cracks	1100	m^2	20.0%	Area already patched	426	m^2	7.7%	Standard Deviation	σ	0.23	mm	IWP	8	73%	Standard Deviation of Rut Depth	7.3	mm
				Area Ravelled	4840	m^2	88.0%	Calibration Correction Factor	F_c	####	0.99						
Average Condition Index	3.8			Area patched during shoulder repair	300	m^2	5.5%	Seasonal Correction Factor	F_w	####					Avg.Radius of Curvature	380	m
Minimum Condition Index	0.6							Design Deflection	δ_d	0.95	mm				Avg.M_r Upper Layers	####	MPa
Maximum Condition Index	5.5							Percentile to equal the Design Deflection	96%	1.00	mm				M_r Base 80%	210	MPa
								Predicted Design Axles	No.	2.62	$x10^6$ Axles				M_r Subbase 20%	67	MPa
								Residual Equivalent Standard Axles	No.	0.30	$x10^6$ ESAs				Avg.M_r of the Foundation	257	MPa
								Percentile of the Road that will Require Reconstruction		4% of the road					M_r Selected Subgrade 80%	348	MPa
								Percentile of the Road that will not Require Strengthening d= 1.00		mm	96%				M_r Subgrade 20%	127	MPa

Target Deflection: 1.5 mm

Existing Base Material: GN

Crushed Rock Granular Overlay Thickness	=	-250	mm
Stabilised Natural Gravel Overlay Thickness	=	-250	mm
Natural Gravel Granular Overlay Thickness	=	-250	mm
Asphalt Overlay Thickness	=	-125	mm

Deflection for HDM model $\delta_{(80kN)} =$ 1.47 mm

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International
in association with **Jatula Partners**

Road Name: Kasungu - Dwangwa | Road Code: 6 | Sample Length No.: S1 | Truck Axle Load - LHS: 3175 kg | Date: 21-Jul-98

Chainage (km) 6.59 to 7.59 | Sample Length Code: 61 | Width: 6.7 m | RHS: 3175 kg | Operator: RI/MOWS

Chainage (km)		Surface Condition																											
		Primary Cracking						Secondary Cracking						Pothole		Patch		Edge		Ravel		Bleed		Skid		Deform			
From	To	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Number	Av.Area (m^2)	Number	Av.Area (m^2)	Length	Av.Width (m)	Extent (%)	Degree	Extent (%)	Degree	Extent (%)	Degree	Condtion	Position	Shoulder Condition	Drainage Condition
6.59	6.69	C/L	CW	2	100	✓		C/L	CW	2	100	✓	✗					200	0.2			100	2			P	CW		
6.69	6.79	C/L	CW	2	100	✓		C/L	CW	2	100	✓	✗					200	0.2			100	2			P	CW		
6.79	6.89	C/L	CW	2	100	✓		C/L	CW	2	100	✓	✗	1	1			200	0.2			100	2			P	CW		
6.89	6.99	C/L	CW	2	100	✓		C/L	CW	2	100	✓	✗					200	0.2			100	2			P	CW		
6.99	7.09	C/L	CW	2	100	✓		C/L	CW	2	100	✓	✗					200	0.2			100	2			P	CW		
7.09	7.19	C/L	CW	2	100	✓		C/L	CW	2	100	✓	✗					200	0.2			100	2						
7.19	7.29	C/L	CW	2	100	✓		C/L	CW	2	100	✓	✗					200	0.2			100	2						
7.29	7.39	C/L	CW	2	100	✓		C/L	CW	2	100	✓	✗					200	0.2			100	2						
7.39	7.49	C/L	CW	2	100	✓		C/L	CW	2	100	✓	✗					200	0.2			100	2						
7.49	7.59	C/L	CW	2	100	✓		C/L	CW	2	100	✓	✗					200	0.2			100	2						

Point Number		Peak Deflection (mm x 100)										Rad.of Curve								Rut Depth (mm)	
		LH Wheelpath				RH Wheelpath						LH Wheelpath									
		Initial	Maximum	Final	Deflection	Initial	Maximum	Final	Deflection	Max Corrected	Wheel Path	Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	LHS	RHS
0	L	2	22	2	40	2	41	3	77	101	IWP	2	17	1	90	90	1.5	119	176	5	7
		0	20	0	40	2	41	1	79			0	16	1	90						
1	L	0	32	-2	66	2	41	3	77	101	IWP	0	20	0	70	71	2.5	64	160	6	19
		2	34	2	64	2	41	1	79			2	21	1	72						
2	L	1	30	2	57	2	45	2	86	111	IWP	0	11	0	127	127	6.6	57	377	14	18
		0	29	0	58	2	45	2	86												
3	L	0	32	1	63	3	44	4	81	106	IWP	0	39	-2	35	38	0.7	89	58	18	9
		2	36	2	68	2	44	2	84			0	36	2	40						
4	L	0	26	1	51	2	37	1	71	90	IWP	2	30	0	48	53	0.8	107	89	13	10
		3	29	3	52	2	37	3	69			0	25	2	58						
5	L	1	41	-2	83	3	50	2	95	123	IWP	4	20	4	88	88	6.6	39	259	14	7
		1	43	1	84	3	50	2	95												
6	L	2	37	1	71	2	39	0	76	97	IWP	0	30	2	48	48	1.4	66	92	16	
		2	39	1	75	3	40	3	74			0	31	3	47						
7	L	1	46	2	89	2	42	2	80	116	OWP	2	50	2	29	29	0.8	63	47	18	5
		1	46	1	90	2	42	3	79			0	48	1	29						
8	L	1	29	2	55	3	41	2	77	98	IWP	0	15	1	97	84	2.6	74	192	17	10
		2	30	1	57	3	41	4	75			0	20	1	72						
9	L	2	42	2	80	2	43	4	80	105	OWP	0	49	1	29	29	0.6	73	44	26	7
		0	42	1	83	2	41	4	76												
10	L	2	41	-1	81	3	41	4	75	103	OWP	0	35	1	41	41	1.2	63	74	18	6
		1	40	0	79	3	40	3	74												

Road Maintenance and Rehabilitation Project - Malawi

Roughton International

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

in association with **Jatula Partners**

Road Name: Kasungu - Dwangwa | Road Code: 6 | Sample Length No.: S1 | Truck Axle Load - LHS: 3175 kg | Date: 21-Jul-98

Chainage (km) 6.59 to 7.59 | Sample Length Code: 61 | Width: 6.7 m | RHS: 3175 kg | Operator: RI/MOWS

Averages and Totals

Area Cracked	6700	m^2	100.0%
Wide Cracks	6700	m^2	100.0%
Average Condition Index	8.5		
Minimum Condition Index	2.5		
Maximum Condition Index	14.5		

Area to be patched	801	m^2	12.0%
Area already patched	0	m^2	0.0%
Area Ravelled	0	m^2	0.0%
Area patched during shoulder repair	300	m^2	4.5%

Average Deflection	δ_p	1.05	mm	
Standard Deviation	σ	0.09	mm	
Calibration Correction Factor	F_c	0.993	0.99	
Seasonal Correction Factor	F_w	1.300		
Design Deflection	δ_d	1.18	mm	
Percentile to equal the Design Deflection	96%	1.20	mm	
Predicted Design Axles	No.	3.80	$x10^6$	Axles
Residual Equivalent Standard Axles	No.	0.87	$x10^6$	ESAs

OWP	3	27%
IWP	8	73%

Average Rut Depth		12.5 mm
Standard Deviation of Rut Depth		5.9 mm
Avg.Radius of Curvature		62 m
Avg.M_r Upper Layers		143 MPa
M_r Base	80%	192 MPa
M_r Subbase	20%	58 MPa
Avg.M_r of the Foundation		74 MPa
M_r Selected Subgrade	80%	89 MPa
M_r Subgrade	20%	63 MPa

Percentile of the Road that will Require Reconstruction 4% of the road

Percentile of the Road that will not Require Strengthening d= 1.20 mm 96%

Target Deflection: 0.8 mm

Existing Base Material: GC

Crushed Rock Granular Overlay Thickness	=	190 mm
Stabilised Natural Gravel Overlay Thickness	=	190 mm
Natural Gravel Granular Overlay Thickness	=	190 mm
Asphalt Overlay Thickness	=	95 mm

Deflection for HDM model $\delta_{(80kN)} =$ 1.82 mm

Road Maintenance and Rehabilitation Project - Malawi

Roughton International

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

in association with **Jatula Partners**

Road Name: Kasungu - Dwangwa | Road Code: 6 | Sample Length No.: S2 | Truck Axle Load - LHS: 3175 kg | Date: 21-Jul-98

Chainage (km) 15.38 to 16.38 | Sample Length Code: 62 | Width: 6.7 m | RHS: 3175 kg | Operator: RI/MOWS

Chainage (km)		Surface Condition																											
		Primary Cracking						Secondary Cracking						Pothole		Patch		Edge		Ravel		Bleed		Skid		Deform			
From	To	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Number	Av.Area (m^2)	Number	Av.Area (m^2)	Length	Av.Width (m)	Extent (%)	Degree	Extent (%)	Degree	Extent (%)	Degree	Condtion	Position	Shoulder Condition	Drainage Condition
15.38	15.48	C/L	CW	3	100	✓		C/L	CW	3	100	✓				11	15			10	3					P	CW		
15.48	15.58	C/L	CW	3	100	✓		C/L	CW	3	100	✓		10	4	1	7			2	3					P	CW		
15.58	15.68	C/L	CW	3	100	✓		C/L	CW	3	100	✓		7	3					10	3					P	CW		
15.68	15.78	C/L	CW	3	100	✓		C/L	CW	3	100	✓		8	4	6	2			30	3					P	CW		
15.78	15.88	C/L	CW	3	100	✓		C/L	CW	3	100	✓														P	CW		
15.88	15.98	C/L	CW	3	100	✓		C/L	CW	3	100	✓		10	7	8	5			20	3								
15.98	16.08	C/L	CW	3	100	✓		C/L	CW	3	100	✓																	
16.08	16.18	C	WP	4	100	✓		C	WP	4	100	✓								5	3								
16.18	16.28	L	WP	3	100	✓		L	WP	3	100	✓								7	3								
16.28	16.38	L	WP	3	100	✓		L	WP	3	100	✓								10	3								

Point Number		Peak Deflection (mm x 100)										Rad.of Curve								Rut Depth (mm)	
		LH Wheelpath				RH Wheelpath						LH Wheelpath									
		Initial	Maximum	Final	Deflection	Initial	Maximum	Final	Deflection	Max Corrected	Wheel Path	Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	LHS	RHS
11	L	1	13	0	25	1	25	1	48	63	IWP									13	4
		2	14	1	25	1	26	1	50												
12	L	1	9	1	16	2	16	2	28	35	IWP									14	0
		0	10	1	19	3	16	2	27												
13	L	6	16	2	24	3	20	3	34	45	IWP									15	11
		5	17	3	26	3	22	5	36												
14	L	4	12	2	18	0	14	1	27	36	IWP	0	8	1	187	187	1.2	286	344	10	11
		1	11	4	17	1	16	2	29												
15	L	3	13	1	22	0	14	0	28	37	IWP	0	10	1	147	147	1.4	207	281	13	0
		2	14	1	25	3	18	3	30												
16	L	1	30	-2	61	1	26	2	49	78	OWP	0	15	1	97	97	4.1	61	250	8	9
		1	30	-1	60	1	24	2	45												
17	L	1	21	0	41	1	22	2	41	55	OWP	0	12	1	122	122	3.2	92	294	0	0
		1	23	1	44	2	21	1	39												
18	L	1	19	0	37	2	15	1	27	49	OWP	0	10	1	147	156	4.2	96	408	0	0
		1	20	0	39	1	16	1	30			1	9	0	165						
19	L	2	22	0	42	2	22	1	41	54	OWP	0	16	1	90	88	1.5	112	173	0	0
		0	21	0	42	1	18	2	33			-1	16	0	85						
20	L	2	15	1	27	2	18	4	30	39	IWP	1	9	1	175	158	2.4	149	350	0	0
		2	16	0	30	2	18	3	31			0	10	0	140						
21	L	2	11	0	20	4	17	3	27	34	IWP	-9	15	0	72	80	0.3	340	99	0	20
		1	12	1	22	4	17	5	25			0	16	0	88						

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International

in association with **Jatula Partners**

Road Name: Kasungu - Dwangwa | Road Code: 6 | Sample Length No.: S2 | Truck Axle Load - LHS: 3175 kg | Date: 21-Jul-98

Chainage (km) 15.38 to 16.38 | Sample Length Code: 62 | Width: 6.7 m | RHS: 3175 kg | Operator: RI/MOWS

Averages and Totals

Area Cracked	6700	m^2	100.0%
Wide Cracks	6700	m^2	100.0%
Average Condition Index	6.6		
Minimum Condition Index	0.2		
Maximum Condition Index	13.2		

Area to be patched	275	m^2	4.1%
Area already patched	168	m^2	2.5%
Area Ravelled	630	m^2	9.4%
Area patched during shoulder repair	300	m^2	4.5%

Average Deflection	δ_p	0.48	mm	
Standard Deviation	σ	0.14	mm	
Calibration Correction Factor	F_c	0.993	0.99	
Seasonal Correction Factor	F_w	1.300		
Design Deflection	δ_d	0.69	mm	
Percentile to equal the Design Deflection	96%	0.72	mm	
Predicted Design Axles	No.	3.80	$x10^6$	Axles
Residual Equivalent Standard Axles	No.	0.87	$x10^6$	ESAs

OWP	4	36%
IWP	7	64%

Percentile of the Road that will Require Reconstruction 4% of the road

Percentile of the Road that will not Require Strengthening d= 0.72 mm 96%

Average Rut Depth		5.8 mm
Standard Deviation of Rut Depth		6.6 mm
Avg.Radius of Curvature		126 m
Avg.M_r Upper Layers		275 MPa
M_r Base	80%	347 MPa
M_r Subbase	20%	204 MPa
Avg.M_r of the Foundation		168 MPa
M_r Selected Subgrade	80%	254 MPa
M_r Subgrade	20%	94 MPa

Target Deflection: 0.8 mm

Existing Base Material: GC

Crushed Rock Granular Overlay Thickness	=	10 mm
Stabilised Natural Gravel Overlay Thickness	=	10 mm
Natural Gravel Granular Overlay Thickness	=	10 mm
Asphalt Overlay Thickness	=	5 mm

Deflection for HDM model $\delta_{(80kN)} =$ 1.06 mm

Road Maintenance and Rehabilitation Project - Malawi
Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International
in association with **Jatula Partners**

Road Name: Madisi - Kasungu | Road Code: 7 | Sample Length No.: S1 | Truck Axle Load - LHS: 3175 kg | Date: 20-Jul-98

Chainage (km) 7.69 to 9.19 | Sample Length Code: 71 | Width: 6.7 m | RHS: 3175 kg | Operator: RI/MOWS

Chainage (km)		Surface Condition																												
		Primary Cracking						Secondary Cracking						Pothole		Patch		Edge		Ravel		Bleed		Skid		Deform				
From	To	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Number	Av.Area (m^2)	Number	Av.Area (m^2)	Length	Av.Width (m)	Extent (%)	Degree	Extent (%)	Degree	Extent (%)	Degree	Condition	Position	Shoulder Condition	Drainage Condition
7.69	7.79	C	WP	3	80	✓	✗	C	WP	3	80	✓				7	8									P	WP	P	P
7.79	7.89	C	WP	3	80	✓	✗	C	WP	3	80	✓		3	1	3	5									P	WP	P	P
7.89	7.99	C/L	CW	3	80	✓	✗	C/L	CW	3	80	✓		7	15	17	55									P	WP	P	P
7.99	8.09	C/L	CW	3	80	✓	✗	C/L	CW	3	80	✓		4	3	4	7									P	WP	P	P
8.09	8.19	C	WP	3	80	✓	✗	C	WP	3	80	✓				17	44									P	WP	P	P
8.19	8.29	C	WP	3	80	✓	✗	C	WP	3	80	✓				2	19									P	WP	P	P
8.29	8.39	C/L	CW	3	80	✓	✗	C/L	CW	3	80	✓		3	4											P	WP	P	P
8.39	8.49	C/L	CW	3	80	✓	✗	C/L	CW	3	80	✓		5	9	8	34									P	WP	P	P
8.49	8.59	C/L	CW	3	80	✓	✗	C/L	CW	3	80	✓		5	3	5	13									P	WP	P	P
8.59	8.69	C/L	CW	3	80	✓	✗	C/L	CW	3	80	✓		9	8	7	40									P	WP	P	P
8.69	8.79	C/L	CW	3	80	✓	✗	C/L	CW	3	80	✓														P	WP	P	P
8.79	8.89	C/L	CW	3	80	✓	✗	C/L	CW	3	80	✓				1	2			4	6					P	WP	P	P
8.89	8.99	C/L	CW	3	80	✓	✗	C/L	CW	3	80	✓														P	WP	P	P
8.99	9.09	C/L	CW	3	80	✓	✗	C/L	CW	3	80	✓														P	WP	P	P
9.09	9.19	C/L	CW	3	80	✓	✗	C/L	CW	3	80	✓														P	WP	P	P

Point Number		Peak Deflection (mm x 100)										Rad.of Curve								Rut Depth (mm)	
		LH Wheelpath				RH Wheelpath						LH Wheelpath									
		Initial	Maximum	Final	Deflection	Initial	Maximum	Final	Deflection	Max Corrected	Wheel Path	Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	LHS	RHS
0	L	6	26	7	39	4	21	5	33	49	OWP	0	0	0						0	0
		3	22	4	37	3	22	5	36			0	5	0	280						
1	L	3	17	3	28	4	15	4	22	37	OWP									8	0
		6	21	7	29	4	15	5	21												
2	L	5	17	5	24	1	15	1	28	36	IWP									10	4
		5	18	6	25	1	15	1	28												
3	L	4	19	2	32	4	21	4	34	44	OWP	0	20	5	80	80	0.8	162	132	16	7
		3	21	3	36	5	21	5	32												
4	L	5	14	4	19	1	19	1	36	49	IWP	0	9	0	156	151	0.9	282	259	17	0
		4	12	1	19	6	26	6	40			0	10	1	147						
5	L	4	19	2	32	4	11	0	18	42	OWP	0	8	1	187	187	4.5	111	495	19	30
		3	19	2	33	3	11	0	19			5	11	2	187						
6	L	7	23	8	31	4	17	1	29	41	OWP	0	20	0	70	73	0.6	187	110	0	0
		5	21	4	33	4	17	1	29			0	19	1	76						
7	L	3	12	2	19	3	10	1	16	23	OWP									14	0
		4	12	3	17	3	10	1	16												
8	L	2	19	0	36	2	18	3	31	47	OWP	2	17	1	90	90	1.2	137	167	12	0
		2	20	1	37	3	18	0	33												
9	L	2	33	1	63	2	23	-2	46	79	OWP	3	24	2	65	63	1.7	74	128	37	0
		2	32	2	60	3	23	0	43			0	23	0	61						
10	L	1	17	-2	35	4	23	2	40	51	IWP	2	16	1	97	95	1.6	118	190	17	0
		4	24	0	44	3	22	2	39			0	15	0	93						
11	L	3	17	0	31	3	13	3	20	41	OWP	0	16	1	90	92	1.0	166	159	24	0
		3	18	0	33	4	13	1	21			0	15	0	93						
12	L	5	22	4	35	3	13	0	23	45	OWP	0	18	0	78	78	0.8	158	129	24	0
		3	20	2	35	3	11	1	18			1	19	1	78						
13	L	6	30	5	49	3	16	1	28	65	OWP	0	19	0	74	74	1.5	94	146	30	5
		6	32	7	51	3	16	0	29			0	19	0	74						
14	L	4	25	3	43	4	13	3	19	55	OWP	0	14	1	104	104	2.3	101	228	17	4
		4	24	2	42	3	12	0	21			2	15	1	104						
15	L	4	11	4	14	3	12	0	21	29	IWP	1	14	0	104	97	0.2	570	106	9	0
		4	11	4	14	3	15	3	24			0	15	-1	90						

Road Maintenance and Rehabilitation Project - Malawi

Roughton International

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

in association with **Jatula Partners**

Road Name:	Madisi - Kasungu	Road Code:	7	Sample Length No.:	S1	Truck Axle Load - LHS:	3175 kg
Chainage (km)	7.69 to 9.19	Sample Length Code:	71	Width:	6.7 m	RHS:	3175 kg

Date: 20-Jul-98

Operator: RI/MOWS

Averages and Totals

Area Cracked	8040	m^2	80.0%
Wide Cracks	8040	m^2	80.0%
Average Condition Index	14.2		
Minimum Condition Index	13.4		
Maximum Condition Index	18.1		

Area to be patched	1484	m^2	14.8%
Area already patched	1829	m^2	18.2%
Area Ravelled	27	m^2	0.3%
Area patched during shoulder repair	450	m^2	4.5%

Average Deflection	δ_p	0.46	mm
Standard Deviation	σ	0.13	mm
Calibration Correction Factor	F_c	0.993	0.99
Seasonal Correction Factor	F_w	1.300	
Design Deflection	δ_d	0.66	mm
Percentile to equal the Design Deflection	96%	0.70	mm
Predicted Design Axles	No.	5.90	$x10^6$ Axles
Residual Equivalent Standard Axles	No.	1.12	$x10^6$ ESAs

OWP	12	75%
IWP	4	25%

Percentile of the Road that will Require Reconstruction 4% of the road

Percentile of the Road that will not Require Strengthening d= 0.70 mm 96%

Average Rut Depth		9.5 mm
Standard Deviation of Rut Depth		10.8 mm
Avg.Radius of Curvature		108 m
Avg.M_r Upper Layers		187 MPa
M_r Base	80%	220 MPa
M_r Subbase	20%	128 MPa
Avg.M_r of the Foundation		180 MPa
M_r Selected Subgrade	80%	183 MPa
M_r Subgrade	20%	103 MPa

Target Deflection: 0.7 mm

Existing Base Material: GC

Crushed Rock Granular Overlay Thickness	=	70 mm
Stabilised Natural Gravel Overlay Thickness	=	70 mm
Natural Gravel Granular Overlay Thickness	=	70 mm
Asphalt Overlay Thickness	=	35 mm

Deflection for HDM model $\delta_{(80kN)} =$ 1.01 mm

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International
in association with **Jatula Partners**

Road Name: Madisi - Kasungu | Road Code: 7 | Sample Length No.: S2 | Truck Axle Load - LHS: 3175 kg | Date: 20-Jul-98

Chainage (km) 31.87 to 33.37 | Sample Length Code: 72 | Width: 6.7 m | RHS: 3175 kg | Operator: RI/MOWS

Chainage (km) From	Chainage (km) To	Primary Cracking Type	Primary Cracking Position	Primary Cracking Degree	Primary Cracking Extent (%)	Primary Cracking Width >3mm	Primary Cracking Pumping	Secondary Cracking Type	Secondary Cracking Position	Secondary Cracking Degree	Secondary Cracking Extent (%)	Secondary Cracking Width >3mm	Secondary Cracking Pumping	Pothole Number	Pothole Av.Area (m^2)	Patch Number	Patch Av.Area (m^2)	Edge Length	Edge Av.Width (m)	Ravel Extent (%)	Ravel Degree	Bleed Extent (%)	Bleed Degree	Skid Extent (%)	Skid Degree	Deform Condition	Deform Position	Shoulder Condition	Drainage Condition
31.87	31.97	L	CW	3	50	✓		L	CW	3	50	✓						70	0.3			60	2						
31.97	32.07	L	CW	3	50	✓		L	CW	3	50	✓						70	0.3			60	2			F	WP		
32.07	32.17	C/L	CW	3	50	✓		C/L	CW	3	50	✓						70	0.3			60	2			F	WP		
32.17	32.27	C/L	CW	3	50	✓		C/L	CW	3	50	✓						70	0.3			60	2						
32.27	32.37	C/L	CW	3	50	✓		C/L	CW	3	50	✓						70	0.3			60	2						
32.37	32.47	L	CW	3	50	✓		L	CW	3	50	✓						70	0.3			60	2						
32.47	32.57	L	CW	3	50	✓		L	CW	3	50	✓						70	0.3			60	2						
32.57	32.67	L	CW	3	50	✓		L	CW	3	50	✓						70	0.3			60	2						
32.67	32.77	C/L	CW	3	50	✓		C/L	CW	3	50	✓						70	0.3	100	5	60	2						
32.77	32.87	C/L	CW	3	50	✓		C/L	CW	3	50	✓						70	0.3			60	2						
32.87	32.97	C/L	CW	3	50	✓		C/L	CW	3	50	✓		1	1			70	0.3	100	5	60	2						
32.97	33.07	C/L	CW	3	50	✓		C/L	CW	3	50	✓						70	0.3	100	5	60	2						
33.07	33.17	L	CW	3	50	✓		L	CW	3	50	✓				1	1	50	0.3	100	5	60	2						
33.17	33.27	L	CW	3	50	✓		L	CW	3	50	✓						50	0.3	100	5	60	2						
33.27	33.37	L	CW	3	50	✓		L	CW	3	50	✓						50	0.3	100	5	60	2						

Point Number		Peak Deflection (mm x 100) LH Wheelpath Initial	LH Maximum	LH Final	LH Deflection	RH Wheelpath Initial	RH Maximum	RH Final	RH Deflection	Max Corrected	Wheel Path	Rad.of Curve LH Wheelpath Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	Rut Depth (mm) LHS	Rut Depth (mm) RHS
16	L	2	30	0	58	3	31	3	56	76	OWP	0	25	0	56	50	0.9	91	85	0	0
		2	31	1	59	3	33	7	56			5	35	0	43						
17	L	2	20	1	37	3	18	3	30	48	OWP									0	11
		0	19	0	38	3	20	3	34												
18	L	3	30	1	56	3	29	3	52	72	OWP	0	10	2	156	148	8.4	55	468	0	9
		2	29	1	55	3	30	3	54			0	10	0	140						
19	L	3	27	3	48	3	30	3	54	72	IWP	0	25	0	56	56	0.8	118	91	0	4
		3	26	2	47	3	31	1	58												
20	L	1	15	0	29	4	31	3	55	71	IWP	0	10	1	147	147	2.0	154	315	7	9
		2	16	2	28	3	31	4	55												
21	L	3	26	2	47	3	32	3	58	76	IWP	0	24	0	58	57	0.8	115	93	9	5
		3	27	2	49	2	32	2	60			0	26	1	55						
22	L	1	17	0	33	0	25	1	49	63	IWP	0	11	0	127	141	2.8	117	330	4	0
		0	18	0	36	2	26	1	49			0	10	2	156						
23	L	3	25	6	41	3	27	3	48	61	IWP									3	0
		3	26	7	42	3	28	6	47			0	15	1	97						
24	L	4	26	4	44	4	21	4	34	58	OWP	0	17	2	88	70	1.1	114	125	0	0
		3	26	3	46	4	22	7	33			0	27	0	52						
25	L	0	20	0	40	3	21	0	39	54	OWP									6	0
		2	24	2	44	2	22	2	40												
26	L	3	23	1	42	3	19	0	35	54	OWP									3	0
		4	23	1	41	3	22	3	38												
27	L	3	25	2	45	3	20	2	35	57	OWP	2	15	0	100	94	2.0	99	199	5	0
		2	24	2	44	2	20	3	35			0	16	0	88						
28	L	2	24	1	45	2	17	1	31	59	OWP									0	3
		3	25	0	47	2	18	2	32			0	10	4	175						
29	L	2	19	4	32	4	22	5	35	46	IWP	0	10	0	140	131	2.2	128	287	0	0
		2	19	1	35	3	22	4	37			0	12	1	122						
30	L	4	26	4	44	3	21	3	36	59	OWP	0	15	1	97	93	2.1	96	201	10	0
		2	25	1	47	3	21	4	35			0	16	1	90						
31	L	2	23	0	44	2	17	2	30	59	OWP	0	11	1	133	119	3.5	84	293	18	0
		2	25	1	47	3	18	2	31			3	16	2	104						

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International

in association with **Jatula Partners**

Road Name:	Madisi - Kasungu	Road Code:	7	Sample Length No.:	S2	Truck Axle Load - LHS:	3175 kg	Date:	20-Jul-98
Chainage (km)	31.87 to 33.37	Sample Length Code:	72	Width:	6.7 m	RHS:	3175 kg	Operator:	RI/MOWS

Averages and Totals

Area Cracked	5025 m^2	50.0%	Area to be patched	596 m^2	5.9%	Average Deflection	δ_p	0.62	mm	OWP 10 63%	Average Rut Depth 3.3 mm
Wide Cracks	5025 m^2	50.0%	Area already patched	1 m^2	0.0%	Standard Deviation	σ	0.09	mm	IWP 6 38%	Standard Deviation of Rut Depth 4.5 mm
			Area Ravelled	4020 m^2	40.0%	Calibration Correction Factor	F_c	0.993	0.99		
Average Condition Index	4.0		Area patched during shoulder repair	450 m^2	4.5%	Seasonal Correction Factor	F_w	1.300			Avg.Radius of Curvature 104 m
Minimum Condition Index	1.4					Design Deflection	δ_d	0.76	mm		Avg.M_r Upper Layers 226 MPa
Maximum Condition Index	9.5					Percentile to equal the Design Deflection	96%	0.76	mm		M_r Base 80% 315 MPa
						Predicted Design Axles	No.	5.90	$x10^6$ Axles		M_r Subbase 20% 93 MPa
						Residual Equivalent Standard Axles	No.	1.12	$x10^6$ ESAs		Avg.M_r of the Foundation 107 MPa
						Percentile of the Road that will Require Reconstruction	4% of the road				M_r Selected Subgrade 80% 118 MPa
						Percentile of the Road that will not Require Strengthening d=	0.76	mm	96%		M_r Subgrade 20% 91 MPa

Target Deflection: 0.7 mm

Existing Base Material: GC

Crushed Rock Granular Overlay Thickness	=	110 mm
Stabilised Natural Gravel Overlay Thickness	=	110 mm
Natural Gravel Granular Overlay Thickness	=	110 mm
Asphalt Overlay Thickness	=	55 mm

Deflection for HDM model $\delta_{(80kN)} =$ 1.16 mm

Road Maintenance and Rehabilitation Project - Malawi
Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International
in association with **Jatula Partners**

Road Name: Madisi - Kasungu | Road Code: 7 | Sample Length No.: S3 | Truck Axle Load - LHS: 3175 kg | Date: 20-Jul-98

Chainage (km) 43.96 to 45.96 | Sample Length Code: 73 | Width: 6.7 m | RHS: 3175 kg | Operator: RI/MOWS

Chainage (km)		Surface Condition																											
		Primary Cracking						Secondary Cracking						Pothole		Patch		Edge		Ravel		Bleed		Skid		Deform			
From	To	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Number	Av.Area (m^2)	Number	Av.Area (m^2)	Length	Av.Width (m)	Extent (%)	Degree	Extent (%)	Degree	Extent (%)	Degree	Condtion	Position	Shoulder Condition	Drainage Condition
43.96	44.06	L	WP	3	100	✓		L	WP	3	100	✓						80	0.3	1	3	100	3					P	
44.06	44.16	C/L	WP	3	100	✓		C/L	WP	3	100	✓						80	0.3	1	3	100	3					P	
44.16	44.26	C/L	WP	3	100	✓		C/L	WP	3	100	✓						80	0.3	1	3	100	3					P	
44.26	44.36	C/L	WP	3	100	✓		C/L	WP	3	100	✓						80	0.3	1	3	100	3					P	
44.36	44.46	C/L	WP	3	100	✓		C/L	WP	3	100	✓						80	0.3	1	3	100	3					P	
44.46	44.56	C/L	WP	3	100	✓		C/L	WP	3	100	✓				2	90	80	0.3	7	3	100	3			P	CW	P	
44.56	44.66	C/L	WP	3	100	✓		C/L	WP	3	100	✓						80	0.3	5	3	100	3			P	CW	P	
44.66	44.76	C/L	WP	3	100	✓		C/L	WP	3	100	✓						80	0.3									P	
44.76	44.86	C/L	WP	3	100	✓		C/L	WP	3	100	✓						80	0.3	10	3							P	
44.86	44.96	C/L	WP	3	100	✓		C/L	WP	3	100	✓				1	140	80	0.3									P	

Point Number		Peak Deflection (mm x 100)										Rad.of Curve								Rut Depth (mm)	
		LH Wheelpath				RH Wheelpath						LH Wheelpath									
		Initial	Maximum	Final	Deflection	Initial	Maximum	Final	Deflection	Max Corrected	Wheel Path	Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	LHS	RHS
33	L	4	37	4	66	3	24	3	42	86	OWP	0	26	1	55	55	1.5	70	108	9	0
		4	38	4	68	3	24	3	42												
34	L	3	35	1	66	3	35	1	66	85	OWP	0	38	1	37	37	0.7	88	58	7	6
		2	35	2	66	3	35	3	64												
35	L	4	34	4	60	3	22	3	38	76	OWP	0	10	0	140	140	8.6	52	445	16	0
		5	34	5	58	3	23	3	40												
36	L	5	17	5	24	3	11	0	19	31	OWP	-1	10	0	133	133	1.1	211	242	6	0
		4	16	4	24	3	12	2	19												
37	L	2	39	1	75	2	33	2	62	100	OWP	0	32	1	44	44	1.3	63	82	14	0
		5	45	5	80	3	34	3	62			0	33	1	43						
38	L	2	32	1	61	2	19	1	35	80	OWP	1	33	0	43	43	0.8	90	70	10	0
		3	33	0	63	2	19	0	36			0	34	2	42						
39	L	2	16	2	28	3	16	3	26	37	OWP	0	19	0	74	74	0.5	216	106	0	0
		3	18	3	30	3	16	3	26												
40	L	3	31	3	56	3	32	2	59	78	IWP	0	21	-1	65	62	1.4	85	119	4	0
		7	36	7	58	3	34	3	62			0	24	0	58						
41	L	2	25	3	45	2	26	2	48	59	OWP									10	0
		3	26	2	47	2	24	3	43												
42	L	1	28	1	54	2	23	2	42	70	OWP	1	30	0	47	49	0.8	102	81	7	0
		1	28	0	55	3	23	3	40			0	28	1	51						
43	L	2	28	1	53	3	21	1	38	68	OWP	1	30	2	49	49	0.7	109	78		
		3	29	3	52	3	22	3	38			0	29	0	48						

Road Maintenance and Rehabilitation Project - Malawi
Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International
in association with **Jatula Partners**

Road Name: Madisi - Kasungu | Road Code: 7 | Sample Length No.: S3 | Truck Axle Load - LHS: 3175 kg | Date: 20-Jul-98

Chainage (km) 43.96 to 45.96 | Sample Length Code: 73 | Width: 6.7 m | RHS: 3175 kg | Operator: RI/MOWS

Averages and Totals

Area Cracked	6700 m^2	50.0%	Area to be patched	640 m^2	4.8%	Average Deflection δ_p	0.70	mm	OWP 10 91%	Average Rut Depth 4.5 mm
Wide Cracks	6700 m^2	50.0%	Area already patched	240 m^2	1.8%	Standard Deviation σ	0.21	mm	IWP 1 9%	Standard Deviation of Rut Depth 5.2 mm
			Area Ravelled	181 m^2	1.4%	Calibration Correction Factor F_c	0.993	0.99		
Average Condition Index	6.1		Area patched during shoulder repair	600 m^2	4.5%	Seasonal Correction Factor F_w	1.300			Avg.Radius of Curvature 62 m
Minimum Condition Index	1.9					Design Deflection δ_d	1.01	mm		Avg.M_r Upper Layers 139 MPa
Maximum Condition Index	17.1					Percentile to equal the Design Deflection 96%	0.94	mm		M_r Base 80% 143 MPa
						Predicted Design Axles No.	5.90	$\times 10^6$ Axles		M_r Subbase 20% 76 MPa
						Residual Equivalent Standard Axles No.	1.12	$\times 10^6$ ESAs		Avg.M_r of the Foundation 109 MPa
						Percentile of the Road that will Require Reconstruction	4% of the road			M_r Selected Subgrade 80% 129 MPa
						Percentile of the Road that will not Require Strengthening d= 0.94 mm	96%			M_r Subgrade 20% 69 MPa

Target Deflection: 0.7 mm

Existing Base Material: GC

Crushed Rock Granular Overlay Thickness	=	200 mm
Stabilised Natural Gravel Overlay Thickness	=	200 mm
Natural Gravel Granular Overlay Thickness	=	200 mm
Asphalt Overlay Thickness	=	100 mm

Deflection for HDM model $\delta_{(80kN)} =$ 1.56 mm

Road Maintenance and Rehabilitation Project - Malawi

Roughton International

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

in association with **Jatula Partners**

Road Name: Lumbadzi - Mponela | Road Code: 8 | Sample Length No.: S1 | Truck Axle Load - LHS: 3175 kg | Date: 18-Jul-98

Chainage (km) 23.08 to 25.08 | Sample Length Code: 81 | Width: 6.7 m | RHS: 3175 kg | Operator: RI/MOWS

Chainage (km)		Surface Condition																											
		Primary Cracking						Secondary Cracking						Pothole		Patch		Edge		Ravel		Bleed		Skid		Deform			
From	To	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Number	Av.Area (m^2)	Number	Av.Area (m^2)	Length	Av.Width (m)	Extent (%)	Degree	Extent (%)	Degree	Extent (%)	Degree	Condtion	Position	Shoulder Condition	Drainage Condition
23.08	23.18	C	CW	3	40	✓		C	CW	3	40	✓				4	19	100	0.3	100	2	100	3			F	WP	P	
23.18	23.28	C	CW	3	40	✓		C	CW	3	40	✓				1	2	100	0.3	100	2	100	3					P	
23.28	23.38	C	CW	3	40	✓		C	CW	3	40	✓						100	0.3	100	2	100	3					P	
23.38	23.48	C	CW	3	40	✓		C	CW	3	40	✓				2	7	100	0.3	100	2	100	3					P	
23.48	23.58	C	CW	3	40	✓		L	CW	3	40	✓		4	21	6	17	100	0.3	100	2	100	3			F	WP	P	
23.58	23.68	C	CW	3	40	✓		L	CW	3	40	✓		2	27	2	31	100	0.3	100	2	100	3					P	
23.68	23.78	C	CW	3	40	✓		L	CW	3	40	✓		1	5	2	3	100	0.3	100	2	100	3					P	
23.78	23.88	C	CW	3	40	✓		L	CW	3	40	✓						100	0.3	100	2	100	3					P	
23.88	23.98	C	CW	3	40	✓		L	CW	3	40	✓		1	3			100	0.3	100	2	100	3					P	
23.98	24.08	C	CW	3	40	✓		L	CW	3	40	✓				1	13	100	0.3	100	2	100	3					P	
24.08	24.18	C	CW	3	40	✓		L	CW	3	40	✓		5	35	7	40	100	0.3	100	2	100	3					P	
24.18	24.28	C	CW	3	40	✓		L	CW	3	40	✓		5	30	7	44	100	0.3	100	2	100	3					P	
24.28	24.38	C	CW	3	40	✓		L	CW	3	40	✓		5	18	8	50	100	0.3	100	2	100	3					P	
24.38	24.48	C	CW	3	40	✓		L	CW	3	40	✓				8	40	100	0.3	100	2	100	3					P	
24.48	24.58	C	CW	3	40	✓		L	CW	3	40	✓				1	2	100	0.3	100	2	100	3					P	
24.58	24.68	C	CW	3	40	✓		L	CW	3	40	✓						100	0.3	100	2	100	3					P	
24.68	24.78	C	CW	3	40	✓		L	CW	3	40	✓						100	0.3	100	2	100	3					P	
24.78	24.88	T	CW	3	40	✓		T	CW	3	40	✓						100	0.3	100	2	100	3					P	
24.88	24.98	B	CW	3	40	✓		B	CW	3	40	✓						100	0.3	100	2	100	3					P	
24.98	25.08	B	CW	3	40	✓		B	CW	3	40	✓		1	1			100	0.3	100	2	100	3					P	

Point Number		Peak Deflection (mm x 100)										Rad.of Curve								Rut Depth (mm)	
		LH Wheelpath				RH Wheelpath						LH Wheelpath									
		Initial	Maximum	Final	Deflection	Initial	Maximum	Final	Deflection	Max Corrected	Wheel Path	Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	LHS	RHS
0	L	6	14	6	16	3	18	4	29	36	IWP	4	17	4	108	106	0.2	516	124	9	8
		4	10	3	13	2	15	1	27			2	16	3	104						
1	L	5	33	1	60	3	29	0	55	76	OWP	9	32	10	62	62	1.5	81	122	4	0
		5	33	4	57	2	30	0	58			8	31	9	62						
2	L	5	31	2	55	3	31	3	56	73	OWP	4	26	3	62	61	1.3	86	116	7	0
		6	34	4	58	3	32	5	56			3	27	4	60						
3	L	3	21	3	36	3	30	3	54	70	IWP	2	19	2	82	82	1.1	138	147	6	18
		3	22	2	39	3	30	3	54			2	19	2	82						
4	L	4	22	5	35	3	29	3	52	67	IWP	5	24	4	72	70	0.6	174	107	28	18
		3	19	2	33	3	29	3	52			3	24	4	68						
5	L	3	36	0	69	3	32	1	60	89	OWP	0	20	0	70	70	2.7	59	162	21	26
		3	37	2	69	3	32	0	61												
6	L	3	44	0	85	3	35	3	64	110	OWP	0	30	0	47	48	1.9	52	101	8	6
		1	44	1	86	3	37	3	68			0	29	1	49						
7	L	5	39	3	70	3	32	2	59	89	OWP	0	30	0	47	47	1.2	73	86	6	7
		5	39	5	68	3	34	3	62			6	35	5	47						
8	L	6	41	5	71	2	36	3	67	95	OWP	2	31	2	48	48	1.4	66	92	7	18
		4	41	2	76	3	36	5	64			0	30	1	47						
9	L	2	34	2	64	3	30	1	56	80	OWP	0	25	1	57	55	1.3	79	105	8	14
		3	33	3	60	2	31	1	59			0	26	0	54						
10	L	2	37	3	69	3	32	0	61	92	OWP	3	30	2	51	50	1.5	67	98	11	17
		2	37	-1	73	3	34	3	62			3	30	1	50						
11	L	2	31	1	59	2	28	2	52	76	OWP	4	20	4	88	88	3.2	67	211	8	12
		2	32	3	59	2	30	2	56			4	20	4	88						
12	L	2	31	-5	65	2	30	1	57	86	OWP	0	25	0	56	56	1.6	70	111	8	15
		0	33	-2	68	3	32	2	59												
13	L	3	24	3	42	2	33	2	62	80	IWP	3	30	3	52	52	0.5	148	75	8	25
		3	24	3	42	2	33	2	62												
14	L	1	30	0	59	2	30	1	57	77	OWP									5	8
		0	30	-1	61	2	30	2	56												
15	L	1	20	2	37	2	30	2	56	72	IWP									5	6
		2	19	3	33	2	30	3	55			2	24	2	64						
16	L	2	19	-1	37	3	20	0	37	48	OWP	0	21	-1	65	68	0.7	156	106	0	5
		2	20	1	37	1	21	5	36			0	20	0	70						
17	L	2	15	0	28	2	15	1	27	37	OWP	0	17	1	85	86	0.7	204	134	9	8
		2	16	1	29	2	16	1	29			0	16	0	88						
18	L	3	22	0	41	3	23	2	41	55	OWP	1	21	0	68	66	0.9	128	111	6	6
		3	25	3	44	3	23	3	40			0	22	0	64						
19	L	3	29	11	44	3	20	3	34	52	OWP	0	17	0	82	82	1.3	122	153	9	11
		3	21	2	37	3	20	6	31												
20	L	3	19	3	32	2	10	2	16	39	OWP	0	15	1	97	95	0.9	175	163	5	4
		2	16	1	29	3	12	7	14			0	16	2	93						

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International
in association with **Jatula Partners**

Road Name:	Lumbadzi - Mponela	Road Code:	8	Sample Length No.:	S1	Truck Axle Load - LHS:	3175 kg
Date:	18-Jul-98						
Chainage (km)	23.08 to 25.08	Sample Length Code:	81	Width:	6.7 m	RHS:	3175 kg
Operator:	RI/MOWS						

Averages and Totals

Area Cracked	5360	m^2	40.0%
Wide Cracks	5360	m^2	40.0%
Average Condition Index	7.1		
Minimum Condition Index	5.7		
Maximum Condition Index	14.8		

Area to be patched	2555	m^2	19.1%
Area already patched	1189	m^2	8.9%
Area Ravelled	13400	m^2	100.0%
Area patched during shoulder repair	600	m^2	4.5%

Average Deflection	δ_p	0.71	mm	
Standard Deviation	σ	0.20	mm	
Calibration Correction Factor	F_c	0.993	0.99	
Seasonal Correction Factor	F_w	1.300		
Design Deflection	δ_d	1.02	mm	
Percentile to equal the Design Deflection	96%	0.98	mm	
Predicted Design Axles	No.	6.03	$x10^6$	Axles
Residual Equivalent Standard Axles	No.	1.12	$x10^6$	ESAs

OWP	16	76%
IWP	5	24%

Average Rut Depth		9.8	mm
Standard Deviation of Rut Depth		6.7	mm
Avg.Radius of Curvature		68	m
Avg.M_r Upper Layers		122	MPa
M_r Base	80%	149	MPa
M_r Subbase	20%	100	MPa
Avg.M_r of the Foundation		130	MPa
M_r Selected Subgrade	80%	163	MPa
M_r Subgrade	20%	67	MPa

Percentile of the Road that will Require Reconstruction 4% of the road

Percentile of the Road that will not Require Strengthening d= 0.98 mm 96%

Target Deflection: 0.7 mm

Existing Base Material: GC

Crushed Rock Granular Overlay Thickness	=	200	mm
Stabilised Natural Gravel Overlay Thickness	=	200	mm
Natural Gravel Granular Overlay Thickness	=	200	mm
Asphalt Overlay Thickness	=	100	mm

Deflection for HDM model $\delta_{(80kN)} =$ 1.57 mm

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International

in association with **Jatula Partners**

Road Name: Lumbadzi - Mponela | Road Code: 8 | Sample Length No.: S2 | Truck Axle Load - LHS: 3175 kg | Date: 18-Jul-98

Chainage (km) 30.77 to 31.77 | Sample Length Code: 82 | Width: 6.7 m | RHS: 3175 kg | Operator: RI/MOWS

Chainage (km)		Surface Condition																											
		Primary Cracking						Secondary Cracking						Pothole		Patch		Edge		Ravel		Bleed		Skid		Deform			
From	To	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Number	Av.Area (m^2)	Number	Av.Area (m^2)	Length	Av.Width (m)	Extent (%)	Degree	Extent (%)	Degree	Extent (%)	Degree	Condition	Position	Shoulder Condition	Drainage Condition
30.77	30.87	C	CW	70	3	✓	✗	L	CW	70	3	✓	✗	1	1	9	7	100	0.2	100	2	60	3					P	
30.87	30.97	C	CW	70	3	✓	✗	L	CW	70	3	✓	✗	1	1	1	3	100	0.2	100	2	60	3					P	
30.97	31.07																	100	0.2	100	2	60	3					P	
31.07	31.17																	100	0.2	100	2	60	3					P	
31.17	31.27																	100	0.2	100	2	60	3					P	
31.27	31.37																	100	0.2	100	2	60	3					P	
31.37	31.47																	100	0.2	100	2	60	3					P	
31.47	31.57															2	3	100	0.2	100	2	60	3					P	
31.57	31.67																	100	0.2	100	2	60	3					P	
31.67	31.77																	100	0.2	100	2	60	3					P	

Chainage (km)		Point Number		Peak Deflection (mm x 100)										Rad.of Curve								Rut Depth (mm)	
				LH Wheelpath				RH Wheelpath						LH Wheelpath									
From	To			Initial	Maximum	Final	Deflection	Initial	Maximum	Final	Deflection	Max Corrected	Wheel Path	Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	LHS	RHS
		21	L	4	30	17	39	3	30	-3	60	77	IWP	0	30	0	47	47	0.3	181	61	9	5
				1	20	2	37	2	32	2	60			0	30	1	47						
30.77	30.87	22	L	2	23	4	40	2	22	0	42	55	IWP	0	20	0	70	70	0.8	144	115	8	4
				3	21	2	37	0	22	1	43												
30.87	30.97	23	L	3	12	3	18				0	23	OWP	0	13	1	112	112	0.4	360	155	6	7
				2	12	4	18				0												
30.97	31.07	24	L	3	19	3	32				0	41	OWP	3	30	2	51	49	0.2	237	58	4	5
				3	18	2	31				0			0	30	0	47						
31.07	31.17	25	L	3	23	0	43				0	59	OWP	0	24	2	61	61	0.8	120	102	11	0
				1	25	1	48				0												
31.17	31.27	26	L	3	10	1	16				0	23	OWP	0	12	2	127	127	0.6	336	190	4	0
				2	12	2	20				0												
31.27	31.37	27	L	3	16	0	29				0	38	OWP	0	20	0	70	75	0.5	209	110	8	0
				2	18	4	30				0			2	20	3	80						
31.37	31.47	28	L	2	12	1	21				0	26	OWP	0	30	0	47	53	0.1	440	50	3	0
				2	12	2	20				0			0	25	2	58						
31.47	31.57	29	L	3	8	3	10				0	13	OWP									8	0
				3	8	3	10				0												
31.57	31.67	30	L	2	8	2	12				0	16	OWP									9	0
				2	8	1	13				0												
31.67	31.77	31	L	2	8	1	13				0	16	OWP										
				2	8	2	12				0												

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International

in association with **Jatula Partners**

Road Name:	Lumbadzi - Mponela	Road Code:	8	Sample Length No.:	S2	Truck Axle Load - LHS:	3175 kg
Date:	18-Jul-98						
Chainage (km)	30.77 to 31.77	Sample Length Code:	82	Width:	6.7 m	RHS:	3175 kg
Operator:	RI/MOWS						

Averages and Totals

Area Cracked	40 m^2	0.6%	
Wide Cracks	40 m^2	0.6%	
Average Condition Index	4.6		
Minimum Condition Index	4.6		
Maximum Condition Index	4.8		

Area to be patched	438 m^2	6.5%
Area already patched	54 m^2	0.8%
Area Ravelled	6700 m^2	100.0%
Area patched during shoulder repair	300 m^2	4.5%

Average Deflection	δ_p	0.35	mm	OWP	9	82%
Standard Deviation	σ	0.21	mm	IWP	2	18%
Calibration Correction Factor	F_c	0.993	0.99			
Seasonal Correction Factor	F_w	1.300				
Design Deflection	δ_d	0.67	mm			
Percentile to equal the Design Deflection	96%	0.70	mm			
Predicted Design Axles	No.	6.03	$x10^6$ Axles			
Residual Equivalent Standard Axles	No.	1.12	$x10^6$ ESAs			

Percentile of the Road that will Require Reconstruction 4% of the road

Percentile of the Road that will not Require Strengthening d= 0.70 mm 96%

Average Rut Depth		4.6 mm
Standard Deviation of Rut Depth		3.6 mm
Avg.Radius of Curvature		68 m
Avg.M_r Upper Layers		105 MPa
M_r Base	80%	139 MPa
M_r Subbase	20%	59 MPa
Avg.M_r of the Foundation		253 MPa
M_r Selected Subgrade	80%	350 MPa
M_r Subgrade	20%	159 MPa

Target Deflection: 0.7 mm

Existing Base Material: GC

Crushed Rock Granular Overlay Thickness	=	70 mm
Stabilised Natural Gravel Overlay Thickness	=	70 mm
Natural Gravel Granular Overlay Thickness	=	70 mm
Asphalt Overlay Thickness	=	35 mm

Deflection for HDM model $\delta_{(80kN)} =$ 1.03 mm

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International

in association with **Jatula Partners**

Road Name: Bunda Turn Off - Chimbiya | Road Code: 9 | Sample Length No.: S1 | Truck Axle Load - LHS: 3175 kg | Date: 13-Aug-98

Chainage (km) 7.69 to 9.69 | Sample Length Code: 91 | Width: 6.7 m | RHS: 3175 kg | Operator: RI/MOWS

Chainage (km)		Surface Condition																													
		Primary Cracking						Secondary Cracking						Pothole		Patch		Edge		0.0	Ravel			Bleed		Skid		Deform			
From	To	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Number	Av.Area (m^2)	Number	Av.Area (m^2)	Length	Av.Width (m)	Min Width	Extent (%)	Degree	Area	Extent (%)	Degree	Extent (%)	Degree	Condition	Position	Shoulder Condition	Drainage Condition
7.69	7.79	C	CW	4	40	✓	✓	L	CW	4	40	✓	✓	5	10	5	20	100	0.5	0.5	100	3	670	100	3	100	3	P	CW	P	F
7.79	7.89	C	CW	4	30	✓	✓	L	CW	4	30	✓	✓	5	5	5	30	100	0.4	0.4	100	3	670	100	3	100	3	P	CW	P	F
7.89	7.99	C	CW	4	35	✓	✓	L	CW	4	35	✓	✓	5	5	5	35	100	0.2	0.5	100	3	670	100	3	100	3	P	CW	P	F
7.99	8.09	C	CW	4	40	✓	✓	L	CW	4	40	✓	✓	5	6	5	30	100	0.4	0.4	100	3	670	100	3	100	3	P	CW	P	F
8.09	8.19	C	CW	4	50	✓	✓	L	CW	4	50	✓	✓	5	10	5	35	100	0.4	0.5	100	3	670	100	3	100	3	P	CW	P	F
8.19	8.29	C	CW	4	30	✓	✓	L	CW	4	30	✓	✓	5	5	5	28	100	0.4	0.4	100	3	670	100	3	100	3	P	CW	P	P
8.29	8.39	C	CW	4	45	✓	✓	L	CW	4	45	✓	✓	5	15	5	35	100	0.4	0.5	100	3	670	100	3	100	3	P	CW	P	F
8.39	8.49	C	CW	4	40	✓	✓	L	CW	4	40	✓	✓	5	10	5	35	100	0.4	0.4	100	3	670	100	3	100	3	P	CW	P	F
8.49	8.59	C	CW	4	50	✓	✓	L	CW	4	50	✓	✓			5	40	100	0.4	0.5	100	3	670	100	3	100	3	P	CW	P	F
8.59	8.69	C	CW	4	50	✓	✓	L	CW	4	50	✓	✓	5	10	5	40	100	0.4	0.4	100	3	670	100	3	100	3	P	CW	P	F
8.69	8.79	C	CW	4	50	✓	✓	L	CW	4	50	✓	✓					100	0.4	0.5	100	3	670	100	3	100	3	P	CW	P	F
8.79	8.89	C	CW	5	40	✓	✓	L	CW	5	40	✓	✓	5	5	5	40	100	0.3	0.4	100	3	670	100	3	100	3	P	CW	P	F
8.89	8.99	C	CW	5	40	✓	✓	L	CW	5	40	✓	✓	5	10	5	35	100	0.3	0.5	100	3	670	100	3	100	3	P	CW	P	F
8.99	9.09	C	CW	5	50	✓	✓	L	CW	5	50	✓	✓	5	5	5	50	100	0.3	0.4	100	3	670	100	3	100	3	P	CW	P	F
9.09	9.19	C	CW	5	50	✓	✓	L	CW	5	50	✓	✓	5	15	5	35	100	0.3	0.5	100	3	670	100	3	100	3	P	CW	P	F
9.19	9.29	C	CW	4	30	✓	✓	L	CW	4	30	✓	✓	5	12	5	25	100	0.3	0.4	100	3	670	100	3	100	3	P	CW	P	F
9.29	9.39	C	CW	2	15	✓	✓	L	CW	2	15	✓	✓	5	10	5	10	100	0.3	0.5	100	3	670	100	3	100	3	P	CW	P	F
9.39	9.49	C	CW	3	30	✓	✓	L	CW	3	30	✓	✓	5	8	5	15	100	0.3	0.4	100	3	670	100	3	100	3	P	CW	P	F
9.49	9.59	C	CW	2	20	✓	✓	L	CW	2	20	✓	✓	5	4	5	8	100	0.3	0.5	100	3	670	100	3	100	3	P	CW	P	F
9.59	9.69	C	CW	3	30	✓	✓	L	CW	3	30	✓	✓	5	4	5	8	100	0.3	0.4	100	3	670	100	3	100	3	P	CW	P	P

Chainage (km)		Point Number		Peak Deflection (mm x 100)										Rad.of Curve								Rut Depth (mm)	
				LH Wheelpath				RH Wheelpath						LH Wheelpath									
From	To			Initial	Maximum	Final	Deflection	Initial	Maximum	Final	Deflection	Max Corrected	Wheel Path	Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	LHS	RHS
		32	R	1	50	4	95	4	50	6	90	123	OWP	0	34	0	41	41	1.7	48	83	15	8
				1	49	1	96	3	49	3	92			0	35	0	40						
7.69	7.79	33	R	1	22	0	43	1	34	4	63	83	IWP	1	20	0	72	71	1.0	121	125		
				1	22	0	43	3	36	4	65			0	20	0	70						
7.79	7.89	34	R	1	34	-1	68	2	46	3	87	115	IWP	0	29	0	48	45	1.1	74	81	5	6
				0	35	0	70	4	50	5	91			0	33	0	42						
7.89	7.99	35	R	2	40	1	77	3	40	3	74	97	OWP	0	30	0	47	45	1.3	66	85	21	0
				1	38	2	73	2	40	3	75			0	32	0	44						
7.99	8.09	36	R	0	54	4	104	3	46	4	85	135	OWP	0	40	0	35	36	1.7	44	73	8	0
				0	52	-1	105	3	48	4	89			0	37	0	38						
8.09	8.19	37	R	1	46	-3	94	2	35	3	65	122	OWP	0	35	0	40	42	1.8	48	86	9	0
				1	48	0	95	2	34	2	64			0	32	0	44						
8.19	8.29	38	R	1	46	1	90	0	45	1	89	116	IWP	0	32	0	44	44	1.8	51	90	10	11
				1	45	0	89	1	46	1	90												
8.29	8.39	39	R	1	24	0	47	3	35	4	63	83	IWP	0	23	0	61	60	1.0	107	103	20	6
				2	27	0	52	4	36	3	65			0	24	0	58						
8.39	8.49	40	R	2	36	3	67	3	30	4	53	83	OWP	0	29	0	48	48	1.1	80	86	22	5
				2	33	2	62	4	31	4	54			0	29	0	48						
8.49	8.59	41	R	1	50	1	98	4	52	3	97	127	IWP	0	36	3	41	38	1.6	48	76	14	4
				1	49	1	96	3	53	4	99			0	39	0	36						
8.59	8.69	42	R	2	39	1	75	3	30	0	57	98	OWP	0	35	0	40	40	1.0	69	70	18	
				2	40	1	77	2	31	3	57			0	36	1	39						
8.69	8.79	43	R	1	36	1	70	4	44	5	79	103	IWP	1	30	1	48	46	1.2	71	85	16	0
				1	36	0	71	3	43	2	81			0	32	1	44						
8.79	8.89	44	R	1	39	4	73	3	40	3	74	100	IWP	0	31	0	45	46	1.3	68	86	23	0
				1	39	4	73	2	43	3	81			0	30	0	47						
8.89	8.99	45	R	3	30	0	57	3	30	5	52	72	OWP	0	36	-1	38	45	0.7	105	70	24	0
				3	30	3	54	2	30	4	54			0	28	1	51						
8.99	9.09	46	R	0	50	4	96	3	60	2	115	150	IWP	0	29	0	48	48	2.4	45	108	13	0
				0	46	0	92	2	61	3	117												
9.09	9.19	47	R	2	35	2	66	2	30	4	54	85	OWP	0	33	0	42	49	1.2	77	89	11	5
				2	35	2	66	2	30	5	53			0	28	5	55						
9.19	9.29	48	R	3	32	2	59	6	35	6	58	77	IWP	0	27	0	52	51	1.0	92	89	12	0
				3	32	5	56	4	35	4	62			0	28	1	51						
9.29	9.39	49	R	2	42	0	82	2	20	2	36	103	OWP	0	32	0	44	43	1.3	61	81	6	0
				2	40	0	78	4	20	6	30			0	33	-1	42						
9.39	9.49	50	R	2	20	0	38	2	34	2	64	83	IWP	0	20	0	70	70	0.7	153	112	15	0
				2	20	2	36	4	36	4	64			0	20	0	70						
9.49	9.59	51	R	2	52	4	98	4	28	3	49	128	OWP	0	35	10	47	47	2.5	42	105	20	5
				2	52	2	100	4	29	5	49												
9.59	9.69	52	R	2	49	2	94	3	30	4	53	121	OWP	0	36	0	39	41	1.7	49	82	13	
				2	49	3	93	2	28	2	52			0	33	0	42						

Road Name:	Bunda Turn Off - Chimbiya	Road Code:	9	Sample Length No.:	S1	Truck Axle Load - LHS:	3175 kg	Date:	13-Aug-98
Chainage (km)	7.69 to 9.69	Sample Length Code:	91	Width:	6.7 m	RHS:	3175 kg	Operator:	RI/MOWS

Averages and Totals

Area Cracked	5125	m^2	38.2%
Wide Cracks	5125	m^2	38.2%
Average Condition Index	22.2		
Minimum Condition Index	21.2		
Maximum Condition Index	22.9		

Area to be patched	3930	m^2	29.3%
Area already patched	2078	m^2	15.5%
Area Ravelled	13400	m^2	100.0%
Area patched during shoulder repair	600	m^2	4.5%

Average Deflection	δ_p	1.05	mm	OWP	11	52%
Standard Deviation	σ	0.22	mm	IWP	10	48%
Calibration Correction Factor	F_c	0.993	0.99			
Seasonal Correction Factor	F_w	1.300				
Design Deflection	δ_d	1.37	mm			
Percentile to equal the Design Deflection	96%	1.37	mm			
Predicted Design Axles	No.	6.16	$x10^6$ Axles			
Residual Equivalent Standard Axles	No.	1.33	$x10^6$ ESAs			

Percentile of the Road that will Require Reconstruction 4% of the road

Percentile of the Road that will not Require Strengthening d= 1.37 mm 96%

Average Rut Depth		8.7 mm
Standard Deviation of Rut Depth		7.7 mm
Avg.Radius of Curvature		47 m
Avg.M_r Upper Layers		89 MPa
M_r Base	80%	103 MPa
M_r Subbase	20%	81 MPa
Avg.M_r of the Foundation		72 MPa
M_r Selected Subgrade	80%	92 MPa
M_r Subgrade	20%	48 MPa

Target Deflection: 0.9 mm

Existing Base Material: CR

Crushed Rock Granular Overlay Thickness	=	200 mm
Stabilised Natural Gravel Overlay Thickness	=	200 mm
Natural Gravel Granular Overlay Thickness	=	200 mm
Asphalt Overlay Thickness	=	100 mm

Deflection for HDM model $\delta_{(80kN)} =$ 2.12 mm

Road Maintenance and Rehabilitation Project - Malawi

Roughton International

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

in association with **Jatula Partners**

Road Name: Bunda Turn Off - Chimbiya | Road Code: 9 | Sample Length No.: S2 | Truck Axle Load - LHS: 3175 kg | Date: 13-Aug-98

Chainage (km) 28.57 to 29.57 | Sample Length Code: 92 | Width: 6.7 m | RHS: 3175 kg | Operator: RI/MOWS

Chainage (km)		Surface Condition																											
		Primary Cracking						Secondary Cracking						Pothole		Patch		Edge		Ravel		Bleed		Skid		Deform			
From	To	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Number	Av.Area (m^2)	Number	Av.Area (m^2)	Length	Av.Width (m)	Extent (%)	Degree	Extent (%)	Degree	Extent (%)	Degree	Condition	Position	Shoulder Condition	Drainage Condition
28.57	28.67	T	CW	2	20	✓	✓	L	CW	2	20	✓	✓					100	0.2	100	3	100	3	100	3	P	CW	P	P
28.67	28.77	T	CW	2	30	✓	✓	L	CW	2	30	✓	✓					100	0.2	100	3	100	3	100	3	P	CW	P	P
28.77	28.87	C	CW	4	40	✓	✓									5	40	100	0.2	100	3	100	3	100	3	P	CW	P	P
28.87	28.97	C	CW	4	40	✓	✓									5	20	100	0.4	100	3	100	3	100	3	P	CW	P	F
28.97	29.07	C	CW	4	40	✓	✓							5	20	5	14	100	0.2	100	3	100	3	100	3	P	CW	P	F
29.07	29.17	C	CW	4	50	✓	✓							5	7	5	28	100	0.4	100	3	100	3	100	3	P	CW	P	F
29.17	29.27	C	CW	4	40	✓	✓							5	7			100	0.4	100	3	100	3	100	3	P	CW	P	F
29.27	29.37	C	CW	4	40	✓	✓							5	14	5	7	100	0.4	100	3	100	3	100	3	P	CW	P	P
29.37	29.47	C	CW	3	30	✓	✓											100	0.4	100	3	100	3	100	3	P	CW	P	P
29.47	29.57	C	CW	3	40	✓	✓							5	11	5	20	100	0.3	100	3	100	3	100	3	P	CW	P	P

Point Number		Peak Deflection (mm x 100)										Rad.of Curve								Rut Depth (mm)	
		LH Wheelpath				RH Wheelpath						LH Wheelpath									
		Initial	Maximum	Final	Deflection	Initial	Maximum	Final	Deflection	Max Corrected	Wheel Path	Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	LHS	RHS
21	L	2	30	4	54	2	32	4	58	77	IWP	0	10	0	140	140	6.8	61	418	0	21
		1	28	3	52	2	34	4	62												
22	L	2	29	5	51	1	31	4	57	77	IWP	0	11	0	127	127	5.3	67	353	4	0
		0	27	2	52	3	35	5	62												
23	L	3	25	5	42	0	24	0	48	62	IWP	0	4	0	350	315	25.1	54	1351	3	4
		2	25	3	45	1	25	1	48			0	5	0	280						
24	L	2	32	2	60	1	40	0	79	102	IWP	0	18	0	78	65	1.9	72	136	8	0
		2	34	2	64	0	40	1	79			0	22	-9	53						
25	L	3	40	6	71	1	25	1	48	90	OWP	0	25	0	56	54	1.6	66	108	8	0
		1	36	2	69	1	25	2	47			0	27	0	52						
26	L	2	26	2	48	1	20	1	38	63	OWP	0	20	0	70	70	1.3	101	132	10	0
		2	27	3	49	2	21	1	39			0	20	0	70						
27	L	3	25	3	44	3	24	3	42	59	OWP									8	0
		2	26	2	48	1	24	2	45												
28	L	0	29	0	58	1	35	-1	70	89	IWP	0	12	0	117	117	5.3	61	325	12	7
		2	29	1	55	2	35	0	68												
29	L	2	29	3	53	2	18	0	34	69	OWP									0	5
		2	28	0	54	2	19	2	34												
30	L	3	35	3	64	1	27	-2	55	80	OWP	0	35	0	40	43	0.8	90	71	11	0
		2	32	2	60	2	29	1	55			0	30	0	47						
31	L	1	25	2	47	2	21	2	38	64	OWP	1	20	-4	65	68	1.3	100	126	18	0
		1	27	1	52	2	22	1	41			0	20	0	70						

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International

in association with **Jatula Partners**

Road Name: Bunda Turn Off - Chimbiya | Road Code: 9 | Sample Length No.: S2 | Truck Axle Load - LHS: 3175 kg | Date: 13-Aug-98

Chainage (km) 28.57 to 29.57 | Sample Length Code: 92 | Width: 6.7 m | RHS: 3175 kg | Operator: RI/MOWS

Averages and Totals

Area Cracked	2479 m^2	37.0%	Area to be patched	1258 m^2	18.8%	Average Deflection δ_p	0.76 mm
Wide Cracks	2479 m^2	37.0%	Area already patched	484 m^2	7.2%	Standard Deviation σ	0.14 mm
			Area Ravelled	6700 m^2	100.0%	Calibration Correction Factor F_c	0.993 0.99
Average Condition Index	21.6		Area patched during shoulder repair	300 m^2	4.5%	Seasonal Correction Factor F_w	1.300
Minimum Condition Index	20.6					Design Deflection δ_d	0.96 mm
Maximum Condition Index	22.4					Percentile to equal the Design Deflection 96%	0.97 mm
						Predicted Design Axles No.	6.16 $x10^6$ Axles
						Residual Equivalent Standard Axles No.	1.33 $x10^6$ ESAs

OWP	6	55%
IWP	5	45%

Average Rut Depth	5.4 mm
Standard Deviation of Rut Depth	6.1 mm
Avg.Radius of Curvature	108 m
Avg.M_r Upper Layers	336 MPa
M_r Base 80%	379 MPa
M_r Subbase 20%	119 MPa
Avg.M_r of the Foundation	75 MPa
M_r Selected Subgrade 80%	94 MPa
M_r Subgrade 20%	61 MPa

Percentile of the Road that will Require Reconstruction 4% of the road

Percentile of the Road that will not Require Strengthening d= 0.97 mm 96%

Target Deflection: 0.9 mm

Existing Base Material: CR

Crushed Rock Granular Overlay Thickness	=	60 mm
Stabilised Natural Gravel Overlay Thickness	=	60 mm
Natural Gravel Granular Overlay Thickness	=	60 mm
Asphalt Overlay Thickness	=	30 mm

Deflection for HDM model $\delta_{(80kN)} =$ 1.49 mm

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International

in association with **Jatula Partners**

Road Name: Bunda Turn Off - Chimbiya | Road Code: 9 | Sample Length No.: S3 | Truck Axle Load - LHS: 3175 kg | Date: 13-Aug-98

Chainage (km) 47.25 to 49.25 | Sample Length Code: 93 | Width: 6.7 m | RHS: 3175 kg | Operator: RI/MOWS

Chainage (km)		Surface Condition: Primary Cracking						Secondary Cracking						Pothole		Patch		Edge		Ravel		Bleed		Skid		Deform			
From	To	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Number	Av.Area (m^2)	Number	Av.Area (m^2)	Length	Av.Width (m)	Extent (%)	Degree	Extent (%)	Degree	Extent (%)	Degree	Condition	Position	Shoulder Condition	Drainage Condition
47.25	47.35	C	CW	4	70	✓	✓	B	CW	4	70	✓	✓							100	3	100	3	100	3			F	F
47.35	47.45	C	CW	4	60	✓	✓	B	CW	4	60	✓	✓							100	3	100	3	100	3			F	F
47.45	47.55	L	CW	4	50	✓	✓	T	CW	4	50	✓	✓							80	4	100	3	100	3			F	F
47.55	47.65	L	CW	4	50	✓	✓	T	CW	4	50	✓	✓							80	4	100	3	100	3			F	F
47.65	47.75	C	CW	3	60	✓	✓	L	CW	3	60	✓	✓							80	4	100	3	100	3			F	F
47.75	47.85	C	CW	3	40	✓	✓	T	CW	3	40	✓	✓							80	4	100	3	100	3	P	CW	F	F
47.85	47.95	C	CW	3	30	✓	✓	T	CW	3	30	✓	✓					100	0.2	80	4	100	3	100	3	P	CW	F	F
47.95	48.05	B	CW	3	40	✓	✓													80	4	100	3	100	3	P	CW	F	F
48.05	48.15	L	CW	3	50	✓	✓	T	CW	3	50	✓	✓							70	4	100	3	100	3	P	CW	F	F
48.15	48.25	L	CW	4	60	✓	✓	T	CW	4	60	✓	✓							80	4	100	3	100	3	P	CW	F	F
48.25	48.35	C	CW	4	70	✓	✓	T	CW	4	70	✓	✓							70	4	100	3	100	3	P	CW	F	F
48.35	48.45	C	CW	4	60	✓	✓	T	CW	4	60	✓	✓							80	4	100	3	100	3	P	CW	F	F
48.45	48.55	C	CW	3	50	✓	✓	C	CW	3	50	✓	✓							90	4	100	3	100	3	P	CW	F	F
48.55	48.65	L	CW	3	40	✓	✓	T	CW	3	40	✓	✓							100	3	100	4	100	4	P	CW	F	F
48.65	48.75	C	CW	5	60	✓	✓									5	4			100	3	100	4	100	4	P	CW	F	F
48.75	48.85	C	CW	5	70	✓	✓									5	30	100	0.2	100	3	100	2	100	3	P	CW	P	F
48.85	48.95	C	CW	5	70	✓	✓							5	14	5	25	100	0.5	100	3	100	2	100	3	P	CW	P	F
48.95	49.05	C	CW	5	60	✓	✓							5	20	5	35			100	3	100	2	100	3	P	CW	P	F
49.05	49.15	C	CW	5	70	✓	✓							5	25	5	25			100	3	100	2	100	3	P	CW	P	F
49.15	49.25	C	CW	5	80	✓	✓							5	25	5	25	100	0.3	100	3	100	2	100	3	P	CW	P	F

Point Number		Peak Deflection (mm x 100): LH Wheelpath				RH Wheelpath				Max Corrected	Wheel Path	Rad.of Curve: LH Wheelpath				Average	MR	E_{SG}	E_B	Rut Depth (mm)	
		Initial	Maximum	Final	Deflection	Initial	Maximum	Final	Deflection			Initial	Maximum	Final	R_c					LHS	RHS
0	L	1	14	2	25	1	8	1	14	34	OWP	0	25	0	56	56	0.2	296	64	6	4
		0	14	1	27	2	9	2	14			0									
1	L	1	19	3	34	2	7	1	11	46	OWP	0	10	0	140	140	3.0	111	333	0	0
		1	20	1	38	2	8	1	13												
2	L	2	24	2	44	1	11	1	20	54	OWP	0	10	0	140	137	3.9	90	348	4	6
		2	22	3	39	1	11	2	19			0	10	-1	133						
3	L	1	23	3	42	1	16	1	30	55	OWP	0	11	0	127	122	3.2	92	295	0	0
		0	22	1	43	1	16	1	30			0	12	0	117						
4	L	1	16	3	28	2	11	2	18	35	OWP	0	11	0	127	137	1.6	169	275	0	0
		0	15	3	27	2	11	3	17			0	9	-1	147						
5	L	3	18	2	31	2	15	2	26	40	OWP	0	8	0	175	158	2.8	131	367	6	0
		1	17	2	31	2	16	3	27			0	10	0	140						
6	L	1	27	1	52	3	11	2	17	68	OWP	0	14	0	100	89	2.6	79	202	3	0
		2	29	3	53	3	11	2	17			0	19	2	78						
7	L	0	23	5	41	1	10	1	18	52	OWP	0	10	-2	127	122	2.8	101	284	0	0
		1	21	2	39	1	9	1	16			0	11	-2	117						
8	L	3	26	2	47	2	18	2	32	59	OWP	0	10	0	140	148	5.7	74	419	0	0
		1	24	2	45	2	17	1	31			2	10	0	156						
9	L	0	26	2	50	2	19	1	35	62	OWP	0	10	0	140	134	5.0	73	366	3	0
		2	24	0	46	3	20	3	34			0	11	0	127						
10	L	1	29	1	56	1	32	1	62	80	IWP	0	19	0	74	78	2.4	73	174	0	31
		0	31	2	60	1	32	1	62			0	16	-2	82						
11	L	0	20	-1	41	3	13	2	21	54	OWP	0	11	-1	122	109	2.5	100	245	8	
		0	21	-1	43	2	12	1	21			0	15	1	97						
12		1	20	1	38	3	8	2	11	48	OWP	0	9	-2	140	137	3.0	107	325		
		2	20	2	36	2	7	1	11			0	10	-1	133						
13	L	1	21	2	39	3	24	4	41	54	IWP	0	11	0	127	125	2.7	106	287	0	0
		0	20	2	38	2	23	2	42			0	11	-1	122						
14	L	0	11	0	22	2	10	2	16	30	OWP	0	10	0	140	134	1.1	225	237	0	0
		2	14	2	24	3	11	3	16			0	11	0	127						
15	L	1	31	5	56	2	40	3	75	79	IWP	0	17	1	85	98	3.6	69	245	0	0
		1	30	4	55	2	40	30	48			0	12	-1	112						
16	L	1	44	1	86	1	31	1	60	112	OWP	0	45	0	31	32	0.8	63	53	0	0
		2	47	4	88	1	32	1	62			0	42	-2	33						
17	L	0	39	4	74	2	30	2	56	92	OWP	0	33	0	42	39	0.9	77	66	13	
		4	39	6	68	2	30	1	57			0	38	-2	36						
18	L	0	51	1	101	1	50	1	98	133	OWP	0	50	-3	27	27	0.9	53	46	22	0
		0	54	3	105	1	50	1	98			0	52	1	27						
19	L	2	33	2	62	2	32	2	60	79	OWP	0	36	-1	38	39	0.6	98	59	13	0
		0	30	0	60	2	32	2	60			0	35	-2	39						
20	L	1	43	-1	86	1	64	1	126	164	IWP	0	49	0	29	33	0.8	66	54	6	8
		1	42	2	81	1	65	1	128			0	38	0	37						

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International

in association with **Jatula Partners**

Road Name: Bunda Turn Off - Chimbiya | Road Code: 9 | Sample Length No.: S3 | Truck Axle Load - LHS: 3175 kg | Date: 13-Aug-98

Chainage (km) 47.25 to 49.25 | Sample Length Code: 93 | Width: 6.7 m | RHS: 3175 kg | Operator: RI/MOWS

Averages and Totals

Area Cracked	7638	m^2	57.0%
Wide Cracks	7638	m^2	57.0%
Average Condition Index	18.4		
Minimum Condition Index	8.6		
Maximum Condition Index	23.6		

Area to be patched	1020	m^2	7.6%
Area already patched	540	m^2	4.0%
Area Ravelled	11859	m^2	88.5%
Area patched during shoulder repair	600	m^2	4.5%

Average Deflection	δ_p	0.68	mm	OWP	17	81%
Standard Deviation	σ	0.34	mm	IWP	4	19%
Calibration Correction Factor	F_c	0.993	0.99			
Seasonal Correction Factor	F_w	1.300				
Design Deflection	δ_d	1.19	mm			
Percentile to equal the Design Deflection	96%	1.38	mm			
Predicted Design Axles	No.	6.16	$x10^6$ Axles			
Residual Equivalent Standard Axles	No.	1.33	$x10^6$ ESAs			

Percentile of the Road that will Require Reconstruction 4% of the road

Percentile of the Road that will not Require Strengthening d= 1.38 mm 96%

Average Rut Depth		3.5 mm
Standard Deviation of Rut Depth		6.7 mm
Avg.Radius of Curvature		100 m
Avg.M_r Upper Layers		226 MPa
M_r Base	80%	333 MPa
M_r Subbase	20%	64 MPa
Avg.M_r of the Foundation		107 MPa
M_r Selected Subgrade	80%	111 MPa
M_r Subgrade	20%	73 MPa

Target Deflection: 0.9 mm

Existing Base Material: CR

Crushed Rock Granular Overlay Thickness	=	140 mm
Stabilised Natural Gravel Overlay Thickness	=	140 mm
Natural Gravel Granular Overlay Thickness	=	140 mm
Asphalt Overlay Thickness	=	70 mm

Deflection for HDM model $\delta_{(80kN)} =$ 1.83 mm

Road Maintenance and Rehabilitation Project - Malawi | **Roughton International**
Detailed Visual Condition Survey and Deflection Survey for Sample Lengths | *in association with* **Jatula Partners**

Road Name: Dedza - Biriwiri | Road Code: 10 | Sample Length No.: S1 | Truck Axle Load - LHS: 3175 kg | Date: 12-Aug-98

Chainage (km) 9.89 to 11.89 | Sample Length Code: 101 | Width: 6.7 m | RHS: 3175 kg | Operator: RI/MOWS

Chainage (km)		Surface Condition																											
		Primary Cracking						Secondary Cracking						Pothole		Patch		Edge		Ravel		Bleed		Skid		Deform		Shoulder Condition	Drainage Condition
From	To	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Number	Av.Area (m^2)	Number	Av.Area (m^2)	Length	Av.Width (m)	Extent (%)	Degree	Extent (%)	Degree	Extent (%)	Degree	Condition	Position		
9.89	9.99	C	CW	2	50	✓	✓											100	3.0					100	2	P	CW	F	F
9.99	10.09	C	CW	2	50	✓	✓											100	3.0					100	2	P	CW	F	F
10.09	10.19	C	CW	2	50	✓	✓											100	3.0					100	2	P	CW	F	F
10.19	10.29	C	CW	2	40	✓	✓											100	3.0					100	2	P	CW	F	F
10.29	10.39	C	CW	2	40	✓	✓											100	3.0					100	2	P	CW	F	F
10.39	10.49	C	CW	2	30	✓	✓											100	3.0	100	2	100	2	100	2	P	CW	F	F
10.49	10.59																	100	3.0	100	2	100	2	100	2	P	CW	F	F
10.59	10.69	C	CW	3	60	✓	✓							5	11			100	3.0	100	2	100	2	100	2	P	CW	F	F
10.69	10.79	C	CW	4	50	✓	✓							5	31			100	3.0	100	2	100	2	100	2	P	CW	F	F
10.79	10.89	C	CW	3	40	✓	✓							5	22			100	3.0	100	2	100	2	100	2	P	CW	F	F
10.89	10.99	C	CW	3	40	✓	✓							5	7			100	3.0	100	2	100	2	100	2	P	CW	F	F
10.99	11.09	C	CW	3	30	✓	✓							5	40			100	3.0	100	2	100	2	100	2	P	CW	F	F
11.09	11.19	C	CW	3	40	✓	✓									5	38			100	3	100	2	100	2	P	CW	F	F
11.19	11.29	C	CW	3	30	✓	✓											100	0.2	100	3	100	2	100	2	P	CW	F	F
11.29	11.39	C	CW	3	40	✓	✓	L	CW	3	40	✓	✓			5	35	100	0.2	100	3	100	2	100	2	P	CW	F	F
11.39	11.49	C	CW	4	50	✓	✓											100	0.2	100	3	100	2	100	2	P	CW	F	F
11.49	11.59	C	CW	4	50	✓	✓									5	22			100	3	100	2	100	2	P	CW	F	F
11.59	11.69	L	CW	3	40	✓	✓													100	3	100	2	100	2	P	CW	F	F
11.69	11.79	C	CW	2	50	✓	✓									5	3			100	3	100	2	100	2	P	CW	F	F
11.79	11.89	C	CW	4	50	✓	✓									5	7			100	3	100	2	100	2	P	CW	F	F

Chainage (km)		Point Number		Peak Deflection (mm x 100)										Rad.of Curve								Rut Depth (mm)	
				LH Wheelpath				RH Wheelpath				Max Corrected	Wheel Path	LH Wheelpath									
From	To			Initial	Maximum	Final	Deflection	Initial	Maximum	Final	Deflection			Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	LHS	RHS
		42	R	1 2	21 22	2 3	39 39	2 2	27 28	2 2	50 52	66	IWP	1 0	21 20	1 0	70 70	70	0.8	141	116	7	0
9.89	9.99	43	R	1 0	20 22	2 1	37 43	3 2	24 25	4 2	41 46	56	IWP	0 0	21 20	1 0	68 70	69	0.8	137	115	7	4
9.99	10.09	44	R	2 1	24 25	2 3	44 46	3 3	22 22	2 2	39 39	58	OWP	0 0	20 20	-2 0	67 70	68	1.1	115	121	14	0
10.09	10.19	45	R	2 1	22 22	6 2	36 41	2 2	18 18	2 2	32 32	50	OWP	0 0	20 20	0 0	70 70	70	0.8	144	115	6	0
10.19	10.29	46	R	1 2	26 25	6 2	45 46	2 2	18 18	3 3	31 31	59	OWP	0 0	22 25	0 0	64 56	60	0.8	121	99	6	0
10.29	10.39	47	R	2 2	30 29	3 3	55 53	2 3	25 25	2 2	46 45	70	OWP	0 0	20 23	0 0	70 61	65	1.4	89	126	4	0
10.39	10.49	48	R	1 1	30 31	4 4	55 57	2 2	30 29	4 3	54 53	72	OWP	0 0	22 28	0 0	64 50	57	1.1	91	103	6	0
10.49	10.59	49	R	2 1	29 26	5 1	51 50	1 1	20 21	1 1	38 40	65	OWP	0	25	0	56	56	0.9	107	95	4	0
10.59	10.69	50	R	1 1	32 34	2 1	61 66	3 2	27 27	2 3	49 49	82	OWP	0	29	1	49	49	1.1	81	88	4	0
10.69	10.79	51	R	3 3	26 27	2 2	47 49	3 2	23 21	3 2	40 38	62	OWP	0	21	-4	61	61	0.9	111	105	6	0
10.79	10.89	52	R	1 2	29 30	4 0	53 58	3 2	27 26	4 3	47 47	72	OWP	0 0	22 23	0 0	64 61	62	1.4	88	118	6	0
10.89	10.99	53	R	1 3	35 38	2 3	67 70	1 2	28 28	2 3	53 51	88	OWP	1 0	36 32	-2 0	38 44	41	0.9	79	69	11	0
10.99	11.09	54	R	0 2	30 35	1 4	59 64	3 2	31 29	4 2	55 54	79	OWP	0 0	20 30	0 0	70 47	58	1.5	78	113	6	0
11.09	11.19	55	R	0 1	27 29	2 4	52 53	2 2	28 29	4 3	50 53	68	OWP	0	27	0	52	52	0.8	105	86	0	0
11.19	11.29	56	R	2 2	27 26	2 3	50 47	2 2	15 14	3 2	25 24	63	OWP	0 0	22 25	0 0	64 56	60	0.9	110	103	4	0
11.29	11.39	57	R	2 1	48 47	3 -1	91 94	3 3	32 31	4 4	57 55	119	OWP	0 0	36 35	0 0	39 40	39	1.5	51	77	13	0
11.39	11.49	58	R	3 3	43 45	4 6	79 81	2 3	31 32	4 4	56 57	103	OWP	0 0	31	0	45	45	1.5	59	88	6	0
11.49	11.59	59	R	3 2	35 34	6 2	61 64	1 1	15 15	1 0	28 29	81	OWP	0	30	0	47	47	0.9	85	80	8	8
11.59	11.69	60	R	3 3	33 30	6 4	57 53	1 2	20 19	3 2	36 34	71	OWP	3 0	42 34	0 0	35 41	38	0.5	116	53	8	5
11.69	11.79	61	R	3 3	35 34	4 3	63 62	2 2	31 31	4 3	56 57	81	OWP	0 0	30 28	-2 -2	45 48	47	0.9	85	80		
11.79	11.89	62	R	4 3	57 55	5 4	105 103	1 3	20 22	1 4	38 37	134	OWP	0 0	45 35	1 0	31 40	36	1.6	45	71		

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International
in association with **Jatula Partners**

Road Name: Dedza - Biriwiri | Road Code: 10 | Sample Length No.: S1 | Truck Axle Load - LHS: 3175 kg | Date: 12-Aug-98

Chainage (km) 9.89 to 11.89 | Sample Length Code: 101 | Width: 6.7 m | RHS: 3175 kg | Operator: RI/MOWS

Averages and Totals

Area Cracked	5561	m^2	41.5%
Wide Cracks	5561	m^2	41.5%
Average Condition Index	21.2		
Minimum Condition Index	18.3		
Maximum Condition Index	25.1		

Area to be patched	9258	m^2	69.1%
Area already patched	394	m^2	2.9%
Area Ravelled	10050	m^2	75.0%
Area patched during shoulder repair	600	m^2	4.5%

Average Deflection	δ_p	0.76	mm	
Standard Deviation	σ	0.21	mm	
Calibration Correction Factor	F_c	0.993	0.99	
Seasonal Correction Factor	F_w	1.300		
Design Deflection	δ_d	1.07	mm	
Percentile to equal the Design Deflection	96%	1.22	mm	
Predicted Design Axles	No.	4.11	$x10^6$	Axles
Residual Equivalent Standard Axles	No.	1.26	$x10^6$	ESAs

OWP	19	90%
IWP	2	10%

Average Rut Depth		3.8 mm
Standard Deviation of Rut Depth		4.0 mm
Avg.Radius of Curvature		55 m
Avg.M_r Upper Layers		96 MPa
M_r Base	80%	115 MPa
M_r Subbase	20%	80 MPa
Avg.M_r of the Foundation		97 MPa
M_r Selected Subgrade	80%	116 MPa
M_r Subgrade	20%	79 MPa

Percentile of the Road that will Require Reconstruction 4% of the road

Percentile of the Road that will not Require Strengthening d= 1.22 mm 96%

Target Deflection: 0.9 mm

Existing Base Material: CR

Crushed Rock Granular Overlay Thickness	=	100 mm
Stabilised Natural Gravel Overlay Thickness	=	100 mm
Natural Gravel Granular Overlay Thickness	=	100 mm
Asphalt Overlay Thickness	=	50 mm

Deflection for HDM model $\delta_{(80kN)} =$ 1.66 mm

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International
in association with **Jatula Partners**

Road Name: Dedza - Biriwiri | Road Code: 10 | Sample Length No.: S2 | Truck Axle Load - LHS: 3175 kg | Date: 12-Aug-98

Chainage (km) 27.47 to 29.47 | Sample Length Code: 102 | Width: 6.7 m | RHS: 3175 kg | Operator: RI/MOWS

Chainage (km)		Surface Condition																											
		Primary Cracking						Secondary Cracking						Pothole		Patch		Edge		Ravel		Bleed		Skid		Deform			
From	To	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Number	Av.Area (m^2)	Number	Av.Area (m^2)	Length	Av.Width (m)	Extent (%)	Degree	Extent (%)	Degree	Extent (%)	Degree	Condtion	Position	Shoulder Condition	Drainage Condition
27.47	27.57	C	CW	3	50	✓	✓	L	CW	3	50	✓	✓			5	12	100	0.5	100	3	80	2	100	3	P	CW	P	P
27.57	27.67	C	CW	4	90	✓	✓	L	CW	4	90	✓	✓			5	21	100	0.3	100	4			100	3	P	CW	P	F
27.67	27.77	C	CW	4	90	✓	✓							5	7	5	26	100	0.3	100	4			100	3	P	CW	P	F
27.77	27.87	C	CW	4	90	✓	✓							5	7	5	39	100	0.3	100	4			100	3	P	CW	P	F
27.87	27.97	C	CW	4	80	✓	✓											100	0.3	100	4			100	3	P	CW	P	F
27.97	28.07																	100	0.3	100	4			100	3	P	CW	P	F
28.07	28.17													5	6	5	12	100	0.3	100	4			100	3	P	CW	P	F
28.17	28.27																	100	0.3	100	4			100	3	P	CW	P	F
28.27	28.37													5	7			100	0.3	100	4			100	3	P	CW	P	F
28.37	28.47																	100	0.3	100	4			100	3	P	CW	P	F
28.47	28.57	C	CW	4	80	✓	✓							5	14	5	22	100	0.2	100	4			100	3	P	CW	P	F
28.57	28.67	C	CW	4	70	✓	✓									5	7	100	0.2	100	4			100	3	P	CW	P	F
28.67	28.77	C	CW	4	60	✓	✓									5	45			70	5			100	3	P	CW	P	F
28.77	28.87	C	CW	3	70	✓	✓									5	48			80	4			100	3	P	CW	P	F
28.87	28.97	C	CW	2	80	✓	✓							5	48					100	3	100	2	100	3	P	CW	P	F
28.97	29.07	C	CW	3	70	✓	✓													100	3	100	2	100	3	P	CW	P	F
29.07	29.17	C	CW	4	60	✓	✓							5	35	5	43	100	0.3	100	3	100	2	100	3	P	CW	P	F
29.17	29.27	C	CW	4	50	✓	✓							5	70	5	41	100	0.3	100	3	100	2	100	3	P	CW	P	F
29.27	29.37	C	CW	4	40	✓	✓									5	21	100	0.3	100	3	100	2	100	3	P	CW	P	F
29.37	29.47	C	CW	4	50	✓	✓	L	CW	4	50	✓	✓			5	15	100	0.3	100	3	100	2	100	3	P	CW	P	F

Point Number		Peak Deflection (mm x 100)										Rad.of Curve								Rut Depth (mm)	
		LH Wheelpath				RH Wheelpath						LH Wheelpath									
		Initial	Maximum	Final	Deflection	Initial	Maximum	Final	Deflection	Max Corrected	Wheel Path	Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	LHS	RHS
21	L	9	40	11	60	3	21	3	36	78	OWP	0	20	0	70	69	2.0	73	147	5	7
		9	40	10	61	3	23	3	40			0	20	-1	68						
22	L	5	37	6	63	2	26	1	49	83	OWP	0	21	0	67	64	2.0	69	134	0	5
		5	39	7	66	2	26	2	48			0	23	0	61						
23	L	5	79	10	143	3	55	3	104	188	OWP	0	32	4	47	45	5.3	24	126	8	0
		5	79	5	148	2	56	3	107			0	32		44						
24	L	7	65	6	117	4	23	3	39	153	OWP	0	23	-9	51	45	3.4	33	110	0	0
		5	65	5	120	3	23	3	40			0	34	-4	39						
25	L	5	48	7	84	3	30	3	54	109	OWP									4	0
		5	48	6	85	3	30	3	54												
26	L	2	55	2	106	2	40	2	76	139	OWP	0	20	-2	67	57	4.6	33	153	17	0
		1	56	1	110	2	40	4	74			0	28	-3	47						
27	L	3	49	2	93	3	30	3	54	118	OWP	0	32	3	46	51	2.6	45	116	5	
		2	47	2	90	3	30	4	53			0	25	0	56						
28	L	2	36	4	66	3	27	2	49	85	OWP	1	36	9	45	44	0.9	81	75	5	4
		3	36	3	66	3	27	3	48			0	33	0	42						
29	L	2	31	2	58	2	18	2	32	77	OWP	0	19	0	74	72	2.1	73	155	0	0
		1	32	2	61	2	18	2	32			0	20	0	70						
30	L	3	42	3	78	2	31	3	57	103	OWP	0	29	-2	47	47	1.6	59	94	3	0
		1	42	2	81	3	30	3	54			0	29	-1	47						
31	L	2	62	4	118	3	53	3	100	150	OWP	0	45	0	31	31	1.5	41	60	7	6
		3	62	6	115	3	55	2	105			0	46	0	30						
32	L	2	56	5	105	3	84	5	160	208	IWP	0	30	-10	40	44	2.6	39	99	6	7
		0	55	1	109	3	83	1	162			0	30	1	47						
33	L	2	57	2	110	3	90	4	173	223	IWP	0	37	-1	37	37	2.0	39	78	4	13
		3	62	5	116	2	88	2	172			0	29	-19	36						
34	L	1	68	0	135	4	75	5	141	186	IWP	0	32	-6	40	33	2.2	32	71	8	0
		3	68	2	131	2	76	3	147			0	55	0	25						
35	L	0	42	1	83	4	34	4	60	108	OWP	0	30	0	47	47	1.8	54	98	0	0
		3	45	3	84	4	33	4	58			0	29	0	48						
36	L	3	41	4	75	3	27	4	47	96	OWP	0	34	0	41	41	1.1	70	73	12	0
		3	40	3	74	3	26	4	45												
37	L	2	56	4	106	4	54	3	101	138	OWP	0	36	0	39	39	2.0	41	83	12	11
		1	56	3	108	3	54	3	102												
38	L	2	53	3	101	2	50	3	95	129	OWP	0	46	0	30	37	1.6	47	74	11	0
		2	52	3	99	3	49	3	92			0	32	0	44						
39	L	0	66	1	131	3	65	5	122	170	OWP	0	50	-10	25	28	1.5	36	55	9	0
		0	67	2	132	3	62	3	118			-1	44	-4	30						
40	L	1	49	1	96	2	46	2	88	125	OWP	0	28	-1	49	43	2.0	46	91	23	0
		3	54	8	97	2	45	3	85			0	38	0	37						
41	L	3	27	4	47	2	26	3	47	62	OWP	0	18	0	78	78	1.6	97	155	0	0
		2	27	3	49	3	26	3	46												

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International
in association with **Jatula Partners**

Road Name: Dedza - Biriwiri | Road Code: 10 | Sample Length No.: S2 | Truck Axle Load - LHS: 3175 kg | Date: 12-Aug-98

Chainage (km) 27.47 to 29.47 | Sample Length Code: 102 | Width: 6.7 m | RHS: 3175 kg | Operator: RI/MOWS

Averages and Totals

Area Cracked	6901	m^2	51.5%
Wide Cracks	6901	m^2	51.5%
Average Condition Index	21.0		
Minimum Condition Index	19.8		
Maximum Condition Index	23.9		

Area to be patched	3050	m^2	22.8%
Area already patched	1320	m^2	9.9%
Area Ravelled	13065	m^2	97.5%
Area patched during shoulder repair	600	m^2	4.5%

Average Deflection	δ_p	1.30	mm	OWP	18	86%
Standard Deviation	σ	0.45	mm	IWP	3	14%
Calibration Correction Factor	F_c	0.993	0.99			
Seasonal Correction Factor	F_w	1.300				
Design Deflection	δ_d	1.98	mm			
Percentile to equal the Design Deflection	96%	2.10	mm			
Predicted Design Axles	No.	4.11	$x10^6$ Axles			
Residual Equivalent Standard Axles	No.	1.26	$x10^6$ ESAs			

Percentile of the Road that will Require Reconstruction 4% of the road

Percentile of the Road that will not Require Strengthening d= 2.10 mm 96%

Average Rut Depth		4.7	mm
Standard Deviation of Rut Depth		5.5	mm
Avg.Radius of Curvature		47	m
Avg.M_r Upper Layers		102	MPa
M_r Base	80%	137	MPa
M_r Subbase	20%	73	MPa
Avg.M_r of the Foundation		52	MPa
M_r Selected Subgrade	80%	70	MPa
M_r Subgrade	20%	35	MPa

Target Deflection: 0.9 mm

Existing Base Material: CR

Crushed Rock Granular Overlay Thickness	=	330 mm
Stabilised Natural Gravel Overlay Thickness	=	330 mm
Natural Gravel Granular Overlay Thickness	=	330 mm
Asphalt Overlay Thickness	=	165 mm

Deflection for HDM model $\delta_{(80kN)} =$ 3.05 mm

Road Maintenance and Rehabilitation Project - Malawi | **Roughton International**

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths | *in association with* **Jatula Partners**

Road Name: Dedza - Biriwiri | Road Code: 10 | Sample Length No.: S3 | Truck Axle Load - LHS: 3175 kg | Date: 12-Aug-98

Chainage (km) 52.75 to 54.75 | Sample Length Code: 103 | Width: 6.7 m | RHS: 3175 kg | Operator: RI/MOWS

Chainage (km)		Surface Condition																												
		Primary Cracking						Secondary Cracking						Pothole		Patch		Edge		Ravel		Bleed		Skid		Deform				
From	To	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Number	Av.Area (m^2)	Number	Av.Area (m^2)	Length	Av.Width (m)	Extent (%)	Degree	Extent (%)	Degree	Extent (%)	Degree	Condition	Position	Shoulder Condition	Drainage Condition	Point Number
																														0
52.75	52.85	L	CW	3	25	✓	✓									5	4			100	3			100	2			P	F	1
52.85	52.95	C	CW	3	50	✓	✓	L	CW	3	50	✓	✓			5	7			100	3			100	2	P	CW	P	F	2
52.95	53.05	C	CW	3	40	✓	✓	L	CW	3	40	✓	✓							100	3			100	2	P	CW	P	F	3
53.05	53.15	C	CW	3	60	✓	✓	L	CW	3	60	✓	✓							100	3			100	2	P	CW	P	F	4
53.15	53.25	C	W	3	50	✓	✓	L	W	3	50	✓	✓			5	25	100	0.4	100	3			100	2	P	W	P	F	5
53.25	53.35	C	CW	3	40	✓	✓	L	CW	3	40	✓	✓			5	21	100	0.4	100	3			100	2	P	CW	P	F	6
53.35	53.45	L	CW	3	50	✓	✓											100	0.4	100	3			100	2	P	CW	P	F	7
53.45	53.55	L	CW	3	60	✓	✓									5	42	100	0.4	100	3			100	2	P	CW	P	F	8
53.55	53.65	L	CW	3	50	✓	✓																			P	CW	P	F	9
53.65	53.75	L	CW	3	40	✓	✓											100	0.4	100	3			100	2	P	CW	P	F	10
53.75	53.85	L	CW	3	50	✓	✓											100	0.4	100	3			100	2	P	CW	P	F	11
53.85	53.95	L	CW	3	50	✓	✓											100	0.2	100	3			100	2			P	F	12
53.95	54.05	C	CW	3	30	✓	✓	L	CW	3	30	✓	✓							100	3			100	2			P	F	13
54.05	54.15	C	CW	3	40	✓	✓	L	CW	3	40	✓	✓					100	0.3	100	3			100	2			P	F	14
54.15	54.25	C	CW	3	30	✓	✓	L	CW	3	30	✓	✓					100	0.3	100	3			100	2			P	F	15
54.25	54.35	C	CW	3	45	✓	✓	L	CW	3	45	✓	✓					100	0.3	100	3			100	2			P	F	16
54.35	54.45	C	CW	3	40	✓	✓	L	CW	3	40	✓	✓					100	0.3	100	3			100	2			P	F	17
54.45	54.55	C	CW	3	40	✓	✓	L	CW	3	40	✓	✓					100	0.4	100	3			100	2			P	P	18
54.55	54.65	C	CW	3	50	✓	✓											100	0.2	100	3			100	2	P	CW	P	P	19
54.65	54.75	C	CW	4	60	✓	✓									5	23	100	0.2	100	3			100	2	P	CW	P	F	20

Point Number		Peak Deflection (mm x 100)										Rad.of Curve								Rut Depth (mm)	
		LH Wheelpath				RH Wheelpath						LH Wheelpath									
		Initial	Maximum	Final	Deflection	Initial	Maximum	Final	Deflection	Max Corrected	Wheel Path	Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	LHS	RHS
0	L	2	29	3	53	2	25	3	45	69	OWP	0	22	0	64	61	1.2	94	112	6	5
		2	29	2	54	2	25	2	46			0	24	0	58						
1	L	2	32	5	57	1	20	-1	40	73	OWP	0	16	5	104	85	2.7	72	197	5	6
		4	32	4	56	1	20	0	39			0	21	0	67						
2	L	3	36	4	65	3	33	2	61	81	OWP	0	29	0	48	48	1.0	83	85	5	0
		3	34	4	61	3	33	3	60												
3	L	3	27	2	49	2	27	2	50	66	IWP	0	24	-4	54	57	0.8	118	94	6	5
		2	24	1	45	2	28	2	52			0	22	-2	61						
4	L	4	42	10	70	2	26	2	48	93	OWP	0	31	-1	44	43	1.1	71	77	7	0
		4	40	2	74	2	27	3	49			0	32	-3	42						
5	L	4	18	0	32	3	19	4	31	46	OWP	0	16	-4	78	78	0.9	151	131	4	0
		0	20	0	40	2	19	3	33												
6	L	0	42	4	80	4	21	4	34	99	OWP	0	29	0	48	48	1.6	61	96	8	0
		4	41	5	73	3	20	3	34												
7	L	3	14	5	20	1	13	1	24	30	IWP	0	10	0	140	140	0.9	262	239	5	4
		2	14	5	21	3	15	4	23												
8	L	2	33	3	61	1	16	1	30	79	OWP	-1	20	-2	65	65	1.8	74	134	0	6
		3	33	2	61	2	17	2	30												
9	L	5	46	20	67	3	22	2	39	88	OWP	0	18	-4	70	82	3.8	55	206	9	0
		5	40	5	70	2	21	2	38			0	15	0	93						
10	L	3	32	10	51	2	20	4	34	61	OWP	0	20	-2	67	65	1.1	109	116	6	0
		1	24	3	44	3	21	4	35			0	20	-4	64						
11	L	3	40	7	70	3	21	4	35	90	OWP	0	28	0	50	48	1.3	70	91	9	0
		3	44	15	70	3	21	3	36			0	30	0	47						
12	L	7	28	8	41	3	19	4	31	53	OWP	0	25	0	56	53	0.5	151	78	5	0
		7	28	8	41	3	20	4	33			0	28	1	51						
13	L	6	30	5	49	2	22	2	40	72	OWP	0	30	0	47	51	0.9	96	88	6	0
		8	40	9	63	3	23	3	40			0	25	0	56						
14	L	6	32	5	53	3	22	2	39	68	OWP	0	28	1	51	50	0.8	107	81	9	0
		6	32	6	52	3	22	2	39			0	29	1	49						
15	L	6	29	14	38	2	16	2	28	48	OWP	0	22	-1	62	62	0.6	163	93	4	0
		6	24	6	36	3	17	3	28			0	23	1	62						
16	L	7	24	7	34	3	18	4	29	44	OWP	0	27	0	52	71	0.6	173	110	6	0
		7	24	7	34	3	17	4	27			-3	13	-2	90						
17	L	7	28	7	42	3	22	4	37	56	OWP	0	23	0	61	65	0.9	127	108	0	4
		6	28	6	44	3	23	3	40			0	20	-1	68						
18	L	7	28	10	39	3	14	4	21	49	OWP	0	20	0	70	68	0.7	149	110	3	0
		7	29	14	37	3	15	4	23			0	21	0	67						
19	L	6	32	7	51	3	33	1	62	80	IWP	0	28	0	50	50	0.7	115	79	5	0
		6	32	9	49	3	34	3	62												
20	L	6	46	7	79	3	36	2	67	100	OWP	0	33	-1	42	41	1.1	66	74	0	0
		6	46	10	76	3	35	0	67			0	35	0	40						

Road Maintenance and Rehabilitation Project - Malawi

Roughton International

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

in association with **Jatula Partners**

Road Name:	Dedza - Biriwiri	Road Code:	10	Sample Length No.:	S3	Truck Axle Load - LHS:	3175 kg	Date:	12-Aug-98
Chainage (km)	52.75 to 54.75	Sample Length Code: 103		Width:	6.7 m	RHS:	3175 kg	Operator:	RI/MOWS

Averages and Totals

Area Cracked	6030	m^2	45.0%
Wide Cracks	6030	m^2	45.0%
Average Condition Index	12.4		
Minimum Condition Index	5.2		
Maximum Condition Index	18.9		

Area to be patched	1365	m^2	10.2%
Area already patched	458	m^2	3.4%
Area Ravelled	12730	m^2	95.0%
Area patched during shoulder repair	600	m^2	4.5%

Average Deflection	δ_p	0.69	mm	OWP	18	86%
Standard Deviation	σ	0.20	mm	IWP	3	14%
Calibration Correction Factor	F_c	0.993	0.99			
Seasonal Correction Factor	F_w	1.300				
Design Deflection	δ_d	0.98	mm			
Percentile to equal the Design Deflection	96%	0.99	mm			
Predicted Design Axles	No.	4.11	$x10^6$ Axles			
Residual Equivalent Standard Axles	No.	1.26	$x10^6$ ESAs			

Percentile of the Road that will Require Reconstruction 4% of the road

Percentile of the Road that will not Require Strengthening d= 0.99 mm 96%

Average Rut Depth		3.3 mm
Standard Deviation of Rut Depth		3.1 mm
Avg.Radius of Curvature		62 m
Avg.M_r Upper Layers		114 MPa
M_r Base	80%	131 MPa
M_r Subbase	20%	81 MPa
Avg.M_r of the Foundation		113 MPa
M_r Selected Subgrade	80%	151 MPa
M_r Subgrade	20%	71 MPa

Target Deflection: 0.9 mm

Existing Base Material: CR

Crushed Rock Granular Overlay Thickness	=	70 mm
Stabilised Natural Gravel Overlay Thickness	=	70 mm
Natural Gravel Granular Overlay Thickness	=	70 mm
Asphalt Overlay Thickness	=	35 mm

Deflection for HDM model $\delta_{(80kN)} =$ 1.51 mm

Road Maintenance and Rehabilitation Project - Malawi
Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International
in association with **Jatula Partners**

Road Name: Salima - Senga Bay | Road Code: 11 | Sample Length No.: S1 | Truck Axle Load - LHS: 3175 kg | Date: 2-Aug-98

Chainage (km) 5.49 to 6.49 | Sample Length Code: 111 | Width: 5.6 m | RHS: 3175 kg | Operator: RI/MOWS

Chainage (km)		Surface Condition																													
		Primary Cracking						Secondary Cracking						Pothole		Patch		Edge		Ravel		Bleed		Skid		Deform			
From	To	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Number	Av.Area (m^2)	Number	Av.Area (m^2)	Length	Av.Width (m)	Extent (%)	Degree	Extent (%)	Degree	Extent (%)	Degree	Condition	Position	Shoulder Condition	Drainage Condition
5.49	5.59	C	CW	3	50	✓	✓							5	15	5	22	100	0.3	100	3	100	3	100	3	P	CW	P	F
5.59	5.69	C	CW	3	50	✓								5	15	5	22	100	0.3	100	3	100	3	100	3	P	CW	P	F
5.69	5.79	C	CW	3	50	✓	✓							5	15	5	22	100	0.3	100	3	100	3	100	3	P	CW	P	F
5.79	5.89	C	CW	3	50	✓								5	15	5	22	100	0.3	100	3	100	3	100	3	P	CW	P	F
5.89	5.99	C	CW	3	50	✓	✓							5	12	5	15	100	0.3	100	3	100	3	100	3	P	CW	P	F
5.99	6.09	C	CW	3	50	✓								5	15	5	22	100	0.3	100	3	100	3	100	3	P	CW	P	F
6.09	6.19	C	CW	3	50	✓	✓							5	15	5	22	100	0.3	100	3	100	3	100	3	P	CW	P	F
6.19	6.29	C	CW	3	50	✓								5	15	5	22	100	0.3	100	3	100	3	100	3	P	CW	P	F
6.29	6.39	C	CW	3	6	✓	✓							5	20	5	15	100	0.3	100	3	100	3	100	3	P	CW	P	F
6.39	6.49	C	CW	3	6	✓								5	20	5	15	100	0.3	100	3	100	3	100	3	P	CW	P	F

Chainage (km)		Point Number		Peak Deflection (mm x 100)										Rad.of Curve								Rut Depth (mm)	
				LH Wheelpath				RH Wheelpath						LH Wheelpath									
From	To			Initial	Maximum	Final	Deflection	Initial	Maximum	Final	Deflection	Max Corrected	Wheel Path	Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	LHS	RHS
							0				0	0	0										
							0				0												
5.49	5.59	0	L	0	33	1	65	2	24	2	44	85	OWP	0	23	0	61	65	2.1	66	141	5	9
				0	34	2	66	2	24	3	43			1	21	1	70						
5.59	5.69	1	L	2	35	3	65	1	21	2	39	86	OWP	0	0	0						0	0
				0	35	1	69	2	22	2	40			1	12	1	127						
5.69	5.79	2	L	2	32	3	59	1	13	0	25	76	OWP	0	22	0	64	67	1.8	77	137	0	4
				0	30	1	59	1	13	1	24			0	20	0	70						
5.79	5.89	3	L	1	24	1	46	2	15	2	26	60	OWP	0	18	0	78	83	1.7	99	167	13	0
				0	24	1	47	2	14	3	23			0	16	0	88						
5.89	5.99	4	L	3	15	5	22	2	14	3	23	29	IWP	0	15	1	97	93	0.4	291	131	13	3
				5	16	5	22	3	14	3	22			0	15	-1	90						
5.99	6.09	5	L	1	17	2	31	2	14	2	24	39	OWP	1	23	0	62	66	0.4	212	92	0	0
				3	18	3	30	2	14	2	24			0	20	0	70						
6.09	6.19	6	L	0	28	1	55	1	21	2	39	74	OWP	0	21	1	68	67	1.7	81	134	9	6
				1	30	0	59	2	21	2	38			2	24	3	65						
6.19	6.29	7	L	2	32	2	60	2	20	2	36	77	OWP	0	17	1	85	74	2.3	72	163	6	7
				2	32	3	59	2	21	2	38			0	22	0	64						
6.29	6.39	8	L	1	35	1	68	0	17	0	34	88	OWP	1	18	0	80	72	2.8	60	168	0	0
				0	34	0	68	1	17	1	32			0	22	0	64						
6.39	6.49	9	L	0	31	1	61	2	38	2	72	93	IWP	1	21	0	68	65	1.9	73	136	11	0
				2	33	2	62	2	38	2	72			0	24	3	62						

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International *in association with* **Jatula Partners**

Road Name:	Salima - Senga Bay	Road Code:	11	Sample Length No.:	S1
Truck Axle Load - LHS:	3175 kg	Date:	2-Aug-98		
Chainage (km)	5.49 to 6.49	Sample Length Code:	111	Width:	5.6 m
RHS:	3175 kg	Operator:	RI/MOWS		

Averages and Totals

Area Cracked	2307	m^2	41.2%
Wide Cracks	2307	m^2	41.2%
Average Condition Index	21.9		
Minimum Condition Index	21.8		
Maximum Condition Index	22.1		

Area to be patched	1883	m^2	33.6%
Area already patched	746	m^2	13.3%
Area Ravelled	5600	m^2	100.0%
Area patched during shoulder repair	300	m^2	5.4%

Average Deflection	δ_p	0.64	mm	
Standard Deviation	σ	0.29	mm	
Calibration Correction Factor	F_c	0.993	0.99	
Seasonal Correction Factor	F_w	1.300		
Design Deflection	δ_d	1.08	mm	
Percentile to equal the Design Deflection	96%	0.91	mm	
Predicted Design Axles	No.	2.24	$x10^6$	Axles
Residual Equivalent Standard Axles	No.	0.13	$x10^6$	ESAs

OWP	8	80%
IWP	2	20%

Average Rut Depth		4.3 mm
Standard Deviation of Rut Depth		4.7 mm
Avg.Radius of Curvature		75 m
Avg.M_r Upper Layers		141 MPa
M_r Base	80%	165 MPa
M_r Subbase	20%	133 MPa
Avg.M_r of the Foundation		115 MPa
M_r Selected Subgrade	80%	144 MPa
M_r Subgrade	20%	70 MPa

Percentile of the Road that will Require Reconstruction 4% of the road

Percentile of the Road that will not Require Strengthening d= 0.91 mm 96%

Target Deflection: 2.0 mm

Existing Base Material: GN

Crushed Rock Granular Overlay Thickness	=	-170 mm
Stabilised Natural Gravel Overlay Thickness	=	-170 mm
Natural Gravel Granular Overlay Thickness	=	-170 mm
Asphalt Overlay Thickness	=	-85 mm

Deflection for HDM model $\delta_{(80kN)} =$ 1.67 mm

Road Maintenance and Rehabilitation Project - Malawi

Roughton International

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

in association with **Jatula Partners**

Road Name: Salima - Senga Bay | Road Code: 11 | Sample Length No.: S2 | Truck Axle Load - LHS: 3175 kg | Date: 2-Aug-98

Chainage (km) 17.58 to 18.58 | Sample Length Code: 112 | Width: 5.6 m | RHS: 3175 kg | Operator: RI/MOWS

Chainage (km)		Surface Condition																													
		Primary Cracking						Secondary Cracking						Pothole		Patch		Edge		Ravel		Bleed		Skid		Deform			
From	To	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Number	Av.Area (m^2)	Number	Av.Area (m^2)	Length	Av.Width (m)	Extent (%)	Degree	Extent (%)	Degree	Extent (%)	Degree	Condition	Position	Shoulder Condition	Drainage Condition
17.58	17.68	C	CW	3	60	✓	✓							5	15	5	14	100	0.5	100	3	100	3	100	2	P	CW	P	F
17.68	17.78	C	CW	3	60	✓	✓							5	7	5	14	100	0.5	100	3	100	3	100	2	P	CW	P	F
17.78	17.88	C	CW	3	60	✓	✓							5	7	5	14	100	0.5	100	3	100	3	100	2	P	CW	P	F
17.88	17.98	C	CW	3	60	✓	✓							5	7	5	18	100	0.5	100	3	100	3	100	2	P	CW	P	F
17.98	18.08	C	CW	3	60	✓	✓							5	17	5	18	100	0.5	100	3	100	3	100	2	P	CW	P	F
18.08	18.18	C	CW	3	50	✓	✓							5	13	5	15	100	0.2	100	3	100	2	100	2	P	CW	P	F
18.18	18.28	C	CW	3	40	✓	✓							5	8	5	15	100	0.2	100	3	100	2	100	2	P	CW	P	F
18.28	18.38	C	CW	3	50	✓	✓							5	8	5	15	100	0.2	100	3	100	2	100	2	P	CW	P	F
18.38	18.48	C	CW	3	60	✓	✓							5	12	5	12	100	0.2	100	3	100	2	100	2	P	CW	P	F
18.48	18.58	C	CW	3	50	✓	✓							5	12	5	12	100	0.3							P	CW	P	F

Point Number		Peak Deflection (mm x 100)										Rad.of Curve								Rut Depth (mm)	
		LH Wheelpath				RH Wheelpath						LH Wheelpath									
		Initial	Maximum	Final	Deflection	Initial	Maximum	Final	Deflection	Max Corrected	Wheel Path	Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	LHS	RHS
11	R	2	20	1	37	2	17	2	30	47	OWP	0	20	0	70	68	0.7	158	107	8	9
		0	18	0	36	2	17	2	30			0	21	0	67						
12	R	2	25	2	46	2	23	3	41	61	OWP	1	19	0	76	73	1.4	102	139	0	0
		2	27	3	49	2	23	1	43			0	20	0	70						
13	R	2	20	2	36	2	15	1	27	49	OWP									0	7
		2	22	2	40	2	16	1	29			0	20	1	72						
14	R	4	26	6	42	2	40	3	75	96	IWP	1	23	2	65	62	0.7	135	99	9	7
		4	25	4	42	2	39	3	73			1	23	-3	58						
15	R	2	27	1	51	3	30	3	54	71	IWP	0	21	0	67	62	1.0	106	109	9	4
		0	24	1	47	3	30	1	56			0	24	-1	57						
16	R	2	24	2	44	3	20	3	34	57	OWP	1	10	1	156	123	3.6	86	307	5	7
		0	23	1	45	2	19	1	35			5	20	4	90						
17	R	1	29	1	56	3	26	3	46	70	OWP	0	20	1	72	60	1.2	92	109	5	5
		3	30	4	53	3	26	3	46			2	32	3	47						
18	R	0	23	0	46	1	26	2	49	65	IWP	1	22	2	68	65	1.0	114	114	0	7
		1	24	1	46	1	27	1	52			3	25	2	62						
19	R	2	26	3	47	2	25	2	46	63	OWP	2	15	-1	97	131	4.9	73	355	3	4
		2	27	2	50	1	25	1	48			5	12	2	165						
20	R	0	22	1	43	2	25	2	46	59	IWP	3	9	3	233	233	12.6	65	827	0	0
		1	22	1	42	2	25	2	46												
21	R	1	19	3	34	3	26	1	48	62	IWP	2	20	0	74	89	1.1	147	158	6	7
		0	18	0	36	2	26	2	48			0	15	3	104						

Road Maintenance and Rehabilitation Project - Malawi **R**oughton International

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths *in association with* **Jatula Partners**

Road Name:	Salima - Senga Bay	Road Code:	11	Sample Length No.:	S2	Truck Axle Load - LHS:	3175 kg	Date: 2-Aug-98
Chainage (km)	17.58 to 18.58	Sample Length Code: 112	Width: 5.6 m			RHS:	3175 kg	Operator: RI/MOWS

Averages and Totals

Area Cracked	2744 m^2	49.0%	Area to be patched	1798 m^2	32.1%	Average Deflection δ_p	0.64 mm	OWP 6 55%	Average Rut Depth 4.6 mm
Wide Cracks	2744 m^2	49.0%	Area already patched	551 m^2	9.8%	Standard Deviation σ	0.13 mm	IWP 5 45%	Standard Deviation of Rut Depth 3.3 mm
			Area Ravelled	4480 m^2	80.0%	Calibration Correction Factor F_c	0.993 0.99		
Average Condition Index	20.2		Area patched during shoulder repair	300 m^2	5.4%	Seasonal Correction Factor F_w	1.300		Avg.Radius of Curvature 88 m
Minimum Condition Index	14.8					Design Deflection δ_d	0.83 mm		Avg.M_r Upper Layers 233 MPa
Maximum Condition Index	21.8					Percentile to equal the Design Deflection 96%	0.85 mm		M_r Base 80% 316 MPa
						Predicted Design Axles No.	2.24 $x10^6$ Axles		M_r Subbase 20% 109 MPa
						Residual Equivalent Standard Axles No.	0.13 $x10^6$ ESAs		Avg.M_r of the Foundation 108 MPa
						Percentile of the Road that will Require Reconstruction	4% of the road		M_r Selected Subgrade 80% 137 MPa
						Percentile of the Road that will not Require Strengthening d= 0.85 mm	96%		M_r Subgrade 20% 83 MPa

Target Deflection: 2.0 mm

Crushed Rock Granular Overlay Thickness = -330 mm
Stabilised Natural Gravel Overlay Thickness = -330 mm
Natural Gravel Granular Overlay Thickness = -330 mm

Existing Base Material: GN

Asphalt Overlay Thickness = -165 mm

Deflection for HDM model $\delta_{(80kN)}$ = 1.28 mm

Road Maintenance and Rehabilitation Project - Malawi — **R**oughton International *in association with* **Jatula Partners**

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Road Name: Benga - Nkhotakota | Road Code: 12 | Sample Length No.: S1 | Truck Axle Load - LHS: 3175 kg | Date: 3-Aug-98

Chainage (km) 5.49 to 7.49 | Sample Length Code: 121 | Width: 5.5 m | RHS: 3175 kg | Operator: RI/MOWS

Chainage (km)		Surface Condition																												
		Primary Cracking						Secondary Cracking						Pothole		Patch		Edge		Ravel		Bleed		Skid		Deform				
From	To	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Number	Av.Area (m^2)	Number	Av.Area (m^2)	Length	Av.Width (m)	Extent (%)	Degree	Extent (%)	Degree	Extent (%)	Degree	Condion	Position	Shoulder Condition	Drainage Condition	Point Number
																														63
5.49	5.59																	100	0.2									P	F	64
5.59	5.69																	100	0.2									P	F	65
5.69	5.79																	100	0.2									P	F	66
5.79	5.89																	100	0.2									P	P	67
5.89	5.99																	100	0.3									P	P	68
5.99	6.09																	100	0.3	100	2	30	2					P	P	69
6.09	6.19																	100	0.5	100	2	50	2					P	P	70
6.19	6.29																	100	0.2	100	2	100	2					F	F	71
6.29	6.39																	100	0.2	100	2	100	2					P	F	72
6.39	6.49																	100	0.2	100	2							F	F	73
6.49	6.59																	100	0.2	100	2	100	2					P	P	74
6.59	6.69																	100	0.2	100	2	100	2					P	P	75
6.69	6.79																	100	0.4	100	2	100	2					P	P	76
6.79	6.89	L	WP	3	20													100	0.2	100	2	100	2					P	P	77
6.89	6.99																	100	0.2	100	2	100	2					P	P	78
6.99	7.09																	100	0.2	100	2	100	2					P	P	79
7.09	7.19																	100	0.2	100	2	100	2					P	P	80
7.19	7.29	L	CL	3	10													100	0.3	100	2	100	2	100	2			P	P	81
7.29	7.39																	100	0.3	100	2	100	2	100	2			P	P	82
7.39	7.49																	100	0.3	100	2	100	2	100	2			P	P	83

Point Number		Peak Deflection (mm x 100)										Rad.of Curve								Rut Depth (mm)	
		LH Wheelpath				RH Wheelpath						LH Wheelpath									
		Initial	Maximum	Final	Deflection	Initial	Maximum	Final	Deflection	Max Corrected	Wheel Path	Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	LHS	RHS
63	R	1	24	1	46	2	24	2	44	58	OWP	0	12	0	117	128	4.0	82	331	7	0
		0	22	0	44	2	24	2	44			0	10	0	140						
64	R	2	10	3	15	2	8	2	12	19	OWP	0	11	2	140	140	0.5	422	199	0	0
		2	9	1	15	2	8	1	13			0	10	0	140						
65	R	0	20	1	39	2	19	1	35	50	OWP	0	12	2	127	127	2.9	103	300	8	6
		2	22	3	39	2	20	2	36												
66	R	1	33	3	62	2	29	1	55	82	OWP	0	15	0	93	93	4.2	58	244	0	4
		1	34	2	65	2	30	2	56												
67	R	1	21	1	40	2	32	1	61	76	IWP	0	11	0	127	134	3.4	96	329	8	4
		2	22	2	40	2	30	1	57			0	10	0	140						
68	R	1	29	2	55	2	31	2	58	75	IWP									9	0
		1	29	1	56	2	31	2	58												
69	R	0	33	0	66	2	32	0	62	85	OWP	0	20	0	70	57	1.6	70	115	13	7
		1	34	1	66	2	32	0	62			0	32	1	44						
70	R	2	26	3	47	2	34	1	65	85	IWP	0	20	1	72	72	1.5	95	140	9	0
		2	28	1	53	2	35	1	67												
71	R	1	34	1	66	2	35	0	68	87	IWP	0	0	0						0	4
		0	33	0	66	2	35	1	67												
72	R	2	39	2	74	2	43	1	83	107	IWP	0	10	0	140	140	14.5	36	515	0	0
		2	40	1	77	2	43	1	83												
73	R	2	40	1	77	2	41	-1	81	103	IWP	0	4	0	350	257	54.1	25	1367	11	6
		1	39	1	76	2	41	1	79			-1	8	0	165						
74	R	2	32	2	60	2	39	2	74	96	IWP	0	10	0	140	131	7.7	52	404	9	0
		0	30	0	60	2	39	2	74			-2	10	-1	122						
75	R	1	30	2	57	2	45	0	88	113	IWP	0	12	0	117	117	5.7	58	332	9	0
		1	31	1	60	2	45	1	87												
76	R	1	25	1	48	1	38	1	74	96	IWP	0	10	-1	133	101	2.9	82	237	0	0
		2	27	2	50	1	38	1	74			0	20	-1	68						
77	R	0	15	0	30	2	38	1	73	94	IWP	0	10	0	140	140	2.0	146	299	8	0
		2	17	2	30	2	38	2	72												
78	R	1	15	0	29	1	30	0	59	78	IWP	0	5	0	280	172	2.7	146	397	10	8
		2	15	1	27	1	32	1	62			0	22	0	64						
79	R	2	29	1	55	3	33	0	63	81	IWP	0	10	1	147	147	8.1	57	461	11	6
		1	28	1	54	2	33	1	63												
80	R	2	9	2	14	2	6	2	8	19	OWP	0	22	0	64	64	0.1	675	56	4	7
		1	9	2	15	2	6	2	8												
81	R	2	9	2	14	3	18	1	32	41	IWP	0	20	0	70	113	0.3	526	135	14	0
		0	7	0	14	3	18	1	32			0	9	0	156						
82	R	2	8	3	11	3	7	1	10	14	OWP	0	10	0	140	210	0.6	547	315	0	0
		1	7	2	11	3	7	2	9			0	5	0	280						
83	R	0	28	1	55	3	35	2	65	83	IWP	0	20	-2	67	100	3.8	66	254	0	0
		0	30	2	58	3	35	3	64			-1	10	0	133						

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International

in association with **Jatula Partners**

Road Name:	Benga - Nkhotakota	Road Code:	12	Sample Length No.:	S1	Truck Axle Load - LHS:	3175 kg
Date:	3-Aug-98						
Chainage (km)	5.49 to 7.49	Sample Length Code:	121	Width:	5.5 m	RHS:	3175 kg
Operator:	RI/MOWS						

Averages and Totals

Area Cracked	165	m^2	1.5%
Wide Cracks	0	m^2	0.0%
Average Condition Index	4.1		
Minimum Condition Index	1.6		
Maximum Condition Index	6.5		

Area to be patched	1400	m^2	12.7%
Area already patched	0	m^2	0.0%
Area Ravelled	8250	m^2	75.0%
Area patched during shoulder repair	600	m^2	5.5%

Average Deflection	δ_p	0.73	mm
Standard Deviation	σ	0.29	mm
Calibration Correction Factor	F_c	0.993	0.99
Seasonal Correction Factor	F_w	1.300	
Design Deflection	δ_d	1.17	mm
Percentile to equal the Design Deflection	96%	1.08	mm
Predicted Design Axles	No.	1.82	$x10^6$ Axles
Residual Equivalent Standard Axles	No.	0.46	$x10^6$ ESAs

Percentile of the Road that will Require Reconstruction 4% of the road

Percentile of the Road that will not Require Strengthening d= 1.08 mm 96%

OWP	7	33%
IWP	14	67%

Average Rut Depth		4.3 mm
Standard Deviation of Rut Depth		4.5 mm
Avg.Radius of Curvature		133 m
Avg.M_r Upper Layers		338 MPa
M_r Base	80%	400 MPa
M_r Subbase	20%	175 MPa
Avg.M_r of the Foundation		176 MPa
M_r Selected Subgrade	80%	257 MPa
M_r Subgrade	20%	57 MPa

Target Deflection: 1.3 mm

Existing Base Material: CR

Crushed Rock Granular Overlay Thickness	=	-70 mm
Stabilised Natural Gravel Overlay Thickness	=	-70 mm
Natural Gravel Granular Overlay Thickness	=	-70 mm
Asphalt Overlay Thickness	=	-35 mm

Deflection for HDM model $\delta_{(80kN)} =$ 1.80 mm

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International
in association with **Jatula Partners**

Road Name: Benga - Nkhotakota | Road Code: 12 | Sample Length No.: S2 | Truck Axle Load - LHS: 3175 kg | Date: 3-Aug-98

Chainage (km) 20.88 to 23.38 | Sample Length Code: 122 | Width: 5.5 m | RHS: 3175 kg | Operator: RI/MOWS

Chainage (km)		Surface Condition																											
		Primary Cracking						Secondary Cracking						Pothole		Patch		Edge		Ravel		Bleed		Skid		Deform			
From	To	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Number	Av.Area (m^2)	Number	Av.Area (m^2)	Length	Av.Width (m)	Extent (%)	Degree	Extent (%)	Degree	Extent (%)	Degree	Condition	Position	Shoulder Condition	Drainage Condition
20.88	20.98																	100	0.2	100	3	100	2	70	2			P	P
20.98	21.08																	100	0.2	100	3	100	2	70	2			P	P
21.08	21.18																	100	0.2	100	3	100	2	80	2			P	F
21.18	21.28																	100	0.2	100	3	100	2	80	2			P	F
21.28	21.38																	100	0.2	100	3	100	2	90	2			P	F
21.38	21.48																	100	0.2	100	3	100	2	70	2			P	F
21.48	21.58																	100	0.2	100	3	60	2	80	2			P	F
21.58	21.68	L	CW	3	20													100	0.2	100	3	60	2	80	2			P	F
21.68	21.78																	100	0.3	100	3	50	2	50	2			P	F
21.78	21.88																	100	0.3	100	3	50	2	50	2			P	F
21.88	21.98																	100	0.3	100	3	50	2	50	2			P	F
21.98	22.08																	100	0.3	100	3	100	2	100	2			P	F
22.08	22.18																	100	0.3	100	3	100	2	100	2			P	F
22.18	22.28																	100	0.3	100	3	100	2	100	2			P	F
22.28	22.38																	100	0.3	100	3	100	2	100	2			F	F
22.38	22.48																	100	0.4	100	3	100	2	100	2			P	F
22.48	22.58																	100	0.4	100	3	100	2	100	2			P	F
22.58	22.68																	100	0.4	100	3	100	2	100	2			P	F
22.68	22.78																	100	0.4	100	3	100	2	100	2			P	F
22.78	22.88																	100	0.4	100	3	100	2	100	2			P	F

Chainage (km)		Point Number		Peak Deflection (mm x 100)										Rad.of Curve								Rut Depth (mm)	
				LH Wheelpath				RH Wheelpath						LH Wheelpath									
From	To			Initial	Maximum	Final	Deflection	Initial	Maximum	Final	Deflection	Max Corrected	Wheel Path	Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	LHS	RHS
		42	L	1 0	17 16	-1 0	34 32	2 2	26 26	2 5	48 45	60	IWP	0	10	0	140	140	2.5	126	316	0	8
20.88	20.98	43	L	0 1	20 20	-2 -2	42 41	2 2	28 28	0 0	54 54	70	IWP	0	12	0	117	117	2.8	98	271	8	5
20.98	21.08	44	L	1 2	49 50	0 2	97 96	2 2	40 40	0 0	78 78	125	OWP	0	30	0	47	47	2.4	44	104	8	5
21.08	21.18	45	L	1 2	41 42	1 -1	80 83	3 2	41 40	4 0	75 78	105	OWP	0	10	0	140	140	17.0	32	539	7	3
21.18	21.28	46	L	2 1	74 72	2 1	144 142	1 2	70 70	0 0	139 138	185	OWP	0	22	0	64	64	10.5	20	214	8	4
21.28	21.38	47	L	2 0	22 21	1 -1	41 43	3 3	26 26	1 3	48 46	61	IWP	0 0	15 25	0 -1	93 55	74	1.1	122	133	0	0
21.38	21.48	48	L	1 0	40 40	-2 -2	81 82	2 2	36 37	0 1	70 71	105	OWP	0 0	8 10	-1 0	165 140	152	20.3	30	616	9	5
21.48	21.58	49	L	0 0	22 24	-1 0	45 48	3 3	7 8	3 3	8 10	60	OWP	0 0	22 12	-2 0	61 117	89	2.0	95	188	0	0
21.58	21.68		L	1 0	42 40	1 0	82 80	1 2	39 40	-5 1	82 77	105	OWP	0 0	15 16	2 -2	100 82	91	6.8	40	272	0	0
21.68	21.78	51	L	2 0	32 30	0 -4	62 64	2 1	38 37	2 0	72 73	94	IWP									0	0
21.78	21.88	52	L	2 1	16 13	4 2	26 23	1 2	22 22	1 2	42 40	53	IWP	0	5	1	311	311	7.2	131	944	6	7
21.88	21.98	53		0 0	20 22	0 6	40 38	2 1	30 30	0 0	58 59	76	IWP	0	10	0	140	140	3.6	98	349		
21.98	22.08	54	L	1 0	42 44	2 1	81 87	1 1	49 50	0 1	97 98	126	IWP	0	10	-4	117	117	12.3	33	411	0	0
22.08	22.18	55	L	0 0	30 30	0 1	60 59	1 1	17 17	0 0	33 33	77	OWP	0	30	14	61	61	1.5	80	119	3	0
22.18	22.28	56	L	1 2	44 46	-2 0	89 90	3 3	43 43	1 1	82 82	116	OWP	0	10	-5	112	112	12.9	31	399	0	0
22.28	22.38	57	L	0 0	32 34	0 2	64 66	2 2	27 26	0 1	52 49	84	OWP	0	12	0	117	117	7.2	49	353	8	9
22.38	22.48	58	L	2 0	26 28	-2 -1	52 57	1 1	26 26	-1 0	52 51	70	OWP	0 0	15 14	2 0	100 100	100	3.6	70	249	5	0
22.48	22.58	59	L	0 1	30 32	-2 -1	62 64	0 1	30 32	-1 0	61 63	81	OWP	0	0	0						9	3
22.58	22.68	60	L	1 0	28 30	-3 0	58 60	2 2	32 32	-2 0	64 62	81	IWP	0 0	10 15	3 2	165 100	132	7.6	54	407	5	0
22.68	22.78	61	L	1 1	16 16	-1 -1	32 32	2 2	30 31	3 0	55 60	74	IWP	0 0	16 15	1 2	90 100	95	1.0	163	168	5	0
22.78	22.88	62	L	0 0	17 16	-1 0	35 32	2 2	31 29	1 1	59 55	74	IWP	0	12	0	117	117	1.8	136	239	9	4

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International
in association with **Jatula Partners**

Road Name:	Benga - Nkhotakota	Road Code:	12	Sample Length No.:	S2	Truck Axle Load - LHS:	3175 kg	Date:	3-Aug-98
Chainage (km)	20.88 to 23.38	Sample Length Code:	122	Width:	5.5 m	RHS:	3175 kg	Operator:	RI/MOWS

Averages and Totals

Area Cracked	110	m^2	0.8%
Wide Cracks	0	m^2	0.0%
Average Condition Index	6.8		
Minimum Condition Index	5.7		
Maximum Condition Index	7.4		

Area to be patched	1140	m^2	8.3%
Area already patched	0	m^2	0.0%
Area Ravelled	11000	m^2	80.0%
Area patched during shoulder repair	750	m^2	5.5%

Average Deflection	δ_p	0.90	mm	
Standard Deviation	σ	0.31	mm	
Calibration Correction Factor	F_c	0.993	0.99	
Seasonal Correction Factor	F_w	1.300		
Design Deflection	δ_d	1.35	mm	
Percentile to equal the Design Deflection	96%	1.36	mm	
Predicted Design Axles	No.	1.82	$x10^6$	Axles
Residual Equivalent Standard Axles	No.	0.46	$x10^6$	ESAs

OWP	11	52%
IWP	10	48%

Percentile of the Road that will Require Reconstruction 4% of the road

Percentile of the Road that will not Require Strengthening d= 1.36 mm 96%

Average Rut Depth		3.6 mm
Standard Deviation of Rut Depth		3.5 mm
Avg.Radius of Curvature		113 m
Avg.M_r Upper Layers		331 MPa
M_r Base	80%	409 MPa
M_r Subbase	20%	180 MPa
Avg.M_r of the Foundation		76 MPa
M_r Selected Subgrade	80%	124 MPa
M_r Subgrade	20%	33 MPa

Target Deflection: 1.3 mm

Existing Base Material: CR

Crushed Rock Granular Overlay Thickness	=	0 mm
Stabilised Natural Gravel Overlay Thickness	=	0 mm
Natural Gravel Granular Overlay Thickness	=	0 mm
Asphalt Overlay Thickness	=	0 mm

Deflection for HDM model $\delta_{(80kN)} =$ 2.09 mm

Road Maintenance and Rehabilitation Project - Malawi
Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International
in association with **Jatula Partners**

Road Name: Nkhotakota - Dwangwa | Road Code: 12 | Sample Length No.: S3 | Truck Axle Load - LHS: 3175 kg | Date: 1-Aug-98

Chainage (km) 32.97 to 34.97 | Sample Length Code: 123 | Width: 5.6 m | RHS: 3175 kg | Operator: RI/MOWS

Chainage (km)		Surface Condition																													
		Primary Cracking						Secondary Cracking						Pothole		Patch		Edge		Ravel		Bleed		Skid		Deform					
From	To	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Number	Av.Area (m^2)	Number	Av.Area (m^2)	Length	Av.Width (m)	Extent (%)	Degree	Extent (%)	Degree	Extent (%)	Degree	Condtion	Position	Shoulder Condition	Drainage Condition	Point Number	
																														21	R
32.97	33.07															1	4	100	0.2	100	2	50	2					P	P	22	R
33.07	33.17	L	CL	3	20									9	5			100	0.3	100	2	50	2			P	WP	P	P	23	R
33.17	33.27																			30	2	30	2					F	F	24	R
33.27	33.37																			50	2	100	2			P	WP	P	F	25	R
33.37	33.47																									P	WP	P		26	R
33.47	33.57													1	3	1	6			80	2	100	2							27	R
33.57	33.67																	40	0.2	70	2	100	2							28	R
33.67	33.77																													29	R
33.77	33.87																	100	0.2	60	2	100	2							30	R
33.87	33.97																	100	0.2	60	2	100	2					P	P	31	R
33.97	34.07																	100	0.2	50	2	100	2					P	P	32	R
34.07	34.17																	100	0.2	40	2	100	2					P	P	33	R
34.17	34.27																			100	2	60	2					P	P	34	R
34.27	34.37																			100	2	60	2					P	F	35	R
34.37	34.47																	100	0.4	100	2	100	3					P	F	36	R
34.47	34.57																	100	0.4	100	2	100	3					P	P	37	R
34.57	34.67																	100	0.4	100	2	100	3					P	F	38	R
34.67	34.77																	100	0.2	100	2	100	2					P	F	39	R
34.77	34.87																	100	0.2	100	2	100	2					P	F	40	R
34.87	34.97																	100	0.2	100	2	100	2					P	F	41	R

Point Number		Peak Deflection (mm x 100)										Rad.of Curve								Rut Depth (mm)	
		LH Wheelpath				RH Wheelpath						LH Wheelpath									
		Initial	Maximum	Final	Deflection	Initial	Maximum	Final	Deflection	Max Corrected	Wheel Path	Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	LHS	RHS
21	R	4	32	5	55	2	38	2	72	94	IWP	1	8	1	200	174	12.1	50	608	5	0
		2	31	3	57	2	38	1	73			0	10	1	147						
22	R	3	28	4	49	2	35	-3	71	90	IWP	1	12	2	133	94	2.7	80	215	5	7
		1	28	2	53	3	38	5	68			0	20	-12	54						
23	R	2	39	2	74	2	32	2	60	94	OWP	1	15	0	97	97	6.1	46	280	8	7
		3	40	5	72	2	32	1	61												
24	R	0	40	1	79	3	38	0	73	104	OWP									5	4
		1	43	3	82	3	39	3	72												
25	R	1	13	2	23	3	31	1	58	74	IWP	0	10	-1	133	130	1.1	207	237	8	4
		1	15	3	26	3	31	3	56			0	10	-2	127						
26	R	2	52	5	97	1	48	-3	98	125	OWP	0	52	2	27	27	0.8	58	45	11	7
		3	50	0	97	2	49	2	94												
27	R	0	28	1	55	3	30	2	55	73	OWP	0	10	0	140	117	5.3	61	325	0	5
		0	29	0	58	2	30	2	56			0	15	0	93						
28	R	1	27	4	49	2	38	2	72	93	IWP	-1	10	1	140	101	3.0	81	239	9	11
		2	28	4	50	2	38	2	72			0	22	-1	62						
29	R	0	32	2	62	1	44	0	87	111	IWP	0	15	4	108	108	5.1	58	296	6	0
		2	31	2	58	1	43	0	85												
30	R	0	27	3	51	0	27	-2	56	70	IWP	0	20	0	70	72	1.5	92	141	0	0
		0	26	1	51	1	27	0	53			0	20	2	74						
31	R	1	25	4	45	3	27	2	49	62	IWP	0	20	3	76	76	1.2	113	141	10	0
		2	25	5	43	3	26	2	47												
32	R	1	11	3	18	2	15	2	26	32	IWP	0	15	0	93	93	0.3	432	112	0	0
		0	9	2	16	2	14	2	24												
33	R	0	21	2	40	2	18	2	32	52	OWP	1	10	0	147	128	3.2	97	308	5	7
		1	22	2	41	2	18	2	32			0	12	-2	108						
34	R	2	18	3	31	2	18	3	31	42	IWP	-2	10	0	127	127	2.0	136	269	5	4
		2	19	2	34	2	19	2	34												
35	R	1	23	1	44	2	18	-1	35	58	OWP	0	10	1	147	147	5.4	77	412	0	3
		1	24	1	46	2	19	0	36												
36	R	2	25	1	47	2	29	0	56	72	IWP	0	15	0	93	89	2.1	90	192	3	3
		2	26	1	49	2	30	2	56			0	17	1	85						
37	R	0	29	2	56	4	25	5	41	70	OWP	0	20	2	74	87	2.6	76	199	0	0
		1	28	2	53	3	23	0	43			0	14	0	100						
38	R	0	36	0	72	3	24	2	43	90	OWP	0	15	4	108	108	7.1	46	325	0	0
		0	34	0	68	0	26	-1	53												
39	R	0	36	0	72	4	26	3	45	92	OWP	0	30	-2	45	45	1.2	71	82	4	3
		0	35	0	70	1	22	0	43												
40	R	0	40	2	78	2	42	2	80	102	IWP	0	0	0						6	9
		0	39	0	78	2	40	0	78			0	30	0	47						
41	R	0	41	1	81	3	36	1	68	103	OWP	0	15	1	97	83	5.4	43	233	5	5
		1	41	2	79	1	34	0	67			0	20	0	70						

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International

in association with **Jatula Partners**

Road Name:	Nkhotakota - Dwangwa	Road Code:	12	Sample Length No.:	S3	Truck Axle Load - LHS:	3175 kg	Date:	1-Aug-98
Chainage (km)	32.97 to 34.97	Sample Length Code:	123	Width:	5.6 m	RHS:	3175 kg	Operator:	RI/MOWS

Averages and Totals

Area Cracked	112	m^2	1.0%
Wide Cracks	0	m^2	0.0%
Average Condition Index	5.5		
Minimum Condition Index	0.0		
Maximum Condition Index	16.5		

Area to be patched	809	m^2	7.2%
Area already patched	8	m^2	0.1%
Area Ravelled	8064	m^2	72.0%
Area patched during shoulder repair	600	m^2	5.4%

Average Deflection	δ_p	0.81	mm	
Standard Deviation	σ	0.24	mm	
Calibration Correction Factor	F_c	0.993	0.99	
Seasonal Correction Factor	F_w	1.300		
Design Deflection	δ_d	1.16	mm	
Percentile to equal the Design Deflection	96%	1.13	mm	
Predicted Design Axles	No.	2.65	$x10^6$	Axles
Residual Equivalent Standard Axles	No.	0.70	$x10^6$	ESAs

OWP	10	48%
IWP	11	52%

Percentile of the Road that will Require Reconstruction 4% of the road

Percentile of the Road that will not Require Strengthening d= 1.13 mm 96%

Average Rut Depth		4.1 mm
Standard Deviation of Rut Depth		3.4 mm
Avg.Radius of Curvature		101 m
Avg.M_r Upper Layers		245 MPa
M_r Base	80%	314 MPa
M_r Subbase	20%	141 MPa
Avg.M_r of the Foundation		101 MPa
M_r Selected Subgrade	80%	103 MPa
M_r Subgrade	20%	55 MPa

Target Deflection: 1.1 mm

Existing Base Material: CR

Crushed Rock Granular Overlay Thickness	=	30 mm
Stabilised Natural Gravel Overlay Thickness	=	30 mm
Natural Gravel Granular Overlay Thickness	=	30 mm
Asphalt Overlay Thickness	=	15 mm

Deflection for HDM model $\delta_{(80kN)} =$ 1.79 mm

Road Maintenance and Rehabilitation Project - Malawi

Roughton International

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

in association with **Jatula Partners**

Road Name: Nkhotakota - Dwangwa | Road Code: 12 | Sample Length No.: S4 | Truck Axle Load - LHS: 3175 kg | Date: 1-Aug-98

Chainage (km) 39.56 to 41.56 | Sample Length Code: 124 | Width: 5.6 m | RHS: 3175 kg | Operator: RI/MOWS

Chainage (km)		Surface Condition																											
		Primary Cracking						Secondary Cracking						Pothole		Patch		Edge		Ravel		Bleed		Skid		Deform			
From	To	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Number	Av.Area (m^2)	Number	Av.Area (m^2)	Length	Av.Width (m)	Extent (%)	Degree	Extent (%)	Degree	Extent (%)	Degree	Condion	Position	Shoulder Condition	Drainage Condition
39.56	39.66																	100	0.5	20	2	100	2					P	P
39.66	39.76															1	12	100	0.5	60	2	100	2					P	P
39.76	39.86	L	WP	2	3	✓										1	3	100	0.2	60	2	100	2					F	P
39.86	39.96																					100	2					F	F
39.96	40.06	C	WP	4	10	✓	✓									1	4	100	0.2	70	2	100	2					F	F
40.06	40.16																			70	2	100	2					F	F
40.16	40.26																			80	2	100	2					F	F
40.26	40.36																			80	2	100	2					P	F
40.36	40.46																			70	2	60	2					P	F
40.46	40.56																	100	0.2	60	2	60	2					P	F
40.56	40.66																			50	2	80	2					P	F
40.66	40.76																											F	F
40.76	40.86																	100	0.2	100	2	100	2					P	F
40.86	40.96													1	1			100	0.2	100	2	100	2					P	F
40.96	41.06													1	1	1	4			100	2	100	2					P	F
41.06	41.16																											F	F
41.16	41.26																	100	0.3									F	
41.26	41.36																	100	0.3									F	P
41.36	41.46	C	WP	4	2	✓	✓									1	1	100	0.3	100	2							F	P
41.46	41.56																	100	0.3	100	2							F	P

Point Number		Peak Deflection (mm x 100)										Rad.of Curve								Rut Depth (mm)	
		LH Wheelpath				RH Wheelpath						LH Wheelpath									
		Initial	Maximum	Final	Deflection	Initial	Maximum	Final	Deflection	Max Corrected	Wheel Path	Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	LHS	RHS
0	R	1	26	2	49	1	16	3	28	63	OWP	0	20	0	70	70	1.3	101	132	5	5
		1	25	1	48	1	16	3	28												
1	R	1	59	1	116	2	70	4	134	173	IWP	0	35	4	42	42	2.8	35	99	5	8
		2	59	1	115	2	70	4	134			0	32	-2	42						
2	R	1	65	2	127	2	70	3	135	174	IWP	0	15	1	97	68	9.4	24	223	12	0
		2	66	4	126	3	70	3	134			0	35	0	40						
3	R	0	90	5	175	2	74	7	139	228	OWP	0	45	-2	30	30	3.5	22	75	9	4
		1	89	-2	179	2	73	2	142												
4	R	2	22	2	40	2	30	3	55	74	IWP	0	25	0	56	63	0.7	136	102	8	0
		0	22	1	43	2	31	1	59			0	20	0	70						
5	R	2	26	2	48	3	28	3	50	62	IWP	0	5	0	280	204	11.7	60	707	8	6
		1	24	1	46	3	26	3	46			0	11	0	127						
6	R	2	26	2	48	3	21	2	37	62	OWP	0	25	1	57	64	1.0	108	112	0	7
		2	26	2	48	3	22	3	38			0	20	0	70						
7	R	1	27	1	52	3	28	3	50	66	OWP									8	7
		1	26	0	51	3	27	4	47												
8	R	0	26	0	52	2	33	3	61	79	IWP									7	0
		0	25	0	50	2	33	2	62			0	10	0	140						
9	R	2	28	2	52	3	29	4	51	69	OWP									0	0
		0	28	1	55	3	29	3	52			0	8	0	175						
10	R	0	19	0	38	2	25	3	45	57	IWP									0	4
		1	21	2	39	3	25	4	43			0	10	1	147						
11	R	2	26	1	49	3	30	1	56	71	IWP	0	10	-2	127	127	4.8	71	345	0	7
		2	27	2	50	3	30	3	54												
12	R	2	28	2	52	3	22	3	38	67	OWP	0	25	2	58	58	1.0	100	103	0	6
		1	27	1	52	3	23	3	40												
13	R	3	29	3	52	4	41	5	73	94	IWP									4	3
		0	26	0	52	3	40	4	73												
14	R	2	30	2	56	3	39	4	71	90	IWP										
		2	30	1	57	3	38	4	69												
15	R	0	38	0	76	0	49	4	94	121	IWP									0	0
		1	38	0	75	1	49	4	93												
16	R	1	41	0	81	2	40	5	73	105	OWP	0	28	0	50	50	1.9	55	104	8	7
		1	42	2	81	2	41	4	76												
17	R	1	38	-2	77	2	44	4	82	106	IWP	0	10	0	140	140	15.5	34	525	8	3
		0	40	1	79	2	44	4	82												
18	R	1	36	1	70	3	33	4	59	93	OWP	0	20	0	70	76	3.6	53	190	9	8
		0	36	-2	74	2	34	3	63			0	18	2	82						
19	R	0	50	1	99	2	52	5	97	129	OWP	0	25	0	56	66	5.3	35	183	13	0
		2	50	-3	101	2	52	5	97			0	20	3	76						
20	R	1	28	1	54	2	35	4	64	81	IWP	2	36	0	40	40	0.5	112	58	16	0
		2	29	0	56	3	34	3	62												

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International
in association with **Jatula Partners**

Road Name:	Nkhotakota - Dwangwa	Road Code:	12	Sample Length No.:	S4	Truck Axle Load - LHS:	3175 kg
Date:	1-Aug-98						
Chainage (km)	39.56 to 41.56	Sample Length Code:	124	Width:	5.6 m	RHS:	3175 kg
Operator:	RI/MOWS						

Averages and Totals

Area Cracked	84	m^2	0.8%
Wide Cracks	84	m^2	0.8%
Average Condition Index	3.2		
Minimum Condition Index	0.8		
Maximum Condition Index	4.7		

Area to be patched	774	m^2	6.9%
Area already patched	18	m^2	0.2%
Area Ravelled	6272	m^2	56.0%
Area patched during shoulder repair	600	m^2	5.4%

Average Deflection	δ_p	0.98	mm	
Standard Deviation	σ	0.45	mm	
Calibration Correction Factor	F_c	0.993	0.99	
Seasonal Correction Factor	F_w	1.300		
Design Deflection	δ_d	1.66	mm	
Percentile to equal the Design Deflection	96%	1.83	mm	
Predicted Design Axles	No.	2.65	$x10^6$	Axles
Residual Equivalent Standard Axles	No.	0.70	$x10^6$	ESAs

OWP	9	43%
IWP	12	57%

Average Rut Depth		4.8 mm
Standard Deviation of Rut Depth		4.2 mm
Avg.Radius of Curvature		89 m
Avg.M_r Upper Layers		211 MPa
M_r Base	80%	272 MPa
M_r Subbase	20%	101 MPa
Avg.M_r of the Foundation		68 MPa
M_r Selected Subgrade	80%	104 MPa
M_r Subgrade	20%	34 MPa

Percentile of the Road that will Require Reconstruction 4% of the road

Percentile of the Road that will not Require Strengthening d= 1.83 mm 96%

Target Deflection: 1.1 mm

Existing Base Material: CR

Crushed Rock Granular Overlay Thickness	=	180 mm
Stabilised Natural Gravel Overlay Thickness	=	180 mm
Natural Gravel Granular Overlay Thickness	=	180 mm
Asphalt Overlay Thickness	=	90 mm

Deflection for HDM model $\delta_{(80kN)} =$ 2.55 mm

Road Maintenance and Rehabilitation Project - Malawi

Roughton International

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

in association with **Jatula Partners**

Road Name: Chingeni - Liwonde | Road Code: 13 | Sample Length No.: S1 | Truck Axle Load - LHS: 3175 kg | Date: 7-Aug-98

Chainage (km) 6.59 to 7.59 | Sample Length Code: 131 | Width: 6.7 m | RHS: 3175 kg | Operator: RI/MOWS

Chainage (km)		Surface Condition																												
		Primary Cracking						Secondary Cracking						Pothole		Patch		Edge		Ravel		Bleed		Skid		Deform				
From	To	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Number	Av.Area (m^2)	Number	Av.Area (m^2)	Length	Av.Width (m)	Extent (%)	Degree	Extent (%)	Degree	Extent (%)	Degree	Condition	Position	Shoulder Condition	Drainage Condition	Point Number
																														0
6.59	6.69	C	CW	4	40	✓	✓	L	CW	4	40	✓	✓			5	20	100	0.4	100	3	100	3	100	2	P	CW	P	P	1
6.69	6.79	C	CW	3	30	✓	✓	L	CW	3	30	✓	✓			5	30	100	0.3	100	3	100	3	100	4	P	CW	P	P	2
6.79	6.89	C	CW	3	50	✓	✓	L	CW	3	50	✓	✓			5	21	100	0.3	100	3	100	3	100	2	P	CW	P	P	3
6.89	6.99	C	CW	4	45	✓	✓	L	CW	4	45	✓	✓			5	30	100	0.3	100	3	100	3	100	2	P	CW	P	F	4
6.99	7.09	B	CW	4	50	✓	✓									5	21	100	0.3	100	3	100	3	100	2	P	CW	P	F	5
7.09	7.19	B	CW	4	50	✓	✓									5	14	100	0.3	100	3	100	3	100	2	P	CW	P	F	6
7.19	7.29	C	CW	4	50	✓	✓	B	CW	4	50	✓	✓			5	18	100	0.3	100	3	100	3	100	2	P	CW	P	F	7
7.29	7.39	C	CW	4	40	✓	✓	B	CW	4	40	✓	✓			5	21	100	0.2	100	3	100	3	100	2	P	CW	P	F	8
7.39	7.49	B	CW	4	30	✓	✓											100	0.2	100	3	100	3	100	2	P	CW	P	F	9
7.49	7.59	B	CW	40	40	✓	✓									5	14	100	0.2	100	3	100	3	100	2	P	CW	P	F	10

Point Number		Peak Deflection (mm x 100)										Rad.of Curve								Rut Depth (mm)	
		LH Wheelpath				RH Wheelpath						LH Wheelpath									
		Initial	Maximum	Final	Deflection	Initial	Maximum	Final	Deflection	Max Corrected	Wheel Path	Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	LHS	RHS
0	L	0	26	0	52	2	50	3	95	123	IWP	2	31	0	47	47	0.7	112	74	5	8
		0	26	0	52	2	50	3	95			0	29	0	48						
1	L	6	32	11	47	2	31	2	58	74	IWP	0	28	0	50	46	0.5	126	68	5	4
		5	30	5	50	2	31	3	57			0	33	0	42						
2	L	5	24	6	37	2	31	2	58	74	IWP	0	19	0	74	76	1.0	136	131	4	5
		4	24	3	41	2	31	3	57			0	18	0	78						
3	L	5	34	11	52	3	41	3	76	96	IWP	0	21	0	67	65	1.3	95	123	0	4
		5	31	5	52	2	39	3	73			0	22	0	64						
4	L	5	36	6	61	3	34	3	62	83	OWP	0	41	0	34	35	0.5	96	52	5	6
		5	42	12	67	3	35	3	64			0	39	0	36						
5	L	5	24	8	35	2	24	3	43	54	IWP	0	16	0	88	88	1.0	151	154	0	0
		5	22	5	34	2	23	3	41												
6	L	3	36	5	64	2	55	3	105	136	IWP	0	29	0	48	43	0.8	86	70	0	3
		4	36	4	64	2	55	2	106			0	38	0	37						
7	L	5	25	5	40	1	25	2	47	60	IWP	0	25	0	56	60	0.7	137	94	0	4
		5	27	5	44	2	25	2	46			0	22	0	64						
8	L	5	25	2	43	3	34	3	62	80	IWP	0	24	0	58	60	0.7	130	96	0	0
		5	26	3	44	3	34	3	62			0	23	0	61						
9	L	5	18	6	25	2	30	1	57	74	IWP	0	20	0	70	75	0.4	246	103	0	0
		5	20	7	28	2	30	1	57			0	17	-1	80						
10	L	5	26	9	38	3	19	3	32	52	OWP	0	21	0	67	68	0.8	138	113	0	0
		3	25	5	42	3	19	3	32			0	20	0	70						

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International
in association with **Jatula Partners**

Road Name:	Chingeni - Liwonde	Road Code:	13	Sample Length No.:	S1	Truck Axle Load - LHS:	3175 kg
Date:	7-Aug-98						
Chainage (km)	6.59 to 7.59	Sample Length Code:	131	Width:	6.7 m	RHS:	3175 kg
Operator:	RI/MOWS						

Averages and Totals

Area Cracked	2847	m^2	42.5%
Wide Cracks	2847	m^2	42.5%
Average Condition Index	21.0		
Minimum Condition Index	19.9		
Maximum Condition Index	23.2		

Area to be patched	1173	m^2	17.5%
Area already patched	709	m^2	10.6%
Area Ravelled	6700	m^2	100.0%
Area patched during shoulder repair	300	m^2	4.5%

Average Deflection	δ_p	0.82	mm	OWP	2	18%
Standard Deviation	σ	0.27	mm	IWP	9	82%
Calibration Correction Factor	F_c	0.993	0.99			
Seasonal Correction Factor	F_w	1.300				
Design Deflection	δ_d	1.22	mm			
Percentile to equal the Design Deflection	96%	1.31	mm			
Predicted Design Axles	No.	3.73	$x10^6$ Axles			
Residual Equivalent Standard Axles	No.	1.22	$x10^6$ ESAs			

Percentile of the Road that will Require Reconstruction 4% of the road

Percentile of the Road that will not Require Strengthening d= 1.31 mm 96%

Average Rut Depth		2.4 mm
Standard Deviation of Rut Depth		2.6 mm
Avg.Radius of Curvature		59 m
Avg.M_r Upper Layers		98 MPa
M_r Base	80%	123 MPa
M_r Subbase	20%	70 MPa
Avg.M_r of the Foundation		132 MPa
M_r Selected Subgrade	80%	138 MPa
M_r Subgrade	20%	96 MPa

Target Deflection: 0.9 mm

Existing Base Material: GN

Crushed Rock Granular Overlay Thickness	=	150 mm
Stabilised Natural Gravel Overlay Thickness	=	150 mm
Natural Gravel Granular Overlay Thickness	=	150 mm
Asphalt Overlay Thickness	=	75 mm

Deflection for HDM model $\delta_{(80kN)} =$ 1.89 mm

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International

in association with **Jatula Partners**

Road Name: Chingeni - Liwonde | Road Code: 13 | Sample Length No.: S2 | Truck Axle Load - LHS: 3175 kg | Date: 7-Aug-98

Chainage (km) 19.78 to 20.78 | Sample Length Code: 132 | Width: 6.7 m | RHS: 3175 kg | Operator: RI/MOWS

Chainage (km)		Surface Condition																											
		Primary Cracking						Secondary Cracking						Pothole		Patch		Edge		Ravel		Bleed		Skid		Deform			
From	To	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Number	Av.Area (m^2)	Number	Av.Area (m^2)	Length	Av.Width (m)	Extent (%)	Degree	Extent (%)	Degree	Extent (%)	Degree	Condition	Position	Shoulder Condition	Drainage Condition
19.78	19.88	C	CW	3	35	✓	✓									5	7	100	0.3	100	3	100	2			P	CW	P	P
19.88	19.98	C	CW	4	50	✓	✓	T	CW	4	50	✓	✓			5	14	100	0.3	100	3	100	2			P	CW	F	F
19.98	20.08	C	CW	4	50	✓	✓	T	CW	4	50	✓	✓			5	15	100	0.3	100	3	100	2			P	CW	P	F
20.08	20.18	C	CW	4	50	✓	✓	T	CW	4	50	✓	✓			5	14	100	0.3	100	3	100	2			P	CW	P	F
20.18	20.28	C	CW	4	50	✓	✓	T	CW	4	50	✓	✓			5	8	100	0.3	100	3	100	2			P	CW	P	F
20.28	20.38	C	CW	3	30	✓	✓	T	CW	3	30	✓	✓	1	35	5	14	100	0.3	100	2	100	2			P	CW	P	F
20.38	20.48	C	CW	3	40	✓	✓	T	CW	3	40	✓	✓	1	70	5	15	100	0.3	100	2	100	2			P	CW	P	F
20.48	20.58	C	CW	3	40	✓	✓	T	CW	3	40	✓	✓			5	15	100	0.3	100	2	100	2			P	CW	P	F
20.58	20.68	C	CW	4	30	✓	✓	T	CW	4	30	✓	✓					100	0.3	100	2	100	2			P	CW	P	F
20.68	20.78	C	CW	3	40	✓	✓	T	CW	3	40	✓	✓			1	15	100	0.3	100	2	100	2			P	CW	P	F

Point Number		Peak Deflection (mm x 100)										Rad.of Curve								Rut Depth (mm)	
		LH Wheelpath				RH Wheelpath						LH Wheelpath									
		Initial	Maximum	Final	Deflection	Initial	Maximum	Final	Deflection	Max Corrected	Wheel Path	Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	LHS	RHS
11	R	4	19	4	30	4	56	2	106	138	IWP	0	18	0	78	74	0.6	195	110	0	0
		4	20	4	32	2	55	0	108			0	20	0	70						
12	R	5	19	5	28	2	10	2	16	36	OWP	0	20	0	70	79	0.5	220	115	0	0
		6	21	8	28	2	9	1	15			0	16	0	88						
13	R	5	27	9	40	2	28	3	51	65	IWP	0	10	0	140	105	2.2	104	229	5	
		5	27	6	43	3	28	3	50			0	20	0	70						
14	R	5	56	17	90	3	50	1	96	124	IWP	0	35	1	41	44	1.6	53	88	6	8
		5	50	11	84	3	51	3	96			0	30	0	47						
15	R	5	15	6	19	3	25	3	44	57	IWP	1	10	2	165	170	1.2	265	310	0	0
		4	14	5	19	3	25	3	44			0	8	0	175						
16	R	4	26	11	37	2	26	4	46	59	IWP	1	25	1	58	57	0.5	174	81	0	0
		4	24	8	36	3	26	4	45			0	25	0	56						
17	R	4	19	4	30	1	34	0	67	86	IWP	0	23	1	62	57	0.3	236	71	0	0
		4	19	4	30	1	35	2	67			0	27	-1	51						
18	R	4	42	2	78	3	42	3	78	108	OWP	0	55	2	26	26	0.5	74	38	0	0
		2	48	4	90	2	42	2	80												
19	R	3	30	9	48	4	48	4	88	116	IWP	0	29	-10	41	41	0.4	138	56	0	0
		3	27	4	47	3	49	4	91			0	34	0	41						
20	R	4	36	2	66	2	20	2	36	71	OWP	0	46	1	31	29	0.3	132	36	3	4
		4	26	4	44	4	20	1	35			0	50	0	28						
21	R	6	22	6	32	2	25	2	46	60	IWP	0	32	0	44	44	0.2	245	49	2	2
		2	22	10	32	2	26	3	47												

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International

in association with **Jatula Partners**

Road Name:	Chingeni - Liwonde	Road Code:	13	Sample Length No.:	S2	Truck Axle Load - LHS:	3175 kg	Date:	7-Aug-98
Chainage (km)	19.78 to 20.78 Sample Length Code: 132	Width:	6.7 m			RHS:	3175 kg	Operator:	RI/MOWS

Averages and Totals

Area Cracked	2781	m^2	41.5%
Wide Cracks	2781	m^2	41.5%
Average Condition Index	18.0		
Minimum Condition Index	17.3		
Maximum Condition Index	18.7		

Area to be patched	968	m^2	14.4%
Area already patched	394	m^2	5.9%
Area Ravelled	6700	m^2	100.0%
Area patched during shoulder repair	300	m^2	4.5%

Average Deflection	δ_p	0.84	mm
Standard Deviation	σ	0.33	mm
Calibration Correction Factor	F_c	0.993	0.99
Seasonal Correction Factor	F_w	1.300	
Design Deflection	δ_d	1.33	mm
Percentile to equal the Design Deflection	96%	1.32	mm
Predicted Design Axles	No.	3.73	$x10^6$ Axles
Residual Equivalent Standard Axles	No.	1.22	$x10^6$ ESAs

Percentile of the Road that will Require Reconstruction 4% of the road

Percentile of the Road that will not Require Strengthening d= 1.32 mm 96%

OWP	3	27%
IWP	8	73%

Average Rut Depth		1.4 mm
Standard Deviation of Rut Depth		2.4 mm
Avg.Radius of Curvature		69 m
Avg.M_r Upper Layers		107 MPa
M_r Base	80%	115 MPa
M_r Subbase	20%	49 MPa
Avg.M_r of the Foundation		167 MPa
M_r Selected Subgrade	80%	236 MPa
M_r Subgrade	20%	104 MPa

Target Deflection: 0.9 mm

Existing Base Material: GN

Crushed Rock Granular Overlay Thickness	=	190 mm
Stabilised Natural Gravel Overlay Thickness	=	190 mm
Natural Gravel Granular Overlay Thickness	=	190 mm
Asphalt Overlay Thickness	=	95 mm

Deflection for HDM model $\delta_{(80kN)} =$ 2.05 mm

Road Maintenance and Rehabilitation Project - Malawi

Roughton International

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

in association with **Jatula Partners**

Road Name: Chingeni - Liwonde | Road Code: 13 | Sample Length No.: S3 | Truck Axle Load - LHS: 3175 kg | Date: 7-Aug-98

Chainage (km) 26.37 to 27.37 | Sample Length Code: 133 | Width: 6.7 m | RHS: 3175 kg | Operator: RI/MOWS

Chainage (km)		Surface Condition																											
		Primary Cracking						Secondary Cracking						Pothole		Patch		Edge		Ravel		Bleed		Skid		Deform			
From	To	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Number	Av.Area (m^2)	Number	Av.Area (m^2)	Length	Av.Width (m)	Extent (%)	Degree	Extent (%)	Degree	Extent (%)	Degree	Condition	Position	Shoulder Condition	Drainage Condition
26.37	26.47	C	CW	3	40	✓	✓									5	30	100	0.3	100	3	100	3	100	2	P	CW	F	F
26.47	26.57	C	CW	3	45	✓	✓									5	15	100	0.3	100	3	100	3	100	2	P	CW	F	F
26.57	26.67	B	CW	4	50	✓	✓									5	10	100	0.2	100	3	100	3	100	2	P	CW	F	F
26.67	26.77	C	CW	4	40	✓	✓									5	15	100	0.2	100	3	100	3	100	2	P	CW	F	F
26.77	26.87	C	CW	4	35	✓	✓	L	CW	4	35	✓	✓			5	15			100	3	100	3	100	2	P	CW	P	P
26.87	26.97	C	CW	4	40	✓	✓									5	30			100	3	100	3	100	2	P	CW	F	F
26.97	27.07	L	CW	4	30	✓	✓									5	30			100	3	100	3	100	2	P	CW	F	F
27.07	27.17	L	CW	4	35	✓	✓									5	15			100	3	100	3	100	2	P	CW	F	F
27.17	27.27	C	CW	4	40	✓	✓	L	CW	4	40	✓	✓			5	20			100	3	100	3	100	2	P	CW	F	F
27.27	27.37	C	CW	4	40	✓	✓	L	CW	4	40	✓	✓			5	15			100	2	100	3	100	2	P	CW	F	F

Point Number		Peak Deflection (mm x 100)										Rad.of Curve								Rut Depth (mm)	
		LH Wheelpath				RH Wheelpath						LH Wheelpath									
		Initial	Maximum	Final	Deflection	Initial	Maximum	Final	Deflection	Max Corrected	Wheel Path	Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	LHS	RHS
22	L	3	76	25	124	1	70	0	139	178	IWP	0	75	0	19	20	0.6	47	30	12	7
		3	65	4	123	1	69	0	137			0	70	5	21						
23	L	3	10	3	14	3	30	-1	58	75	IWP	0	3	0	467	303	1.9	329	638	13	5
		2	9	3	13	2	30	0	58			0	10	0	140						
24	L	3	70	0	137	1	30	0	59	176	OWP	0	25	-2	54	41	3.7	28	103	8	0
		6	74	7	135	1	31	0	61			0	50	0	28						
25	L	2	25	0	48	2	46	-2	92	120	IWP	0	30	0	47	51	0.7	114	82	3	0
		4	30	4	52	2	47	-2	94			0	25	0	56						
26	L	1	30	0	59	1	23	0	45	74	OWP	0	49	0	29	30	0.3	125	37	9	3
		1	28	0	55	2	24	0	46			0	45	-1	31						
27	L	1	38	1	74	2	31	1	59	95	OWP	0	52	1	27	28	0.4	88	38	0	4
		2	38	1	73	2	31	3	57			0	50	0	28						
28	L	2	58	6	108	2	90	2	176	228	IWP	0	54	-4	25	25	0.7	56	40	4	0
		4	50	0	96	2	90	0	178			0	50	-12	25						
29	L	4	32	8	52	4	40	4	72	94	IWP	0	50	-2	27	28	0.2	136	33	4	0
		0	30	2	58	4	41	4	74			0	50	0	28						
30	L	0	20	0	40	1	31	1	60	79	IWP	0	25	1	57	59	0.6	155	88	7	0
		2	20	0	38	1	32	1	62			0	23	0	61						
31	L	2	19	1	35	2	34	3	63	83	IWP									6	6
		2	20	2	36	2	35	2	66												
32	L	2	22	3	39	2	24	0	46	59	IWP	0	33	0	42	43	0.3	170	54	8	0
		2	22	-1	43	2	25	2	46			0	32	-1	43						

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International

in association with **Jatula Partners**

Road Name:	Chingeni - Liwonde	Road Code:	13	Sample Length No.:	S3	Truck Axle Load - LHS:	3175 kg
Chainage (km)	26.37 to 27.37	Sample Length Code:	133	Width:	6.7 m	RHS:	3175 kg
Date:	7-Aug-98	Operator:	RI/MOWS				

Averages and Totals

Area Cracked	2647	m^2	39.5%
Wide Cracks	2647	m^2	39.5%
Average Condition Index	19.9		
Minimum Condition Index	19.1		
Maximum Condition Index	20.5		

Area to be patched	728	m^2	10.9%
Area already patched	731	m^2	10.9%
Area Ravelled	6700	m^2	100.0%
Area patched during shoulder repair	300	m^2	4.5%

Average Deflection	δ_p	1.15	mm
Standard Deviation	σ	0.55	mm
Calibration Correction Factor	F_c	0.993	0.99
Seasonal Correction Factor	F_w	1.300	
Design Deflection	δ_d	1.97	mm
Percentile to equal the Design Deflection	96%	2.08	mm
Predicted Design Axles	No.	3.73	$x10^6$ Axles
Residual Equivalent Standard Axles	No.	1.22	$x10^6$ ESAs

OWP	3	27%
IWP	8	73%

Average Rut Depth		4.5 mm
Standard Deviation of Rut Depth		4.0 mm
Avg.Radius of Curvature		63 m
Avg.M_r Upper Layers		114 MPa
M_r Base	80%	91 MPa
M_r Subbase	20%	36 MPa
Avg.M_r of the Foundation		125 MPa
M_r Selected Subgrade	80%	158 MPa
M_r Subgrade	20%	54 MPa

Percentile of the Road that will Require Reconstruction 4% of the road

Percentile of the Road that will not Require Strengthening d= 2.08 mm 96%

Target Deflection: 0.9 mm

Existing Base Material: GN

Crushed Rock Granular Overlay Thickness	=	320 mm
Stabilised Natural Gravel Overlay Thickness	=	320 mm
Natural Gravel Granular Overlay Thickness	=	320 mm
Asphalt Overlay Thickness	=	160 mm

Deflection for HDM model $\delta_{(80kN)} =$ 3.04 mm

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International
in association with **Jatula Partners**

Road Name: Liwonde - Zomba | Road Code: 13 | Sample Length No.: S4 | Truck Axle Load - LHS: 3175 kg | Date: 7-Aug-98

Chainage (km) 42.86 to 44.86 | Sample Length Code: 134 | Width: 6.7 m | RHS: 3175 kg | Operator: RI/MOWS

Chainage (km) From	Chainage (km) To	Primary Cracking Type	Primary Cracking Position	Primary Cracking Degree	Primary Cracking Extent (%)	Primary Cracking Width >3mm	Primary Cracking Pumping	Secondary Cracking Type	Secondary Cracking Position	Secondary Cracking Degree	Secondary Cracking Extent (%)	Secondary Cracking Width >3mm	Secondary Cracking Pumping	Pothole Number	Pothole Av.Area (m^2)	Patch Number	Patch Av.Area (m^2)	Edge Length	Edge Av.Width (m)	Ravel Extent (%)	Ravel Degree	Bleed Extent (%)	Bleed Degree	Skid Extent (%)	Skid Degree	Deform Condition	Deform Position	Shoulder Condition	Drainage Condition	Point Number		LH Wheelpath Initial	LH Wheelpath Maximum	LH Wheelpath Final	LH Wheelpath Deflection	RH Wheelpath Initial	RH Wheelpath Maximum	RH Wheelpath Final	RH Wheelpath Deflection	Max Corrected	Wheel Path	Rad. of Curve LH Wheelpath Initial	Rad. of Curve LH Wheelpath Maximum	Rad. of Curve LH Wheelpath Final	R_c	Average	MR	E_{SG}	E_B	Rut Depth (mm) LHS	Rut Depth (mm) RHS
																														33	L	4	38	11	61	3	59	2	113	147	IWP	0	36	3	41	44	0.9	85	75	11	4
																																4	38	6	66	3	60	2	115			0	29	0	48						
42.86	42.96	C	CW	4	50	✓	✓									5	30	100	0.2	100	3	100	3	100	2	P	CW	F	F	34	L	4	40	4	72	2	50	-1	99	127	IWP	0	29	0	48	45	1.1	73	82	7	0
																																2	36	2	68	2	50	0	98			0	33	0	42						
42.96	43.06	C	CW	4	50	✓	✓									5	30	100	0.2	100	3	100	3	100	2	P	CW	F	F	35	L	3	23	7	36	3	39	2	73	95	IWP	0	23	0	61	63	0.5	184	90	5	0
																																1	18	3	32	2	39	2	74			0	22	1	65						
43.06	43.16	C	CW	4	50	✓	✓									5	3			100	3	100	3	100	2	P	CW	F	F	36	L	4	46	3	85	2	40	2	76	108	OWP	2	42	0	34	35	0.9	63	60	12	0
																																5	46	4	83	2	40	0	78			2	41	1	35						
43.16	43.26	C	CW	3	40	✓	✓	L	CW	3	40	✓	✓							100	3	100	3	100	2	P	CW	F	F	37	L	1	20	0	39	2	32	1	61	82	IWP	0	30	0	47	51	0.4	167	71	0	4
																																1	20	0	39	2	35	2	66			0	25	0	56						
43.26	43.36																			100	3	100	2	100	2	P	CW	F	F	38	L	1	33	0	65	3	45	2	85	109	IWP	1	46	0	31	33	0.5	98	47	4	3
																																1	33	2	63	3	44	1	84			1	40	0	35						
43.36	43.46																	100	0.2	100	3	100	2	100	2	P	CW	F	F	39	L	1	31	2	59	2	28	1	53	74	OWP	0	30	-4	44	45	0.7	100	72	6	0
																																1	29	2	55	2	27	2	50			0	30	0	47						
43.46	43.56																	100	0.2	100	3	100	2	100	2	P	CW	F	F	40	L	4	36	3	65	2	23	0	44	85	OWP	0	38	0	37	40	0.7	85	64		
																																3	36	2	67	2	25	2	46			0	33	0	42						
43.56	43.66	C	CW	3	45	✓	✓											100	0.3	100	3	100	2	100	2	P	CW	F	F	41	L	2	35	1	67	1	40	-5	84	106	IWP	0	47	0	30	36	0.6	91	55		
																																1	34	3	64	1	40	-2	81			0	33	0	42						
43.66	43.76	C	CW	3	40	✓	✓									5	20			100	3	100	2	100	2	P	CW	F	F	42	L	3	24	4	41	1	45	0	89	115	IWP	0	24	-1	57	59	0.7	138	92	8	0
																																3	24	2	43	1	45	0	89			0	23	0	61						
43.76	43.86	C	CW	3	20	✓	✓									5	27			100	2	100	2	100	2	P	CW	F	F	43	L	2	28	3	51	2	30	0	58	76	IWP	0	42	0	33	41	0.5	119	59	0	0
																																2	28	0	54	2	32	2	60			0	30	2	48						
43.86	43.96	C	CW	3	20	✓	✓									5	30	100	0.2	100	2	100	2	100	2	P	CW	F	F	44	L	2	20	0	38	2	36	1	69	89	IWP	0	26	1	55	59	0.5	176	83	6	0
																																2	20	4	34	2	36	1	69			1	22	-2	62						
43.96	44.06	C	CW	4	40	✓	✓									5	30	100	0.2	100	2	100	2	100	2	P	CW	F	F	45	L	3	29	3	52	3	48	-3	96	122	IWP	0	32	-1	43	40	0.4	142	54	16	12
																																3	23	1	42	3	48	0	93			1	38	1	38						
44.06	44.16	C	CW	3	50	✓	✓									5	30	100	0.2	100	3	100	2	100	2	P	CW	F	F	46	L	1	32	6	57	3	36	1	68	87	IWP	0	52	1	27	28	0.3	128	34	4	0
																																2	30	1	57	3	36	2	67			0	48	0	29						
44.16	44.26	C	CW	3	40	✓	✓									5	15	100	0.2	100	3	100	2	100	2	P	CW	F	F	47	L	2	42	6	76	2	48	-2	96	123	IWP	0	51	0	27	28	0.5	82	40	10	0
																																2	44	9	77	2	49	1	95			0	50	0	28						
44.26	44.36	C	CW	3	40	✓	✓									5	5	100	0.2	100	3	100	2	100	2	P	CW	F	F	48	L	2	38	1	73	1	48	0	95	122	IWP	0	52	0	27	26	0.4	91	35	7	0
																																2	38	1	73	2	48	0	94			1	55	0	26						
44.36	44.46	C	CW	3	35	✓	✓									5	25	100	0.2	100	3	100	2	100	2	P	CW	F	F	49	L	2	50	3	95	1	38	-1	76	123	OWP	0	44	1	32	30	0.9	57	50	10	15
																																6	54	6	96	2	38	0	74			0	52	0	27						
44.46	44.56	C	CW	3	40	✓	✓									5	20	100	0.2	100	3	100	2	100	2	P	CW	F	F	50	L	3	27	1	50	2	39	-2	78	100	IWP	0	33	0	42	39	0.4	129	54	10	0
																																2	27	1	51	2	40	1	77			1	40	1	36						
44.56	44.66	C	CW	2	50	✓	✓									5	4	100	0.2	100	3	100	2	100	2	P	CW	F	F	51	L	5	45	2	83	2	42	-2	84	106	IWP	0	39	-2	35	32	0.8	68	52	7	0
																																5	45	4	81	2	42	2	80			1	48	0	29						
44.66	44.76	C	CW	2	30	✓	✓									5	13	100	0.2	100	3	100	2	100	2	P	CW	F	F	52	L	5	35	2	63	2	34	0	66	86	IWP	0	42	0	33	39	0.6	97	59	11	0
																																5	35	5	60	2	35	1	67			0	32	0	44						
44.76	44.86	C	CW	2	35	✓	✓									5	17	100	0.2	100	3	100	2	100	2	F	F	F	F	53	L	5	25	7	38	1	24	-1	48	61	IWP	0	21	0	67	55	0.5	161	78	0	0
																																6	26	6	40	2	25	1	47			0	33	0	42						

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International
in association with **Jatula Partners**

Road Name: Liwonde - Zomba | Road Code: 13 | Sample Length No.: S4 | Truck Axle Load - LHS: 3175 kg | Date: 7-Aug-98

Chainage (km) 42.86 to 44.86 | Sample Length Code: 134 | Width: 6.7 m | RHS: 3175 kg | Operator: RI/MOWS

Averages and Totals

Area Cracked	4523	m^2	33.8%
Wide Cracks	4523	m^2	33.8%
Average Condition Index	18.9		
Minimum Condition Index	15.1		
Maximum Condition Index	20.6		

Area to be patched	1368	m^2	10.2%
Area already patched	1121	m^2	8.4%
Area Ravelled	13400	m^2	100.0%
Area patched during shoulder repair	600	m^2	4.5%

Average Deflection	δ_p	1.02	mm	OWP	4	19%
Standard Deviation	σ	0.21	mm	IWP	17	81%
Calibration Correction Factor	F_c	0.993	0.99			
Seasonal Correction Factor	F_w	1.300				
Design Deflection	δ_d	1.34	mm			
Percentile to equal the Design Deflection	96%	1.31	mm			
Predicted Design Axles	No.	4.56	$x10^6$ Axles			
Residual Equivalent Standard Axles	No.	0.86	$x10^6$ ESAs			

Percentile of the Road that will Require Reconstruction 4% of the road

Percentile of the Road that will not Require Strengthening d= 1.31 mm 96%

Average Rut Depth		4.5	mm
Standard Deviation of Rut Depth		5.0	mm
Avg.Radius of Curvature		41	m
Avg.M_r Upper Layers		62	MPa
M_r Base	80%	78	MPa
M_r Subbase	20%	50	MPa
Avg.M_r of the Foundation		111	MPa
M_r Selected Subgrade	80%	142	MPa
M_r Subgrade	20%	82	MPa

Target Deflection: 1.0 mm

Existing Base Material: GN

Crushed Rock Granular Overlay Thickness	=	140	mm
Stabilised Natural Gravel Overlay Thickness	=	140	mm
Natural Gravel Granular Overlay Thickness	=	140	mm
Asphalt Overlay Thickness	=	70	mm

Deflection for HDM model $\delta_{(80kN)} =$ 2.07 mm

Road Maintenance and Rehabilitation Project - Malawi **Roughton International**

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths *in association with* **Jatula Partners**

Road Name: Liwonde - Zomba Road Code: 13 Sample Length No.: S5 Truck Axle Load - LHS: 3175 kg Date: 7-Aug-98

Chainage (km) 65.93 to 67.93 Sample Length Code: 135 Width: 6.7 m RHS: 3175 kg Operator: RI/MOWS

Chainage (km)		Surface Condition																													
		Primary Cracking						Secondary Cracking						Pothole		Patch		Edge		Ravel		Bleed		Skid		Deform					
From	To	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Number	Av.Area (m^2)	Number	Av.Area (m^2)	Length	Av.Width (m)	Extent (%)	Degree	Extent (%)	Degree	Extent (%)	Degree	Condtion	Position	Shoulder Condition	Drainage Condition	Point Number	
																														54	R
65.93	66.03	C	CW	3	40	✓	✓	L	CW	3	40	✓	✓			1	70	100	0.3	100	3	100	3	100	2	P	CW	P	F	55	R
66.03	66.13	C	CW	3	40	✓	✓	L	CW	3	40	✓	✓			1	70	100	0.3	100	3	100	3	100	2	P	CW	P	F	56	R
66.13	66.23	C	CW	3	50	✓	✓	L	CW	3	50	✓	✓			1	70	100	0.3	100	3	100	3	100	2	P	CW	P	F	57	R
66.23	66.33	C	CW	3	40	✓	✓	L	CW	3	40	✓	✓			1	70	100	0.3	100	3	100	3	100	2	P	CW	P	F	58	R
66.33	66.43	C	CW	3	50	✓	✓	L	CW	3	50	✓	✓			1	70	100	0.3	100	3	100	3	100	2	P	CW	P	F	59	R
66.43	66.53	C	CW	3	40	✓	✓	L	CW	3	40	✓	✓			1	70	100	0.3	100	3	100	3	100	2	P	CW	P	F	60	R
66.53	66.63	C	CW	3	30	✓	✓	L	CW	3	30	✓	✓			1	70	100	0.3	100	3	100	3	100	2	P	CW	P	F	61	R
66.63	66.73	C	CW	3	20	✓	✓	L	CW	3	20	✓	✓			1	70	100	0.4	100	3	100	3	100	2	P	CW	P	F	62	R
66.73	66.83	C	CW	3	15	✓	✓	L	CW	3	15	✓	✓			1	70	100	0.3	100	3	100	3	100	2	P	CW	P	F	63	R
66.83	66.93	L	CW	2	10	✓	✓									1	70	100	0.3	100	3	100	3	100	2	P	CW	P	F	64	R
66.93	67.03	L	CW	2	20	✓	✓									1	70	100	0.2	100	3	100	3	100	2	P	CW	P	F	65	R
67.03	67.13	C	CW	3	30	✓	✓	L	CW	3	30	✓	✓			1	70	100	0.2	100	3	100	3	100	3	P	CW	P	F	66	R
67.13	67.23	L	CW	2	10	✓	✓									1	70	100	0.3	100	3	100	2	100	3	P	CW	P	F	67	R
67.23	67.33	C	CW	2	10	✓	✓	L	CW	2	10	✓	✓			1	70	100	0.2	100	3	100	2	100	2	P	CW	P	F	68	R
67.33	67.43	C	CW	2	5	✓	✓	L	CW	2	5	✓	✓			1	70	100	0.3	100	3	100	2	100	2	P	CW	P	F	69	R
67.43	67.53	C	CW	2	10	✓	✓	L	CW	2	10	✓	✓					100	0.4	100	3	100	2	100	2	P	CW	P	F	70	R
67.53	67.63	C	CW	2	10	✓	✓	L	CW	2	10	✓	✓					100	0.4	100	3	100	2	100	2	P	CW	P	F	71	R
67.63	67.73	C	CW	3	30	✓	✓	L	CW	3	30	✓	✓					100	0.4	100	3	100	3	100	2	P	CW	P	F	72	R
67.73	67.83	C	CW	2	20	✓	✓	L	CW	2	20	✓	✓					100	0.4	100	3	100	2	100	2	P	CW	P	F	73	R
67.83	67.93	C	CW	2	15	✓	✓	L	CW	2	15	✓	✓					100	0.4	100	3	100	3	100	2	P	CW	P	F	74	R

Point Number		Peak Deflection (mm x 100)										Rad.of Curve								Rut Depth (mm)	
		LH Wheelpath				RH Wheelpath						LH Wheelpath									
		Initial	Maximum	Final	Deflection	Initial	Maximum	Final	Deflection	Max Corrected	Wheel Path	Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	LHS	RHS
54	R	1	32	2	61	3	35	3	64	83	OWP	0	22	0	64	64	1.9	70	133	11	0
		2	36	3	67	3	34	3	62												
55	R	1	34	3	64	2	31	3	57	82	OWP	0	25	0	56	51	1.2	79	93	14	0
		2	34	3	63	2	33	3	61			0	30	-1	46						
56	R	2	18	2	32	3	18	3	30	43	OWP	0	20	0	70	70	0.6	182	105	0	0
		1	18	1	34	4	17	3	27												
57	R	2	30	5	53	3	32	4	57	76	IWP	0	20	0	70	70	1.6	88	139	3	0
		4	31	5	53	3	33	3	60			0	20	0	70						
58	R	2	34	5	61	1	22	4	39	80	OWP	2	38	0	38	35	0.5	101	50	8	0
		3	36	6	63	3	22	3	38			0	42	-5	31						
59	R	1	40	8	71	1	40	8	71	94	IWP	0	32	0	44	50	1.4	68	96	10	0
		0	36	1	71	2	40	4	74			0	25	0	56						
60	R	1	17	2	31	4	33	6	56	72	IWP	0	19	0	74	68	0.5	204	97	0	0
		2	18	3	31	2	30	3	55			-3	20	-2	62						
61	R	2	25	5	43	5	31	6	51	70	IWP	0	20	0	70	73	1.1	117	132	6	10
		5	27	5	44	2	32	4	58			1	20	2	76						
62	R	2	33	2	62	2	32	4	58	77	OWP	0	33	0	42	45	0.8	94	72	10	0
		0	29	1	57	3	32	5	56			0	30	0	47						
63	R	0	30	0	60	2	34	2	64	83	IWP	0	37	0	38	39	0.6	101	59	11	0
		1	31	2	59	3	35	3	64			0	35	1	41						
64	R	1	27	3	50	2	15	3	25	63	OWP	0	37	-1	37	45	0.5	126	66	7	0
		1	25	1	48	2	16	3	27			1	27	0	53						
65	R	2	32	3	59	3	38	2	71	92	IWP	0	28	0	50	45	0.8	94	74	15	0
		2	32	2	60	6	42	6	72			0	35	0	40						
66	R	2	28	1	53	3	45	3	84	108	IWP	0	29	0	48	49	0.7	113	77	10	0
		1	26	2	49	3	45	3	84			0	29	2	50						
67	R	1	27	0	53	2	30	3	55	69	IWP	0	27	0	52	54	0.9	106	90	3	
		0	25	0	50	6	32	6	52			1	25	-1	56						
68	R	1	26	4	47	3	30	3	54	70	IWP	0	30	0	47	58	0.8	115	97	4	0
		1	25	1	48	2	29	2	54			0	20	0	70						
69	R	2	30	2	56	1	32	1	62	80	IWP	0	30	0	47	46	0.7	106	72	0	0
		1	28	2	53	5	36	5	62			0	31	0	45						
70	R	1	18	1	34	3	30	3	54	66	IWP	0	22	0	64	64	0.5	196	89	6	0
		1	17	2	31	5	30	6	49												
71	R	1	26	3	48	2	30	4	54	66	IWP	0	31	0	45	44	0.5	133	62	4	0
		2	25	1	47	2	30	9	49			0	32	-1	43						
72	R	2	20	2	36	2	27	2	50	63	IWP	0	22	0	64	62	0.5	174	91	5	0
		2	19	1	35	3	27	4	47			0	23	0	61						
73	R	0	18	3	33	4	25	4	42	54	IWP	0	20	0	70	70	0.6	170	108	0	0
		3	21	3	36	4	24	3	41												
74	R	2	30	2	56	4	26	3	45	71	OWP	0	25	0	56	53	1.0	96	92	12	6
		2	29	2	54	4	28	5	47			0	27	-1	51						

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International

in association with **Jatula Partners**

Road Name:	Liwonde - Zomba	Road Code:	13	Sample Length No.:	S5	Truck Axle Load - LHS:	3175 kg
Date:	7-Aug-98						
Chainage (km)	65.93 to 67.93	Sample Length Code:	135	Width:	6.7 m	RHS:	3175 kg
Operator:	RI/MOWS						

Averages and Totals

Area Cracked	3316 m^2	24.7%	Area to be patched	1905 m^2	14.2%		
Wide Cracks	3316 m^2	24.7%	Area already patched	788 m^2	5.9%		
			Area Ravelled	13400 m^2	100.0%		
Average Condition Index	20.3		Area patched during shoulder repair	600 m^2	4.5%		
Minimum Condition Index	19.4						
Maximum Condition Index	21.1						

Average Deflection	δ_p	0.74	mm	OWP 7	33%
Standard Deviation	σ	0.14	mm	IWP 14	67%
Calibration Correction Factor	F_c	0.993	0.99		
Seasonal Correction Factor	F_w	1.300			
Design Deflection	δ_d	0.96	mm		
Percentile to equal the Design Deflection	96%	0.96	mm		
Predicted Design Axles	No.	4.56	$x10^6$ Axles		
Residual Equivalent Standard Axles	No.	0.86	$x10^6$ ESAs		

Percentile of the Road that will Require Reconstruction 4% of the road

Percentile of the Road that will not Require Strengthening d= 0.96 mm 96%

Average Rut Depth		3.8 mm
Standard Deviation of Rut Depth		4.8 mm
Avg.Radius of Curvature		54 m
Avg.M_r Upper Layers		90 MPa
M_r Base	80%	105 MPa
M_r Subbase	20%	72 MPa
Avg.M_r of the Foundation		121 MPa
M_r Selected Subgrade	80%	170 MPa
M_r Subgrade	20%	94 MPa

Target Deflection: 1.0 mm

Existing Base Material: GN

Crushed Rock Granular Overlay Thickness	=	0 mm
Stabilised Natural Gravel Overlay Thickness	=	0 mm
Natural Gravel Granular Overlay Thickness	=	0 mm
Asphalt Overlay Thickness	=	0 mm

Deflection for HDM model $\delta_{(80kN)}$ = 1.47 mm

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International

in association with **Jatula Partners**

Road Name: Liwonde - Zomba | Road Code: 13 | Sample Length No.: S6 | Truck Axle Load - LHS: 3175 kg | Date: 7-Aug-98

Chainage (km) 87.91 to 88.91 | Sample Length Code: 136 | Width: 6.7 m | RHS: 3175 kg | Operator: RI/MOWS

Chainage (km)		Surface Condition																											
		Primary Cracking						Secondary Cracking						Pothole		Patch		Edge		Ravel		Bleed		Skid		Deform			
From	To	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Number	Av.Area (m^2)	Number	Av.Area (m^2)	Length	Av.Width (m)	Extent (%)	Degree	Extent (%)	Degree	Extent (%)	Degree	Condition	Position	Shoulder Condition	Drainage Condition
87.91	88.01	L	CW	3	30	✓	✓											100	0.4			100	4	100	3	P	CW	P	P
88.01	88.11	L	CW	3	30	✓	✓											100	0.4			100	4	100	3	P	CW	P	P
88.11	88.21	L	CW	3	40	✓	✓											100	0.4			100	4	100	3	P	CW	P	P
88.21	88.31	C	CW	3	30	✓	✓	L	CW	3	30	✓	✓					100	0.4			100	4	100	3	P	CW	P	P
88.31	88.41	C	CW	3	40	✓	✓	L	CW	3	40	✓	✓					100	0.4			100	4	100	3	P	CW	P	P
88.41	88.51	L	CW	3	30	✓	✓											100	0.4			100	4	100	3	P	CW	P	P
88.51	88.61	L	CW	3	20	✓	✓											100	0.4			100	4	100	3	P	CW	P	P
88.61	88.71	L	CW	3	15	✓	✓											100	0.4			100	4	100	3	P	CW	P	P
88.71	88.81	L	CW	3	10	✓	✓											100	0.4			100	4	100	3	P	CW	P	P
88.81	88.91	L	CW	3	14	✓	✓											100	0.4			100	4	100	3	P	CW	P	P

Point Number		Peak Deflection (mm x 100)										Rad.of Curve								Rut Depth (mm)	
		LH Wheelpath				RH Wheelpath						LH Wheelpath									
		Initial	Maximum	Final	Deflection	Initial	Maximum	Final	Deflection	Max Corrected	Wheel Path	Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	LHS	RHS
75	L	1	32	9	54	2	34	6	60	77	IWP	0	39	0	36	40	0.5	116	57	10	14
		1	30	5	54	2	33	4	60			0	32	0	44						
76	L	2	20	4	34	2	20	3	35	46	IWP	0	22	0	64	60	0.4	203	81	6	8
		2	18	3	31	2	20	1	37			0	25	0	56						
77	L	2	20	2	36	2	17	0	32	45	OWP	0	20	0	70	70	0.7	167	109	0	6
		2	19	2	34	3	15	3	24												
78	L	2	18	2	32	5	25	6	39	52	IWP	0	20	0	70	68	0.6	181	102	0	8
		2	20	3	35	3	25	5	42			-2	20	0	67						
79	L	1	11	1	20	5	15	6	19	28	OWP	0	10	0	140	144	1.1	232	259	0	7
		3	17	7	24	5	14	4	19			0	10	1	147						
80	L	1	14	1	26	4	17	5	25	34	OWP	0	21	0	67	68	0.3	266	88	4	10
		0	13	0	26	3	16	3	26			0	20	0	70						
81	L	1	17	2	31	4	22	4	36	44	IWP	0	15	0	93	93	1.0	168	161	0	8
		0	16	0	32	4	20	4	32			0	15	0	93						
82	L	1	9	1	16	1	25	4	45	61	IWP	2	10	2	175	165	0.8	334	273	8	0
		0	9	1	17	4	29	4	50			0	9	0	156						
83	L	5	29	5	48	4	29	5	49	66	IWP	0	20	0	70	68	1.0	120	118	0	8
		0	22	4	40	3	30	3	54			0	22	1	65						
84	L	0	13	1	25	5	19	6	27	35	IWP	0	18	0	78	78	0.4	272	104	0	5
		2	14	2	24	4	18	5	27			0	18	0	78						
85	L	2	20	3	35	3	29	4	51	68	IWP	0	20	3	76	73	0.7	163	116	5	5
		3	21	4	35	4	32	5	55			0	20	0	70						

Road Maintenance and Rehabilitation Project - Malawi
Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International
in association with **Jatula Partners**

Road Name: Liwonde - Zomba	Road Code: 13	Sample Length No.: S6	Truck Axle Load - LHS: 3175 kg	Date: 7-Aug-98
Chainage (km) 87.91 to 88.91	Sample Length Code: 136	Width: 6.7 m	RHS: 3175 kg	Operator: RI/MOWS

Averages and Totals

Area Cracked	1735	m^2	25.9%
Wide Cracks	1735	m^2	25.9%
Average Condition Index	20.3		
Minimum Condition Index	20.2		
Maximum Condition Index	20.5		

Area to be patched	800	m^2	11.9%
Area already patched	0	m^2	0.0%
Area Ravelled	0	m^2	0.0%
Area patched during shoulder repair	300	m^2	4.5%

Average Deflection	δ_p	0.51	mm	
Standard Deviation	σ	0.16	mm	
Calibration Correction Factor	F_c	0.993	0.99	
Seasonal Correction Factor	F_w	1.300		
Design Deflection	δ_d	0.75	mm	
Percentile to equal the Design Deflection	96%	0.74	mm	
Predicted Design Axles	No.	4.56	$x10^6$	Axles
Residual Equivalent Standard Axles	No.	0.86	$x10^6$	ESAs

OWP	3	27%
IWP	8	73%

Average Rut Depth		5.1	mm
Standard Deviation of Rut Depth		4.1	mm
Avg.Radius of Curvature		85	m
Avg.M_r Upper Layers		134	MPa
M_r Base	80%	161	MPa
M_r Subbase	20%	88	MPa
Avg.M_r of the Foundation		202	MPa
M_r Selected Subgrade	80%	266	MPa
M_r Subgrade	20%	163	MPa

Percentile of the Road that will Require Reconstruction 4% of the road

Percentile of the Road that will not Require Strengthening d= 0.74 mm 96%

Target Deflection: 1.0 mm

Existing Base Material: GN

Crushed Rock Granular Overlay Thickness	=	-110	mm
Stabilised Natural Gravel Overlay Thickness	=	-110	mm
Natural Gravel Granular Overlay Thickness	=	-110	mm
Asphalt Overlay Thickness	=	-55	mm

Deflection for HDM model $\delta_{(80kN)} =$ 1.15 mm

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International

in association with **Jatula Partners**

Road Name: Liwonde - Mangochi | Road Code: 14 | Sample Length No.: S1 | Truck Axle Load - LHS: 3175 kg | Date: 4-Aug-98

Chainage (km) 4.95 to 6.95 | Sample Length Code: 141 | Width: 6.7 m | RHS: 3175 kg | Operator: RI/MOWS

Chainage (km)		Surface Condition: Primary Cracking						Secondary Cracking						Pothole		Patch		Edge		Ravel		Bleed		Skid		Deform			
From	To	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Number	Av.Area (m^2)	Number	Av.Area (m^2)	Length	Av.Width (m)	Extent (%)	Degree	Extent (%)	Degree	Extent (%)	Degree	Condion	Position	Shoulder Condition	Drainage Condition
4.95	5.05	C	CW	4	80	✓	✓									5	60			100	4					P	CW	F	F
5.05	5.15	C	CW	4	80	✓	✓									5	8			100	4					P	CW	P	F
5.15	5.25	C	CW	4	80	✓	✓									5	45	50	0.4	100	4					P	CW	P	P
5.25	5.35	C	CW	4	80	✓	✓									5	35			90	5					P	CW	P	P
5.35	5.45	C	CW	4	80	✓	✓									5	7			80	4	100	3			P	CW	F	P
5.45	5.55	C	CW	4	70	✓	✓									5	31			100	4	100	3			P	CW	F	F
5.55	5.65	C	CW	4	70	✓	✓									5	10			100	4	100	3			P	CW	F	F
5.65	5.75	C	CW	4	80	✓	✓									5	20			100	4	100	3			P	CW	F	F
5.75	5.85	C	CW	4	60	✓	✓									5	20			100	4	100	3			P	CW	F	F
5.85	5.95	C	CW	4	80	✓	✓									5	30			100	4	100	3			P	CW	F	F
5.95	6.05	C	CW	4	70	✓	✓									5	20			100	4	100	3			P	CW	F	F
6.05	6.15	C	CW	4	70	✓	✓									5	15			100	3	100	3			P	CW	F	P
6.15	6.25	C	CW	4	100	✓	✓									5	30	100	0.2	100	4	100	3			P	CW	F	F
6.25	6.35	C	CW	4	100	✓	✓									5	50	100	0.3	100	4	100	3			P	CW	F	F
6.35	6.45	C	CW	4	100	✓	✓									5	20	100	0.2	100	5	100	3			P	CW	F	F
6.45	6.55	C	CW	4	100	✓	✓									5	50	100	0.2	100	4	100	3			P	CW	F	F
6.55	6.65	C	CW	4	100	✓	✓									5	15	100	0.2	100	4	100	3			P	CW	F	F
6.65	6.75	C	CW	4	100	✓	✓									5	15	100	0.2	100	4	100	3			P	CW	F	F
6.75	6.85	C	CW	4	100	✓	✓									5	10	100	0.2	100	4	100	3			P	CW	F	F
6.85	6.95	C	CW	4	100	✓	✓									5	12	100	0.2	100	4	100	3			P	CW	P	P

Point Number		Peak Deflection (mm x 100): LH Wheelpath				RH Wheelpath				Max Corrected	Wheel Path	Rad.of Curve: LH Wheelpath								Rut Depth (mm)	
		Initial	Maximum	Final	Deflection	Initial	Maximum	Final	Deflection			Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	LHS	RHS
0	L	1	22	1	42	6	25	8	36	55	OWP									17	9
		0	22	1	43	2	22	5	37												
1	L	0	52	2	102	5	65	5	120	155	IWP	0	40	2	36	36	1.6	46	71	17	5
		0	55	6	104	2	65	8	120												
2	L	0	22	1	43	1	27	3	50	62	IWP	0	10	3	165	165	6.2	77	479	13	5
		1	23	2	43	6	30	8	46												
3	L	0	59	0	118	2	40	5	73	153	OWP	0	40	-4	33	36	2.1	37	78	13	0
		0	60	1	119	6	42	8	70			0	36	0	39						
4	L	3	36	7	62	4	64	7	117	153	IWP									14	6
		2	35	4	64	2	63	4	120												
5	L	1	20	2	37	8	25	7	35	46	OWP									5	4
		0	18	1	35	2	20	4	34												
6	L	0	54	0	108	3	62	4	117	151	IWP	0	22	0	64	78	8.9	28	252	10	11
		0	55	4	106	1	60	2	117			0	15	0	93						
7	L	1	14	3	24	4	44	5	79	104	IWP	0	8	0	175	170	2.0	180	361	8	10
		0	13	1	25	2	44	4	82			0	10	3	165						
8	L	2	38	4	70	2	50	5	93	123	IWP	0	20	0	70	80	4.0	51	206	0	0
		1	40	5	74	5	55	7	98			0	15	-1	90						
9	L	1	26	2	49	1	45	4	85	106	IWP	0	20	0	70	105	3.1	80	253	4	0
		2	27	3	49	5	45	6	79			0	10	0	140						
10	L	1	26	1	50	3	32	4	57	76	IWP	0	10	-5	112	126	4.6	73	338	13	3
		1	25	1	48	2	32	2	60			0	10	0	140						
11	L	2	34	4	62	2	42	5	77	97	IWP	0	5	-1	255	197	20.4	39	799	11	5
		0	33	2	64	7	43	5	74			0	10	0	140						
12	L	2	32	3	59	2	33	8	56	75	OWP	0	10	0	140	158	10.6	50	532	0	0
		2	31	3	57	2	30	4	54			0	8	0	175						
13	L	0	38	2	74	1	58	5	110	144	IWP	0	8	0	175	107	7.9	42	333	0	0
		1	39	2	75	2	60	5	113			0	35	-2	39						
14	L	0	20	1	39	3	26	3	46	58	IWP	0	30	-3	44	48	0.4	173	63	4	5
		1	21	2	39	5	27	5	44			0	28	1	51						
15	L	2	23	3	41	2	30	5	53	70	IWP	0	20	0	70	105	2.4	98	234	4	3
		1	24	2	45	2	30	3	55			0	10	0	140						
16	L	0	16	2	30	4	40	9	67	92	IWP	0	10	1	147	144	2.1	148	308	0	0
		0	15	1	29	4	43	6	76			0	10	0	140						
17	L	0	15	0	30	4	12	3	17	37	OWP	0	11	0	127	151	2.2	148	331	3	4
		0	14	0	28	5	15	5	20			0	8	0	175						
18	L	1	18	0	35	2	12	4	18	45	OWP	0	12	0	117	125	2.2	123	273	0	0
		2	19	1	35	3	12	4	17			0	10	-1	133						
19	L	0	22	1	43	4	36	4	64	83	IWP	0	8	2	200	174	7.1	74	524	6	0
		0	23	2	44	6	38	6	64			0	9	-1	147						
20	L	2	36	2	68	2	38	4	70	92	IWP	0	10	0	140	128	9.8	43	424	13	8
		0	35	1	69	4	40	4	72			0	12		117						

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International

in association with **Jatula Partners**

Road Name:	Liwonde - Mangochi	Road Code:	14	Sample Length No.:	S1	Truck Axle Load - LHS:	3175 kg
Date:	4-Aug-98						
Chainage (km)	4.95 to 6.95	Sample Length Code:	141	Width:	6.7 m	RHS:	3175 kg
Operator:	RI/MOWS						

Averages and Totals

Area Cracked	11390 m^2	85.0%	Area to be patched	1698 m^2	12.7%	Average Deflection δ_p	0.94 mm	OWP 6 29%	Average Rut Depth 5.5 mm
Wide Cracks	11390 m^2	85.0%	Area already patched	1886 m^2	14.1%	Standard Deviation σ	0.39 mm	IWP 15 71%	Standard Deviation of Rut Depth 5.2 mm
			Area Ravelled	13199 m^2	98.5%	Calibration Correction Factor F_c	0.993 0.99		
Average Condition Index	20.1		Area patched during shoulder repair	600 m^2	4.5%	Seasonal Correction Factor F_w	1.300		Avg.Radius of Curvature 120 m
Minimum Condition Index	18.1					Design Deflection δ_d	1.53 mm		Avg.M_r Upper Layers 325 MPa
Maximum Condition Index	21.7					Percentile to equal the Design Deflection 96%	1.53 mm		M_r Base 80% 457 MPa
						Predicted Design Axles No.	9.47 $x10^6$ Axles		M_r Subbase 20% 217 MPa
						Residual Equivalent Standard Axles No.	1.56 $x10^6$ ESAs		Avg.M_r of the Foundation 84 MPa
						Percentile of the Road that will Require Reconstruction	4% of the road		M_r Selected Subgrade 80% 138 MPa
						Percentile of the Road that will not Require Strengthening d= 1.53 mm	96%		M_r Subgrade 20% 42 MPa

Target Deflection: 0.8 mm

Existing Base Material: CR

Crushed Rock Granular Overlay Thickness	=	280 mm
Stabilised Natural Gravel Overlay Thickness	=	280 mm
Natural Gravel Granular Overlay Thickness	=	280 mm
Asphalt Overlay Thickness	=	140 mm

Deflection for HDM model $\delta_{(80kN)} =$ 2.36 mm

Road Maintenance and Rehabilitation Project - Malawi
Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International
in association with **Jatula Partners**

Road Name: Liwonde - Mangochi | Road Code: 14 | Sample Length No.: S2 | Truck Axle Load - LHS: 3175 kg | Date: 4-Aug-98

Chainage (km) 13.19 to 14.19 | Sample Length Code: 142 | Width: 6.7 m | RHS: 3175 kg | Operator: RI/MOWS

Chainage (km)		Surface Condition																													
		Primary Cracking						Secondary Cracking						Pothole		Patch		Edge		Ravel		Bleed		Skid		Deform					
From	To	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Number	Av.Area (m^2)	Number	Av.Area (m^2)	Length	Av.Width (m)	Extent (%)	Degree	Extent (%)	Degree	Extent (%)	Degree	Condtion	Position	Shoulder Condition	Drainage Condition	Point Number	
																														21	R
13.19	13.29	L	CW	3	30	✓	✓													100	2	100	3	100	2	P	CW	F	F	22	R
13.29	13.39	C	CW	3	60	✓	✓	L	CW	3	60	✓	✓							100	2	100	3	100	2	P	CW	F	F	23	R
13.39	13.49	C	CW	3	50	✓	✓									5	20			100	2	100	3	100	2	P	CW	F	F	24	R
13.49	13.59	C	CW	3	40	✓	✓													100	2	100	3	100	2	P	CW	F	F	25	R
13.59	13.69	C	CW	3	30	✓	✓	L	CW	3	30	✓	✓							100	2	100	3	100	2	P	CW	F	F	26	R
13.69	13.79	C	CW	3	50	✓	✓	L	CW	3	50	✓	✓			5	5			100	2	100	3	100	2	P	CW	F	F	27	R
13.79	13.89	C	CW	2	40	✓	✓									5	10			100	2	100	2	100	2	P	CW	F	F	28	R
13.89	13.99	C	CW	2	60	✓	✓	L	CW	2	60	✓	✓							100	2	100	3	100	2	P	CW	F	F	29	R
13.99	14.09	C	CW	4	80	✓	✓													100	2	100	3	100	2	P	CW	F	F	30	R
14.09	14.19	C	CW	4	60	✓	✓	L	CW	4	60	✓	✓			5	50			100	2	80	3	100	2	P	CW	F	F	31	R

Point Number		Peak Deflection (mm x 100)										Rad.of Curve								Rut Depth (mm)	
		LH Wheelpath				RH Wheelpath						LH Wheelpath									
		Initial	Maximum	Final	Deflection	Initial	Maximum	Final	Deflection	Max Corrected	Wheel Path	Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	LHS	RHS
21	R	2	52	2	100	2	23	2	42	129	OWP	-2	35	-1	38	47	2.6	41	108	14	13
		0	50	0	100	2	22	2	40			0	25	0	56						
22	R	2	80	-2	160	4	72	-2	142	210	OWP	0	10	0	140	83	24.2	15	351	14	7
		4	88	6	166	3	74	6	139			0	55	-1	25						
23	R	2	70	0	138	2	55	2	106	181	OWP	0	72	-2	19	20	0.9	39	34	22	0
		0	70	-2	142	0	52	-1	105			0	65	-2	21						
24	R	0	78	-4	160	2	87	3	169	219	IWP	0	65	-5	21	21	1.2	31	39	28	0
		0	80	-1	161	4	89	3	171												
25	R	0	52	2	102	3	65	1	126	163	IWP	0	8	1	187	163	36.4	21	777	12	5
		0	50	2	98	3	67	4	127			0	10	0	140						
26	R	0	54	2	106	5	75	4	141	182	IWP	0	25	1	57	77	8.6	29	244	8	0
		0	55	1	109	3	75	6	141			0	15	1	97						
27	R	0	44	1	87	2	62	2	120	154	IWP	0	10	-1	133	125	15.7	30	471	8	5
		4	49	5	89	5	65	6	119			0	12	0	117						
28	R	2	52	1	101	5	24	4	39	132	OWP	0	11	-1	122	122	20.6	24	494	12	0
		2	54	2	104	5	24	6	37												
29	R	2	32	1	61	5	34	6	57	81	OWP	0	8	-2	156	141	9.9	47	468	7	13
		2	34	2	64	4	35	9	57			0	10	-2	127						
30	R	2	68	1	133	6	83	9	151	200	IWP	0	8	-11	104	74	13.0	20	266	3	8
		0	68	-1	137	4	82	1	159			0	30	-2	45						
31	R	1	52	-6	109	5	82	7	152	192	IWP									11	7
		2	60	2	116	5	78	6	145												

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International

in association with **Jatula Partners**

Road Name:	Liwonde - Mangochi	Road Code:	14	Sample Length No.:	S2	Truck Axle Load - LHS:	3175 kg	Date:	4-Aug-98
Chainage (km)	13.19 to 14.19	Sample Length Code:	142	Width:	6.7 m	RHS:	3175 kg	Operator:	RI/MOWS

Averages and Totals

Area Cracked	3350	m^2	50.0%
Wide Cracks	3350	m^2	50.0%
Average Condition Index	18.7		
Minimum Condition Index	17.8		
Maximum Condition Index	19.6		

Area to be patched	213	m^2	3.2%
Area already patched	319	m^2	4.8%
Area Ravelled	6700	m^2	100.0%
Area patched during shoulder repair	300	m^2	4.5%

Average Deflection	δ_p	1.68	mm	
Standard Deviation	σ	0.41	mm	
Calibration Correction Factor	F_c	0.993	0.99	
Seasonal Correction Factor	F_w	1.300		
Design Deflection	δ_d	2.30	mm	
Percentile to equal the Design Deflection	96%	2.16	mm	
Predicted Design Axles	No.	9.47	$x10^6$	Axles
Residual Equivalent Standard Axles	No.	1.56	$x10^6$	ESAs

OWP	5	45%
IWP	6	55%

Percentile of the Road that will Require Reconstruction 4% of the road

Percentile of the Road that will not Require Strengthening d= 2.16 mm 96%

Average Rut Depth		9.0	mm
Standard Deviation of Rut Depth		7.0	mm
Avg.Radius of Curvature		89	m
Avg.M_r Upper Layers		325	MPa
M_r Base	80%	476	MPa
M_r Subbase	20%	94	MPa
Avg.M_r of the Foundation		30	MPa
M_r Selected Subgrade	80%	39	MPa
M_r Subgrade	20%	21	MPa

Target Deflection: 0.8 mm

Existing Base Material: CR

Crushed Rock Granular Overlay Thickness	=	410	mm
Stabilised Natural Gravel Overlay Thickness	=	410	mm
Natural Gravel Granular Overlay Thickness	=	410	mm
Asphalt Overlay Thickness	=	205	mm

Deflection for HDM model $\delta_{(80kN)} =$ 3.54 mm

Road Maintenance and Rehabilitation Project - Malawi
Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International
in association with **Jatula Partners**

Road Name: Liwonde - Mangochi | Road Code: 14 | Sample Length No.: S3 | Truck Axle Load - LHS: 3175 kg | Date: 4-Aug-98

Chainage (km) 43.96 to 44.96 | Sample Length Code: 143 | Width: 6.7 m | RHS: 3175 kg | Operator: RI/MOWS

Chainage (km)		Surface Condition																												
		Primary Cracking						Secondary Cracking						Pothole		Patch		Edge		Ravel		Bleed		Skid		Deform				
From	To	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Number	Av.Area (m^2)	Number	Av.Area (m^2)	Length	Av.Width (m)	Extent (%)	Degree	Extent (%)	Degree	Extent (%)	Degree	Condition	Position	Shoulder Condition	Drainage Condition	Point Number
																														32
43.96	44.06	C	CW	4	40	✓	✓	L	CW	4	40	✓	✓			5	5			100	3	100	3	100	3	P	CW	F	P	33
44.06	44.16	C	CW	4	50	✓	✓	L	CW	4	50	✓	✓			5	12	100	0.3	100	3	100	3	100	3	P	CW	P	P	34
44.16	44.26	C	CW	4	40	✓	✓	L	CW	4	40	✓	✓			5	22	100	0.3	100	3	100	3	100	3	P	CW	P	P	35
44.26	44.36	C	CW	2	30	✓	✓	L	CW	2	30	✓	✓			5	20	100	0.2	100	3	100	3	100	3	P	CW	P	P	36
44.36	44.46	L	CW	2	30	✓	✓											100	0.2	100	2	100	2	100	2			F	P	37
44.46	44.56																	100	0.3	100	2	100	2	100	2			P	F	38
44.56	44.66	L	CW	3	50	✓	✓											100	0.2	100	2	100	2	100	2	P	CW	P	P	39
44.66	44.76	L	CW	3	40	✓	✓	T	CW	3	40	✓	✓							100	3	100	2	100	2	P	CW	P	P	40
44.76	44.86	C	CW	3	50	✓	✓	L	CW	3	50	✓	✓							100	4	100	2	100	2	P	CW	P	P	41
44.86	44.96	C	CW	3	50	✓	✓	L	CW	3	50	✓	✓							100	4	100	2	100	2	P	CW	P	P	42

Point Number		Peak Deflection (mm x 100)										Rad.of Curve								Rut Depth (mm)	
		LH Wheelpath				RH Wheelpath						LH Wheelpath									
		Initial	Maximum	Final	Deflection	Initial	Maximum	Final	Deflection	Max Corrected	Wheel Path	Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	LHS	RHS
32	L	1	82	4	159	0	89	1	177	228	IWP	0	40	-1	35	35	3.7	24	87	32	8
		0	82	2	162	0	88	0	176												
33	L	2	80	4	154	8	79	8	142	201	OWP	0	52	0	27	25	1.7	29	50	15	4
		2	84	9	157	3	76	3	146			0	55	-13	23						
34	L	2	80	4	154	0	72	1	143	199	OWP	2	40	0	36	29	2.4	27	65	9	0
		2	80	4	154	0	70	3	137			0	60	-5	22						
35	L	0	60	-3	123	3	72	-1	142	187	IWP	0	10	0	140	83	14.3	21	306	12	0
		0	64	-1	129	2	75	1	147			0	52	0	27						
36	L	2	78	5	149	2	74	-1	147	196	OWP	0	70	1	20	20	1.0	34	35	9	0
		1	78	1	154	3	75	1	146			0	71	0	20						
37	L	2	64	0	126	2	62	2	120	168	OWP	0	75	1	19	23	1.0	40	41	13	5
		0	68	1	135	1	63	2	123			0	50	-2	27						
38	L	2	56	3	107	2	62	1	121	157	IWP	0	10	0	140	131	26.5	21	570	6	0
		1	56	3	108	2	63	2	122			0	10	-3	122						
39	L	1	60	1	118	0	56	1	111	150	OWP	0	12	0	117	128	29.9	19	578	11	5
		4	62	6	114	0	55	1	109			0	10	0	140						
40	L	2	46	3	87	1	55	2	107	136	IWP	0	10	-1	133	133	17.8	29	520	12	0
		1	46	3	88	1	54	3	104												
41	L	0	26	2	50	1	20	2	37	66	OWP	0	10	0	140	140	6.3	65	409	14	8
		2	30	6	52	0	20	1	39												
42	L	2	43	-1	85	0	60	0	120	157	IWP										
		2	48	6	88	0	61	-1	123												

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International

in association with **Jatula Partners**

Road Name:	Liwonde - Mangochi	Road Code:	14	Sample Length No.:	S3	Truck Axle Load - LHS:	3175 kg	Date:	4-Aug-98
Chainage (km)	43.96 to 44.96	Sample Length Code:	143	Width:	6.7 m	RHS:	3175 kg	Operator:	RI/MOWS

Averages and Totals

Area Cracked	2546 m^2	38.0%	Area to be patched	508 m^2	7.6%	Average Deflection δ_p 1.68 mm	OWP 6 55%	Average Rut Depth 8.2 mm
Wide Cracks	2546 m^2	38.0%	Area already patched	221 m^2	3.3%	Standard Deviation σ 0.43 mm	IWP 5 45%	Standard Deviation of Rut Depth 7.6 mm
			Area Ravelled	6700 m^2	100.0%	Calibration Correction Factor F_c 0.993 0.99		
Average Condition Index	17.6		Area patched during shoulder repair	300 m^2	4.5%	Seasonal Correction Factor F_w 1.300		Avg.Radius of Curvature 70 m
Minimum Condition Index	5.9					Design Deflection δ_d 2.33 mm		Avg.M_r Upper Layers 266 MPa
Maximum Condition Index	21.8					Percentile to equal the Design Deflection 96% 2.17 mm		M_r Base 80% 530 MPa
						Predicted Design Axles No. 9.47 $x10^6$ Axles		M_r Subbase 20% 49 MPa
						Residual Equivalent Standard Axles No. 1.56 $x10^6$ ESAs		Avg.M_r of the Foundation 31 MPa
						Percentile of the Road that will Require Reconstruction 4% of the road		M_r Selected Subgrade 80% 36 MPa
						Percentile of the Road that will not Require Strengthening d= 2.17 mm 96%		M_r Subgrade 20% 21 MPa

Target Deflection: 0.8 mm

Existing Base Material: CR

Crushed Rock Granular Overlay Thickness	=	420 mm
Stabilised Natural Gravel Overlay Thickness	=	420 mm
Natural Gravel Granular Overlay Thickness	=	420 mm
Asphalt Overlay Thickness	=	210 mm

Deflection for HDM model $\delta_{(80kN)} =$ 3.58 mm

Road Maintenance and Rehabilitation Project - Malawi
Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International
in association with **Jatula Partners**

Road Name: Liwonde - Mangochi | Road Code: 14 | Sample Length No.: S4 | Truck Axle Load - LHS: 3175 kg | Date: 4-Aug-98

Chainage (km) 58.24 to 60.24 | Sample Length Code: 144 | Width: 6.7 m | RHS: 3175 kg | Operator: RI/MOWS

Chainage (km)		Surface Condition																											
		Primary Cracking						Secondary Cracking						Pothole		Patch		Edge		Ravel		Bleed		Skid		Deform			
From	To	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Number	Av.Area (m^2)	Number	Av.Area (m^2)	Length	Av.Width (m)	Extent (%)	Degree	Extent (%)	Degree	Extent (%)	Degree	Condition	Position	Shoulder Condition	Drainage Condition
58.24	58.34																									P	CW	P	P
58.34	58.44																	100	0.2	100	2							P	P
58.44	58.54																	100	0.2	100	2							P	F
58.54	58.64																	100	0.2	100	2							P	P
58.64	58.74																	100	0.3	100	2							P	P
58.74	58.84															5	10	100	0.3	100	2							P	P
58.84	58.94															5	10	100	0.3	100	2							P	P
58.94	59.04																	100	0.3	100	2							P	F
59.04	59.14																	100	0.3	100	2							P	F
59.14	59.24	L	CW	3	40	✓	✓											100	0.3	100	2	100	2					P	P
59.24	59.34																	100	0.3	100	2	100	2					P	P
59.34	59.44	C	CW	2	30	✓	✓											100	0.3	100	2	100	2					P	P
59.44	59.54																	100	0.2	100	2	100	2					P	P
59.54	59.64															5	12	100	0.3	100	3	100	2	100	2			P	P
59.64	59.74																	100	0.3	100	3	100	2	100	2			P	P
59.74	59.84	L	CW	3	30	✓	✓									5	25	100	0.3	100	3	100	2	100	2			P	P
59.84	59.94																	100	0.3	100	3	100	2	100	2			P	P
59.94	60.04																	100	0.3	100	3	100	2	100	2			P	P
60.04	60.14															5	24	100	0.3	100	3	100	2	100	2			P	P
60.14	60.24																	100	0.3	100	3	100	2	100	2			P	P

Chainage (km)		Point Number		Peak Deflection (mm x 100)										Rad.of Curve								Rut Depth (mm)	
				LH Wheelpath				RH Wheelpath						LH Wheelpath									
From	To			Initial	Maximum	Final	Deflection	Initial	Maximum	Final	Deflection	Max Corrected	Wheel Path	Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	LHS	RHS
		43	R	4	44	3	81	1	45	2	87	114	IWP									8	5
				3	45	3	84	1	46	1	90												
58.24	58.34	44	R	4	50	2	94	1	45	0	89	121	OWP									10	0
				2	49	2	94	0	45	0	90												
58.34	58.44	45	R	2	29	2	54	2	39	2	74	95	IWP									6	3
				2	30	3	55	2	39	3	73												
58.44	58.54	46	R	2	45	1	87	2	43	1	83	113	OWP	0	30	-1	46	46	1.9	51	95	4	0
				2	46	2	88	2	44	2	84												
58.54	58.64	47	R	2	37	0	72	2	36	1	69	92	OWP									4	0
				3	38	3	70	2	37	2	70												
58.64	58.74	48	R	3	39	2	73	1	33	1	64	96	OWP	1	46	1	31	31	0.6	81	47	0	0
				2	40	2	76	2	33	3	61			0	45	0	31						
58.74	58.84	49	R	2	12	2	20	2	15	2	26	36	OWP	0	22	0	64	64	0.3	247	82	14	5
				2	20	2	36	2	15	1	27												
58.84	58.94	50	R	3	26	2	47	1	29	1	56	71	IWP	0	28	0	50	50	0.6	129	75	0	0
				3	26	3	46	2	29	2	54			0	28	0	50						
58.94	59.04	51	R	3	53	0	103	3	40	2	75	134	OWP	0	46	1	31	30	1.1	50	53	4	0
				1	53	1	104	2	40	2	76			0	50	2	29						
59.04	59.14	52	R	2	40	1	77	2	28	2	52	101	OWP	0	42	-10	30	32	0.7	73	51	0	7
				2	42	2	80	2	27	1	51			0	40	-1	35						
59.14	59.24	53	R	3	22	4	37	2	34	3	63	81	IWP	0	21	0	67	67	0.8	142	108	4	0
				2	24	4	42	2	34	3	63												
59.24	59.34	54	R	4	42	2	78	2	44	2	84	106	IWP	0	33	1	43	43	1.3	62	81	4	3
				2	42	2	80	2	43	3	81												
59.34	59.44	55	R	2	39	2	74	2	50	2	96	125	IWP	0	31	0	45	44	1.2	68	80	7	7
				2	38	0	74	2	50	1	97			0	33	0	42						
59.44	59.54	56	R	3	20	3	34	3	33	4	59	78	IWP	0	16	0	88	89	1.1	150	158	11	8
				2	20	3	35	3	34	3	62			0	17	3	90						
59.54	59.64	57	R	1	23	2	43	3	16	4	25	57	OWP	0	19	0	74	74	1.2	114	135	6	5
				1	24	2	45	2	16	2	28												
59.64	59.74	58	R	2	30	0	58	1	16	3	28	74	OWP	0	21	0	67	64	1.5	83	125	11	10
				2	30	2	56	2	16	3	27			0	23	0	61						
59.74	59.84	59	R	3	34	3	62	2	39	2	74	95	IWP	0	25	-1	55	52	1.1	82	94	14	5
				1	32	1	62	2	38	1	73			0	29	0	48						
59.84	59.94	60	R	2	48	1	93	2	38	2	72	118	OWP	0	44	0	32	33	1.0	57	57	6	0
				2	47	2	90	2	37	2	70			0	42	0	33						
59.94	60.04	61	R	2	48	3	91	2	35	3	65	117	OWP	0	55	-10	23	29	0.8	61	47	0	0
				1	46	0	91	2	34	3	63			0	40	0	35						
60.04	60.14	62	R	2	49	3	93	1	42	0	83	121	OWP	2	49	3	30	30	0.9	58	51	16	0
				3	50	3	94	2	44	3	83												
60.14	60.24	63	R	3	42	4	77	3	48	3	90	117	IWP	0	33	0	42	43	1.2	65	80	5	5
				3	42	4	77	3	49	4	91			0	32	0	44						

Road Maintenance and Rehabilitation Project - Malawi
Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International
in association with **Jatula Partners**

Road Name: Liwonde - Mangochi | Road Code: 14 | Sample Length No.: S4 | Truck Axle Load - LHS: 3175 kg | Date: 4-Aug-98

Chainage (km) 58.24 to 60.24 | Sample Length Code: 144 | Width: 6.7 m | RHS: 3175 kg | Operator: RI/MOWS

Averages and Totals

Area Cracked	670	m^2	5.0%	Area to be patched	1283	m^2	9.6%
Wide Cracks	670	m^2	5.0%	Area already patched	304	m^2	2.3%
				Area Ravelled	12730	m^2	95.0%
Average Condition Index	5.6			Area patched during shoulder repair	600	m^2	4.5%
Minimum Condition Index	3.2						
Maximum Condition Index	13.2						

Average Deflection	δ_p	0.98	mm	OWP	12	57%
Standard Deviation	σ	0.25	mm	IWP	9	43%
Calibration Correction Factor	F_c	0.993	0.99			
Seasonal Correction Factor	F_w	1.300				
Design Deflection	δ_d	1.35	mm			
Percentile to equal the Design Deflection	96%	1.26	mm			
Predicted Design Axles	No.	9.47	$x10^6$ Axles			
Residual Equivalent Standard Axles	No.	1.56	$x10^6$ ESAs			

Percentile of the Road that will Require Reconstruction 4% of the road

Percentile of the Road that will not Require Strengthening d= 1.26 mm 96%

Average Rut Depth		4.7	mm
Standard Deviation of Rut Depth		4.4	mm
Avg.Radius of Curvature		47	m
Avg.M_r Upper Layers		83	MPa
M_r Base	80%	106	MPa
M_r Subbase	20%	51	MPa
Avg.M_r of the Foundation		93	MPa
M_r Selected Subgrade	80%	126	MPa
M_r Subgrade	20%	59	MPa

Target Deflection: 0.8 mm

Existing Base Material: CR

Crushed Rock Granular Overlay Thickness	=	240	mm
Stabilised Natural Gravel Overlay Thickness	=	240	mm
Natural Gravel Granular Overlay Thickness	=	240	mm
Asphalt Overlay Thickness	=	120	mm

Deflection for HDM model $\delta_{(80kN)} =$ 2.09 mm

Road Maintenance and Rehabilitation Project - Malawi
Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International
in association with **Jatula Partners**

Road Name: Mangochi - Monkey Bay | Road Code: 14 | Sample Length No.: S5 | Truck Axle Load - LHS: 3175 kg | Date: 6-Aug-98

Chainage (km) 85.71 to 87.71 | Sample Length Code: 145 | Width: 6.7 m | RHS: 3175 kg | Operator: RI/MOWS

Chainage (km)		Surface Condition																											
		Primary Cracking						Secondary Cracking						Pothole		Patch		Edge		Ravel		Bleed		Skid		Deform			
From	To	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Number	Av.Area (m^2)	Number	Av.Area (m^2)	Length	Av.Width (m)	Extent (%)	Degree	Extent (%)	Degree	Extent (%)	Degree	Condition	Position	Shoulder Condition	Drainage Condition
85.71	85.81	C	CW	4	30	✓	✓	L	CW	4	30	✓	✓	5	20	5	30			80	3					P	CW	F	F
85.81	85.91	C	CW	4	50	✓	✓	L	CW	4	50	✓	✓	5	35	5	35			100	3	100	3			P	CW	P	F
85.91	86.01	C	CW	4	60	✓	✓	L	CW	4	60	✓	✓	5	30	5	35			100	3	100	3			P	CW	P	F
86.01	86.11	C	CW	4	60	✓	✓	L	CW	4	60	✓	✓	5	30	5	35			100	3	100	3			P	CW	F	F
86.11	86.21	C	CW	4	70	✓	✓	L	CW	4	70	✓	✓	5	30	5	35	100	0.4	100	3	100	3			P	CW	F	F
86.21	86.31	C	CW	4	70	✓	✓	L	CW	4	70	✓	✓	5	8	5	12	100	0.4	100	3	100	3			P	CW	F	F
86.31	86.41	C	CW	4	60	✓	✓	L	CW	4	60	✓	✓	5	10	5	8	100	0.4	100	3	100	3			P	CW	F	F
86.41	86.51	C	CW	4	70	✓	✓	L	CW	4	70	✓	✓	5	30	5	40	100	0.4	100	3	100	3			P	CW	F	F
86.51	86.61	C	CW	4	60	✓	✓	L	CW	4	60	✓	✓	5	10	5	10	100	0.4	100	3	100	3			P	CW	F	F
86.61	86.71	C	CW	4	70	✓	✓	L	CW	4	70	✓	✓	5	10	5	20	100	0.4	100	3	100	3			P	CW	F	F
86.71	86.81	C	CW	4	80	✓	✓	L	CW	4	80	✓	✓	5	10	5	20	100	0.4	100	3	100	3			P	CW	F	F
86.81	86.91	C	CW	3	50	✓	✓	L	CW	3	50	✓	✓					100	0.4	100	3	60	3			P	SH	P	P
86.91	87.01	C	CW	3	20	✓	✓	L	CW	3	20	✓	✓					100	0.4	100	3	80	3			P	SH	P	P
87.01	87.11	C	CW	3	30	✓	✓	L	CW	3	30	✓	✓					100	0.4	100	3	70	3			P	SH	P	P
87.11	87.21	C	CW	3	50	✓	✓	L	CW	3	50	✓	✓					100	0.4	100	3	100	3			P	SH	P	P
87.21	87.31	C	CW	3	30	✓	✓	L	CW	3	30	✓	✓	5	5	5	7	100	0.4	100	3	100	3			P	SH	P	P
87.31	87.41	C	CW	3	20	✓	✓	L	CW	3	20	✓	✓	5	5			100	0.4	100	3	100	3			P	SH	P	P
87.41	87.51	C	CW	3	30	✓	✓	L	CW	3	30	✓	✓	5	10	5	12	100	0.4	100	3	100	3			P	SH	P	P
87.51	87.61	C	CW	3	40	✓	✓	L	CW	3	40	✓	✓	5	10	5	10	100	0.4	100	3	100	3			P	SH	P	P
87.61	87.71	C	CW	3	30	✓	✓	L	CW	3	30	✓	✓	5	15	5	10	100	0.3	100	3	100	3			P	SH	P	P

Point Number		Peak Deflection (mm x 100)										Rad.of Curve								Rut Depth (mm)	
		LH Wheelpath				RH Wheelpath						LH Wheelpath									
		Initial	Maximum	Final	Deflection	Initial	Maximum	Final	Deflection	Max Corrected	Wheel Path	Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	LHS	RHS
0	L	0	22	6	38	1	25	2	47	61	IWP	0	18		78	74	1.0	132	128	10	8
		0	22	2	42	1	25	2	47			0	20		70						
2	L	2	41	6	74	1	27	2	51	96	OWP	0	37		38	37	0.8	74	62	70	0
		1	42	9	74	2	27	2	50			2	39		37						
3	L	1	40	7	72	2	35	3	65	94	OWP	0	33	-1	42	41	1.0	72	72	14	15
		0	37	1	73	2	35	3	65			0	34	-1	41						
4	L	0	33	7	59	2	50	1	97	125	IWP	0	29	0	48	52	1.1	84	94	23	0
		0	30	-2	62	2	50	2	96			0	25	0	56						
5	L	0	33	0	66	1	35	1	68	88	IWP	0	29	0	48	47	1.0	81	82	20	5
		0	32	1	63	1	35	1	68			0	31	0	45						
6	L	1	25	2	47	2	40	2	76	98	IWP	0	46	0	30	29	0.2	164	32	0	7
		2	26	1	49	2	40	2	76			0	49	-3	28						
7	L	0	43	6	80	2	45	3	85	112	IWP	0	39	0	36	35	0.9	68	58	0	15
		0	44	7	81	2	45	0	88			0	42	0	33						
8	L	1	29	2	55	3	38	2	71	92	IWP	0	22	0	64	61	1.3	87	115	0	9
		1	30	2	57	3	38	2	71			0	24	0	58						
9	L	1	22	1	42	3	39	2	73	95	IWP										
		2	23	0	44	3	40	3	74			0	39	0	36						
10	L	0	14	1	27	2	45	2	86	113	IWP	0	9	2	175	151	2.0	160	321	8	5
		2	16	2	28	2	46	1	89			0	11	0	127						
11	L	2	46	3	87	2	40	0	78	114	OWP	0	31	2	47	47	1.9	50	98	0	4
		3	47	2	89	2	40	2	76												
12	L	4	49	5	89	2	60	-1	119	153	IWP									0	0
		4	50	5	91	2	60	0	118												
13	L	2	44	9	77	2	69	0	136	176	IWP	0	41	0	34	33	0.7	74	53	2	0
		2	45	10	78	2	69	0	136			-5	39	-5	32						
14	L	1	21	0	41	3	21	0	39	53	IWP	1	21	-1	67	68	0.8	138	113	9	0
		0	20	1	39	3	23	0	43			0	20	0	70						
15	L	0	19	0	38	3	45	2	85	111	IWP	0	28	1	51	51	0.4	166	71	3	0
		0	20	0	40	3	46	2	87			0	27	0	52						
16	L	5	86	16	151	3	90	-1	178	228	IWP	0	61	2	23	21	1.1	34	37	6	0
		5	94	29	154	3	90	2	175			0	79	2	18						
17	L	0	20	0	40	3	40	2	75	97	IWP	0	29	-1	47	49	0.4	175	65	0	8
		1	20	2	37	3	40	2	75			1	29	1	50						
18	L	1	41	0	81	2	50	-1	99	125	IWP	0	31	0	45	37	1.0	65	65	29	10
		1	45	8	81	3	50	2	95			1	51	5	29						
19	L	1	10	2	17	1	31	-2	63	81	IWP	2	11	2	156	120	0.4	396	165	19	5
		1	9	1	16	3	33	1	62			0	15	-3	85						
20	L	0	10	0	20	4	52	3	97	126	IWP	2	11	1	147	156	1.1	247	284	25	0
		0	11	1	21	2	50	0	98			2	11	3	165						
21	L	3	36	11	58	3	28	1	52	76	OWP	0	39	2	37	37	0.5	106	54	11	0
		3	36	10	59	2	27	1	51			3	41	4	37						

Road Name: Mangochi - Monkey Bay | Road Code: 14 | Sample Length No.: S5 | Truck Axle Load - LHS: 3175 kg | Date: 6-Aug-98

Chainage (km) 85.71 to 87.71 | Sample Length Code: 145 | Width: 6.7 m | RHS: 3175 kg | Operator: RI/MOWS

Averages and Totals

Area Cracked	6566	m^2	49.0%
Wide Cracks	6566	m^2	49.0%
Average Condition Index	15.1		
Minimum Condition Index	8.5		
Maximum Condition Index	21.1		

Area to be patched	3418	m^2	25.5%
Area already patched	1196	m^2	8.9%
Area Ravelled	13266	m^2	99.0%
Area patched during shoulder repair	600	m^2	4.5%

Average Deflection	δ_p	1.10	mm	
Standard Deviation	σ	0.39	mm	
Calibration Correction Factor	F_c	0.993	0.99	
Seasonal Correction Factor	F_w	1.300		
Design Deflection	δ_d	1.68	mm	
Percentile to equal the Design Deflection	96%	1.85	mm	
Predicted Design Axles	No.	6.44	$x10^6$	Axles
Residual Equivalent Standard Axles	No.	0.61	$x10^6$	ESAs

OWP	4	19%
IWP	17	81%

Average Rut Depth		8.5 mm
Standard Deviation of Rut Depth		12.4 mm
Avg.Radius of Curvature		60 m
Avg.M_r Upper Layers		104 MPa
M_r Base	80%	120 MPa
M_r Subbase	20%	56 MPa
Avg.M_r of the Foundation		125 MPa
M_r Selected Subgrade	80%	165 MPa
M_r Subgrade	20%	71 MPa

Percentile of the Road that will Require Reconstruction 4% of the road

Percentile of the Road that will not Require Strengthening d= 1.85 mm 96%

Target Deflection: 1.1 mm

Existing Base Material: GN

Crushed Rock Granular Overlay Thickness	=	190 mm
Stabilised Natural Gravel Overlay Thickness	=	190 mm
Natural Gravel Granular Overlay Thickness	=	190 mm
Asphalt Overlay Thickness	=	95 mm

Deflection for HDM model $\delta_{(80kN)} =$ 2.59 mm

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International

in association with **Jatula Partners**

Road Name: Mangochi - Monkey Bay | Road Code: 14 | Sample Length No.: S6 | Truck Axle Load - LHS: 3175 kg | Date: 6-Aug-98

Chainage (km) 97.80 to 98.80 | Sample Length Code: 146 | Width: 6.7 m | RHS: 3175 kg | Operator: RI/MOWS

Chainage (km)		Surface Condition																											
		Primary Cracking						Secondary Cracking						Pothole		Patch		Edge		Ravel		Bleed		Skid		Deform			
From	To	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Number	Av.Area (m^2)	Number	Av.Area (m^2)	Length	Av.Width (m)	Extent (%)	Degree	Extent (%)	Degree	Extent (%)	Degree	Condition	Position	Shoulder Condition	Drainage Condition
97.80	97.90	C	CW	3	50	✓	✓	L	CW	3	50	✓	✓			5	14			100	3	100	2			P	CW	F	F
97.90	98.00	C	CW	3	60	✓	✓	L	CW	3	60	✓	✓			5	10	100	0.2	100	3	100	2			P	CW	F	F
98.00	98.10	C	CW	3	50	✓	✓	L	CW	3	50	✓	✓					100	0.2	100	3	100	2			P	CW	F	F
98.10	98.20	C	CW	3	50	✓	✓	L	CW	3	50	✓	✓					100	0.3	100	3	100	2			P	CW	F	F
98.20	98.30	C	CW	3	30	✓	✓	L	CW	3	30	✓	✓	5	18	5	20	100	0.4	100	3	100	2			P	CW	F	F
98.30	98.40	C	CW	3	40	✓	✓	L	CW	3	40	✓	✓	5	20	5	14	100	0.4	100	3	100	2			P	CW	F	F
98.40	98.50	C	CW	3	40	✓	✓	L	CW	3	40	✓	✓					100	0.4	100	3	100	2			P	CW	F	F
98.50	98.60	C	CW	3	40	✓	✓	L	CW	3	40	✓	✓	5	20	5	28	100	0.4	100	2	100	2			P	CW	F	F
98.60	98.70	C	CW	3	60	✓	✓	L	CW	3	60	✓	✓	5	5	5	20	100	0.4	100	2	100	2			P	CW	P	P
98.70	98.80	C	CW	3	30	✓	✓	L	CW	3	30	✓	✓					100	0.2	100	2	100	2			P	CW	P	P

Chainage (km)		Point Number		Peak Deflection (mm x 100)										Rad.of Curve								Rut Depth (mm)	
				LH Wheelpath				RH Wheelpath						LH Wheelpath									
From	To			Initial	Maximum	Final	Deflection	Initial	Maximum	Final	Deflection	Max Corrected	Wheel Path	Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	LHS	RHS
		22	R	1	11	1	20	2	50	2	96	124	IWP	0	24	0	58	73	0.2	370	85	15	8
				0	11	1	21	2	50	2	96			0	16	0	88						
97.80	97.90	23	R	4	51	15	83	5	51	5	92	119	IWP	0	49	1	29	29	0.7	68	45	7	0
				3	51	10	89	5	52	6	93			0	49	0	29						
97.90	98.00	24	R	1	44	4	83	0	37	-1	75	106	OWP	-5	31	-7	38	34	0.9	65	58	0	3
				1	42	1	82	1	37	2	71			5	49	3	31						
98.00	98.10	25	R	2	78	2	152	0	60	-2	122	199	OWP	0	60	1	24	22	1.3	32	41	10	0
				2	80	2	156	3	64	2	123			0	70	0	20						
98.10	98.20	26	R	2	64	1	125	0	68	-3	139	181	IWP	0	85	1	17	18	0.6	47	27	0	10
				3	70	6	131	0	72	2	142			0	72	0	19						
98.20	98.30	27	R	2	52	11	91	4	55	5	101	134	IWP	0	51	0	27	28	0.7	62	45	8	0
				2	54	13	93	3	56	3	106			0	49	0	29						
98.30	98.40	28	R	1	30	0	59	2	38	4	70	93	IWP	0	40	0	35	35	0.5	103	50	6	7
				1	34	4	63	1	38	1	74			0	40	-1	35						
98.40	98.50	29	R	2	44	2	84	1	54	4	103	128	IWP	0	60	1	24	27	0.6	72	40	4	6
				2	45	3	85	4	52	4	96			0	45	-2	30						
98.50	98.60	30	R	2	17	2	30	2	44	3	83	105	IWP	0	28	-3	47	51	0.2	264	58	4	3
				0	14	0	28	2	42	2	80			0	25	-2	54						
98.60	98.70	31	R	3	40	4	73	0	36	2	70	94	OWP	0	50	3	29	28	0.4	88	39	3	4
				3	41	6	73	4	40	4	72			0	50	-3	27						
98.70	98.80	32	R	2	27	2	50	2	32	4	58	73	IWP	0	32	-7	39	45	0.5	126	66	9	6
				0	26	4	48	2	30	3	55			0	25	-5	51						

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International
in association with **Jatula Partners**

Road Name: Mangochi - Monkey Bay | Road Code: 14 | Sample Length No.: S6 | Truck Axle Load - LHS: 3175 kg | Date: 6-Aug-98

Chainage (km) 97.80 to 98.80 | Sample Length Code: 146 | Width: 6.7 m | RHS: 3175 kg | Operator: RI/MOWS

Averages and Totals

Area Cracked	3015 m^2	45.0%	Area to be patched	1200 m^2	17.9%	Average Deflection δ_p	1.23 mm	OWP	3	27%	Average Rut Depth 5.1 mm
Wide Cracks	3015 m^2	45.0%	Area already patched	398 m^2	5.9%	Standard Deviation σ	0.38 mm	IWP	8	73%	Standard Deviation of Rut Depth 4.0 mm
			Area Ravelled	6700 m^2	100.0%	Calibration Correction Factor F_c	0.993 0.99				
Average Condition Index	17.9		Area patched during shoulder repair	300 m^2	4.5%	Seasonal Correction Factor F_w	1.300				Avg.Radius of Curvature 35 m
Minimum Condition Index	16.9					Design Deflection δ_d	1.80 mm				Avg.M_r Upper Layers 50 MPa
Maximum Condition Index	18.8					Percentile to equal the Design Deflection 96%	1.92 mm				M_r Base 80% 58 MPa
						Predicted Design Axles No.	6.44 $x10^6$ Axles				M_r Subbase 20% 40 MPa
						Residual Equivalent Standard Axles No.	0.61 $x10^6$ ESAs				Avg.M_r of the Foundation 118 MPa
						Percentile of the Road that will Require Reconstruction	4% of the road				M_r Selected Subgrade 80% 126 MPa
						Percentile of the Road that will not Require Strengthening d= 1.92 mm	96%				M_r Subgrade 20% 62 MPa

Target Deflection: 1.1 mm

Crushed Rock Granular Overlay Thickness = 210 mm
Stabilised Natural Gravel Overlay Thickness = 210 mm
Natural Gravel Granular Overlay Thickness = 210 mm

Existing Base Material: GN

Asphalt Overlay Thickness = 105 mm

Deflection for HDM model $\delta_{(80kN)} =$ 2.77 mm

Road Maintenance and Rehabilitation Project - Malawi **Roughton International**
Detailed Visual Condition Survey and Deflection Survey for Sample Lengths *in association with* **Jatula Partners**

Road Name: Mangochi - Monkey Bay | Road Code: 14 | Sample Length No.: S7 | Truck Axle Load - LHS: 3175 kg | Date: 6-Aug-98

Chainage (km) 110.99 to 112.99 | Sample Length Code: 147 | Width: 6.7 m | RHS: 3175 kg | Operator: RI/MOWS

Chainage (km)		Surface Condition: Primary Cracking						Secondary Cracking						Pothole		Patch		Edge		Ravel		Bleed		Skid		Deform				Point Number
From	To	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Number	Av.Area (m^2)	Number	Av.Area (m^2)	Length	Av.Width (m)	Extent (%)	Degree	Extent (%)	Degree	Extent (%)	Degree	Condition	Position	Shoulder Condition	Drainage Condition	
																														33
110.99	111.09	L	CW	3	30	✓												100	0.3			50	2					P	F	34
111.09	111.19	L	CW	3	40	✓												100	0.3									P	P	35
111.19	111.29	L	CW	3	30	✓												100	0.3									P	P	36
111.29	111.39	L	CW	3	20	✓		T	CW	3	20	✓						100	0.3									P	F	37
111.39	111.49	L	CW	3	40	✓		T	CW	3	40	✓						100	0.3									P	F	38
111.49	111.59	L	CW	3	30	✓		T	CW	3	30	✓						100	0.3									P	P	39
111.59	111.69	L	CW	3	30	✓		T	CW	3	30	✓																F	F	40
111.69	111.79	L	CW	3	40	✓		T	CW	3	40	✓																F	P	41
111.79	111.89	L	CW	4	10	✓		T	CW	4	10	✓																P	P	42
111.89	111.99	L	CW	4	30	✓		T	CW	4	30	✓																F	F	43
111.99	112.09	L	CW	4	20	✓		T	CW	4	20	✓																F	F	44
112.09	112.19					✓						✓																F	F	45
112.19	112.29	L	CW	4	20	✓		T	CW	4	20	✓								100	2	100	2					F	F	46
112.29	112.39	L	CW	4	10	✓		T	CW	4	10	✓								100	2	100	2					F	F	47
112.39	112.49	L	CW	3	15	✓		T	CW	3	15	✓								100	2	100	2					F	F	48
112.49	112.59																			100	2	100	2					F	F	49
112.59	112.69	L	CW	4	10	✓		T	CW	4	10	✓								100	2	100	2					F	F	50
112.69	112.79	L	CW	4	5	✓		T	CW	4	5	✓								100	2	100	2					F	F	51
112.79	112.89	T	CW	4	5	✓														100	2	100	2			P	CW	P	F	52
112.89	112.99	L	CW	4	50	✓		T	CW	4	50	✓								100	2	100	2			P	CW	P	F	53

Point Number		Peak Deflection (mm x 100): LH Wheelpath Initial	Maximum	Final	Deflection	RH Wheelpath Initial	Maximum	Final	Deflection	Max Corrected	Wheel Path	Rad.of Curve LH Wheelpath: Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	Rut Depth (mm) LHS	RHS
33	L	1	22	7	36	5	15	7	18	47	OWP	0	29	2	50	48	0.3	192	60	0	0
		2	21	3	37	5	14	5	18			0	31	0	45						
34	L	4	23	5	37	2	37	2	70	93	IWP	0	21	0	67	63	0.7	147	98	0	0
		2	25	6	42	1	38	1	74			0	24	0	58						
35	L	2	18	-3	37	1	7	2	11	54	OWP									5	8
		3	28	6	47	0	5	0	10												
36	L	5	33	10	51	2	32	2	60	78	IWP	0	19	0	74	74	1.5	97	144	10	0
		2	25	1	47	1	32	2	61												
37	L	2	31	3	57	0	13	1	25	73	OWP									0	0
		4	35	10	56	0	11	2	20												
38	L	2	27	8	44	0	42	2	82	108	IWP										
		2	27	8	44	0	43	1	85												
39	L	0	54	6	102	3	50	10	87	132	OWP	0	46	1	31	31	1.1	50	57	0	0
		2	54	4	102	4	50	6	90			0	44	0	32						
40	L	1	52	11	92	5	42	6	73	118	OWP	0	42	0	33	33	1.0	57	58	12	0
		2	52	11	91	6	45	8	76			0	43	0	33						
41	L	2	9	2	14	6	15	8	16	21	IWP	0	5	0	280	257	1.5	340	500	22	0
		2	9	2	14	3	12	5	16			0	6		233						
42	L	2	18	4	30	2	15	3	25	38	OWP	0	11	0	127	122	1.5	161	238	6	0
		2	18	5	29	2	14	3	23			0	12	0	117						
43	L	3	17	7	24	5	22	7	32	41	IWP	0	11	0	127	146	1.3	215	273	5	4
		3	15	5	22	5	21	6	31			0	9	1	165						
44	L	2	18	3	31	2	20	5	33	40	IWP	0	18	0	78	78	0.5	222	113	0	0
		6	19	7	25	5	20	6	29												
45	L	3	40	4	73	3	22	4	37	97	OWP	0	29	0	48	47	1.4	64	90	7	5
		5	45	8	77	4	22	6	34			0	31	0	45						
46	L	3	19	6	29	4	26	8	40	53	IWP	0	16	0	88	107	1.1	173	194	4	8
		3	19	5	30	4	25	4	42			0	11	0	127						
47	L	2	31	2	58	5	24	8	35	77	OWP	0	23	0	61	61	1.5	80	119	0	7
		3	34	4	61	2	22	5	37												
48	L	5	31	10	47	3	28	2	51	67	IWP	0	29	0	48	48	0.6	129	72	8	3
		1	27	6	47	3	30	4	53			0	29	0	48						
49	L	2	21	2	38	3	18	3	30	46	OWP									4	3
		2	19	3	33	4	20	5	31												
50	L	2	45	4	84	2	54	6	100	130	IWP	0	31	0	45	45	1.6	56	89	4	0
		2	46	8	82	2	55	6	102			0	31	-1	44						
51	L	2	39	4	72	3	54	6	99	128	IWP	0	31	0	45	42	1.0	72	73	11	6
		1	38	2	73	4	55	7	99			2	39	3	38						
52	L	1	13	2	23	5	15	4	21	29	OWP	-1	30	0	46	61	0.2	353	67	4	5
		2	13	2	22	4	15	3	23			0	19	1	76						
53	L	3	34	0	65	3	17	2	29	87	OWP									16	0
		0	36	2	70	3	17	2	29												

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International
in association with **Jatula Partners**

Road Name: Mangochi - Monkey Bay | Road Code: 14 | Sample Length No.: S7 | Truck Axle Load - LHS: 3175 kg | Date: 6-Aug-98

Chainage (km) 110.99 to 112.99 | Sample Length Code: 147 | Width: 6.7 m | RHS: 3175 kg | Operator: RI/MOWS

Averages and Totals

Area Cracked	2914	m^2	21.7%
Wide Cracks	2914	m^2	21.7%
Average Condition Index	3.7		
Minimum Condition Index	0.8		
Maximum Condition Index	16.4		

Area to be patched	360	m^2	2.7%
Area already patched	0	m^2	0.0%
Area Ravelled	5360	m^2	40.0%
Area patched during shoulder repair	600	m^2	4.5%

Average Deflection	δ_p	0.74	mm	
Standard Deviation	σ	0.35	mm	
Calibration Correction Factor	F_c	0.993	0.99	
Seasonal Correction Factor	F_w	1.300		
Design Deflection	δ_d	1.26	mm	
Percentile to equal the Design Deflection	96%	1.31	mm	
Predicted Design Axles	No.	6.44	$x10^6$	Axles
Residual Equivalent Standard Axles	No.	0.61	$x10^6$	ESAs

OWP	11	52%
IWP	10	48%

Average Rut Depth		4.2 mm
Standard Deviation of Rut Depth		5.0 mm
Avg.Radius of Curvature		80 m
Avg.M_r Upper Layers		140 MPa
M_r Base	80%	194 MPa
M_r Subbase	20%	67 MPa
Avg.M_r of the Foundation		151 MPa
M_r Selected Subgrade	80%	215 MPa
M_r Subgrade	20%	64 MPa

Percentile of the Road that will Require Reconstruction 4% of the road

Percentile of the Road that will not Require Strengthening d= 1.31 mm 96%

Target Deflection: 1.1 mm

Existing Base Material: GN

Crushed Rock Granular Overlay Thickness	=	70 mm
Stabilised Natural Gravel Overlay Thickness	=	70 mm
Natural Gravel Granular Overlay Thickness	=	70 mm
Asphalt Overlay Thickness	=	35 mm

Deflection for HDM model $\delta_{(80kN)} =$ 1.95 mm

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International

in association with **Jatula Partners**

Road Name: Mangochi - Monkey Bay | Road Code: 14 | Sample Length No.: S8 | Truck Axle Load - LHS: 3175 kg | Date: 6-Aug-98

Chainage (km) 127.80 to 128.80 | Sample Length Code: 148 | Width: 6.7 m | RHS: 3175 kg | Operator: RI/MOWS

Chainage (km)		Surface Condition																											
		Primary Cracking						Secondary Cracking						Pothole		Patch		Edge		Ravel		Bleed		Skid		Deform			
From	To	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Number	Av.Area (m^2)	Number	Av.Area (m^2)	Length	Av.Width (m)	Extent (%)	Degree	Extent (%)	Degree	Extent (%)	Degree	Condtion	Position	Shoulder Condition	Drainage Condition
127.80	127.90	L	CW	2	20	✓														100	3					P	CW	F	F
127.90	128.00	L	CW	2	30	✓								5	17	5	24	100	0.3	100	3	100	3			P	CW	P	F
128.00	128.10	C	CW	4	50	✓		L	CW	4	50	✓		5	5	5	28			100	3	100	3			P	CW	P	F
128.10	128.20	L	CW	4	40	✓		T	CW	4	40	✓		5	5	5	14			100	3	100	3			P	CW	F	F
128.20	128.30	T	CW	10	30	✓														100	3	100	3			P	CW	F	F
128.30	128.40	L/T	CW	3	30	✓										5	6			100	3	100	3			P	CW	F	F
128.40	128.50	L	CW	3	20	✓														100	3	100	3			P	CW	F	F
128.50	128.60	L/T	CW	3	30	✓										5	5			100	3	100	3			P	CW	F	F
128.60	128.70																			100	3	100	3			P	CW	F	F
128.70	128.80	L	CW	3	20	✓		T	CW	3	20	✓								100	3	100	3			P	CW	F	F

Point Number		Peak Deflection (mm x 100)										Rad.of Curve								Rut Depth (mm)	
		LH Wheelpath				RH Wheelpath						LH Wheelpath									
		Initial	Maximum	Final	Deflection	Initial	Maximum	Final	Deflection	Max Corrected	Wheel Path	Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	LHS	RHS
53	L	2	27	4	48	1	46	2	89	117	IWP	3	51	4	29	29	0.2	174	32	0	10
		2	25	4	44	1	48	2	93												
54	L	0	10	0	20	1	22	0	43	56	IWP	0	8	0	175	175	1.2	261	325	26	0
		0	9	0	18	2	25	4	44												
55	L	2	7	3	9	3	16	4	25	32	IWP	0	0	0						6	14
		1	7	2	11	2	15	3	25			0	3	0	467						
56	L	1	13	3	22	2	50	4	94	118	IWP	0	9	0	156	156	1.4	215	298	39	5
		0	13	3	23	2	48	5	89												
57	L	3	13	7	16	3	26	2	47	59	IWP	3	11	3	175	204	1.3	299	383	0	12
		1	10	2	17	6	29	7	45			3	9	3	233						
58	L	2	27	2	50	3	54	3	102	128	IWP	0	23	0	61	57	0.8	114	95	6	14
		1	25	3	46	2	51	3	97			0	26	0	54						
59	L	2	26	5	45	5	28	4	47	63	IWP	3	21	4	80	70	1.0	120	123	4	0
		0	22	2	42	5	30	4	51			0	24	1	60						
60	L	1	25	5	44	5	36	8	59	79	IWP	0	18	0	78	73	1.2	115	133	13	0
		0	22	0	44	5	38	7	64			1	21	0	68						
61	L	2	45	3	85	3	63	2	121	157	IWP	1	35	-10	35	41	1.4	55	79	5	0
		2	48	6	88	7	68	7	122			0	35	10	47						
62	L	2	30	4	54	5	75	0	145	186	IWP	2	29	2	52	49	0.7	112	76	6	12
		1	26	2	49	6	78	7	143			0	32	2	45						
63	L	1	21	1	40	5	56	4	103	135	IWP	0	19	-3	68	68	0.9	130	116	8	13
		0	22	1	43	5	58	5	106												

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International
in association with **Jatula Partners**

Road Name:	Mangochi - Monkey Bay	Road Code:	14	Sample Length No.:	S8	Truck Axle Load - LHS:	3175 kg
Date:	6-Aug-98						
Chainage (km)	127.80 to 128.80	Sample Length Code:	148	Width:	6.7 m	RHS:	3175 kg
Operator:	RI/MOWS						

Averages and Totals

Area Cracked	1809	m^2	27.0%
Wide Cracks	1809	m^2	27.0%
Average Condition Index	17.7		
Minimum Condition Index	15.1		
Maximum Condition Index	19.6		

Area to be patched	388	m^2	5.8%
Area already patched	289	m^2	4.3%
Area Ravelled	6700	m^2	100.0%
Area patched during shoulder repair	300	m^2	4.5%

Average Deflection	δ_p	1.03	mm	
Standard Deviation	σ	0.48	mm	
Calibration Correction Factor	F_c	0.993	0.99	
Seasonal Correction Factor	F_w	1.300		
Design Deflection	δ_d	1.75	mm	
Percentile to equal the Design Deflection	96%	1.74	mm	
Predicted Design Axles	No.	6.44	$x10^6$	Axles
Residual Equivalent Standard Axles	No.	0.61	$x10^6$	ESAs

OWP	0	0%
IWP	11	100%

Percentile of the Road that will Require Reconstruction 4% of the road

Percentile of the Road that will not Require Strengthening d= 1.74 mm 96%

Average Rut Depth		8.8 mm
Standard Deviation of Rut Depth		9.4 mm
Avg.Radius of Curvature		111 m
Avg.M_r Upper Layers		166 MPa
M_r Base	80%	304 MPa
M_r Subbase	20%	79 MPa
Avg.M_r of the Foundation		159 MPa
M_r Selected Subgrade	80%	224 MPa
M_r Subgrade	20%	114 MPa

Target Deflection: 1.1 mm

Existing Base Material: GN

Crushed Rock Granular Overlay Thickness	=	200 mm
Stabilised Natural Gravel Overlay Thickness	=	200 mm
Natural Gravel Granular Overlay Thickness	=	200 mm
Asphalt Overlay Thickness	=	100 mm

Deflection for HDM model $\delta_{(80kN)} =$ 2.70 mm

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International
in association with **Jatula Partners**

Road Name: Zomba - Blantyre | Road Code: 15 | Sample Length No.: S1 | Truck Axle Load - LHS: 3175 kg | Date: 8-Aug-98

Chainage (km) 10.99 to 11.99 | Sample Length Code: 151 | Width: 6.1 m | RHS: 3175 kg | Operator: RI/MOWS

Chainage (km)		Surface Condition																											
		Primary Cracking						Secondary Cracking						Pothole		Patch		Edge		Ravel		Bleed		Skid		Deform			
From	To	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Number	Av.Area (m^2)	Number	Av.Area (m^2)	Length	Av.Width (m)	Extent (%)	Degree	Extent (%)	Degree	Extent (%)	Degree	Condition	Position	Shoulder Condition	Drainage Condition
10.99	11.09																	100	0.4	100	3	100	4	100	3	P	CW	P	P
11.09	11.19																	100	0.4	100	3	100	4	100	3	P	CW	P	P
11.19	11.29																	100	0.4	100	3	100	4	100	3	P	CW	P	P
11.29	11.39																	100	0.4	100	3	100	4	100	3	P	CW	P	P
11.39	11.49																	100	0.4	100	3	100	4	100	3	P	CW	P	P
11.49	11.59																	100	0.4	100	3	100	4	100	3	P	CW	P	P
11.59	11.69																	100	0.4	100	3	100	4	100	3	P	CW	P	P
11.69	11.79															5	12	100	0.4	100	3	100	4	100	3	P	CW	P	F
11.79	11.89																	100	0.4	100	3	100	4	100	3	P	CW	P	F
11.89	11.99																	100	0.4	100	3	100	4	100	3	P	CW	P	F

Point Number		Peak Deflection (mm x 100)										Rad.of Curve								Rut Depth (mm)	
		LH Wheelpath				RH Wheelpath						LH Wheelpath									
		Initial	Maximum	Final	Deflection	Initial	Maximum	Final	Deflection	Max Corrected	Wheel Path	Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	LHS	RHS
0	L	1	18	6	29	5	25	5	40	54	IWP	0	22	0	64	69	0.4	219	95	22	5
		2	17	2	30	2	22	-1	43			0	19	0	74						
1	L	3	17	3	28	3	20	2	35	47	IWP	0	18	0	78	78	0.5	216	114	10	0
		3	18	4	29	4	23	4	38												
2	L	1	15	2	27	1	22	6	37	46	IWP	1	17	-1	82	82	0.5	234	119	18	0
		0	14	2	26	2	18	0	34			0	17	0	82						
3	L	1	10	3	16	4	19	4	30	40	IWP	0	21	0	67	80	0.2	515	85	30	0
		1	9	1	16	3	19	3	32			0	15	0	93						
4	L	0	8	0	16	3	10	3	14	21	OWP	2	18	3	90	92	0.2	478	105	15	0
		2	10	2	16	3	10	2	15			0	15	0	93						
5	L	0	19	2	36	4	26	4	44	58	IWP	0	23	4	67	62	0.5	178	89	12	0
		1	18	1	34	4	27	4	46			0	25	1	57						
6	L	1	7	2	11	5	19	4	29	36	IWP	0	25	1	57	57	0.0	1091	40	20	0
		0	6	1	11	4	17	3	27												
7	L	1	7	1	12	4	17	4	26	34	IWP	2	12	2	140	126	0.2	670	144	9	6
		1	7	2	11	5	18	5	26			0	13	1	112						
8	L	3	9	3	12	3	14	0	25	32	IWP	0	10	-2	127	134	0.3	609	162	7	5
		1	8	3	12	3	13	-2	25			0	10	0	140						
9	L	2	10	2	16	5	11	3	14	19	OWP									10	7
		0	7	0	14	3	9	1	14												
10	L	3	9	2	13	3	18	2	31	40	IWP									5	5
		2	9	1	15	3	17	0	31												

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International *in association with* **Jatula Partners**

Road Name: Zomba - Blantyre | Road Code: 15 | Sample Length No.: S1 | Truck Axle Load - LHS: 3175 kg | Date: 8-Aug-98

Chainage (km) 10.99 to 11.99 | Sample Length Code: 151 | Width: 6.1 m | RHS: 3175 kg | Operator: RI/MOWS

Averages and Totals

Area Cracked	0 m^2	0.0%	Area to be patched	830 m^2	13.6%	Average Deflection	δ_p	0.39	mm	OWP	2	18%	Average Rut Depth		8.5	mm
Wide Cracks	0 m^2	0.0%	Area already patched	45 m^2	0.7%	Standard Deviation	σ	0.12	mm	IWP	9	82%	Standard Deviation of Rut Depth		8.2	mm
			Area Ravelled	6100 m^2	100.0%	Calibration Correction Factor	F_c	0.993	0.99							
Average Condition Index	22.6		Area patched during shoulder repair	300 m^2	4.9%	Seasonal Correction Factor	F_w	1.300					Avg.Radius of Curvature		89	m
Minimum Condition Index	22.6					Design Deflection	δ_d	0.57	mm				Avg.M_r Upper Layers		106	MPa
Maximum Condition Index	22.8					Percentile to equal the Design Deflection	96%	0.56	mm				M_r Base	80%	129	MPa
						Predicted Design Axles	No.	13.16	$x10^6$ Axles				M_r Subbase	20%	88	MPa
						Residual Equivalent Standard Axles	No.	2.42	$x10^6$ ESAs				Avg.M_r of the Foundation		468	MPa
						Percentile of the Road that will Require Reconstruction	4% of the road						M_r Selected Subgrade	80%	633	MPa
						Percentile of the Road that will not Require Strengthening d=	0.56 mm	96%					M_r Subgrade	20%	218	MPa

Target Deflection: 0.7 mm

Existing Base Material: CM

Crushed Rock Granular Overlay Thickness	=	40	mm
Stabilised Natural Gravel Overlay Thickness	=	40	mm
Natural Gravel Granular Overlay Thickness	=	40	mm
Asphalt Overlay Thickness	=	20	mm

Deflection for HDM model $\delta_{(80kN)} =$ 0.88 mm

Road Maintenance and Rehabilitation Project - Malawi
Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International
in association with **Jatula Partners**

Road Name: Zomba - Blantyre | Road Code: 15 | Sample Length No.: #N/A | Truck Axle Load - LHS: 3175 kg | Date: 8-Aug-98

Chainage (km) #N/A to #N/A | Sample Length Code: 152 | Width: 6.1 m | RHS: 3175 kg | Operator: RI/MOWS

Chainage (km)		Surface Condition																											
		Primary Cracking						Secondary Cracking						Pothole		Patch		Edge		Ravel		Bleed		Skid		Deform			
From	To	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Number	Av.Area (m^2)	Number	Av.Area (m^2)	Length	Av.Width (m)	Extent (%)	Degree	Extent (%)	Degree	Extent (%)	Degree	Condition	Position	Shoulder Condition	Drainage Condition
#N/A	#N/A	C	CW	3	30	✓		L	CW	3	30	✓				5	8	100	0.4	100	3	100	4	100	3	P	CW	P	P
#N/A	#N/A	C	CW	3	30	✓												100	0.4	100	3	100	4	100	3	P	CW	P	P
#N/A	#N/A	C	CW	3	30	✓												100	0.4	100	3	100	4	100	3	P	CW	P	P
#N/A	#N/A	C	CW	3	40	✓												100	0.4	100	3	100	4	100	3	P	CW	P	P
#N/A	#N/A	C	CW	3	50	✓												100	0.4	100	3	100	4	100	3	P	CW	P	P
#N/A	#N/A	C	CW	3	20													100	0.4	100	3	100	4	100	3	P	CW	P	P
#N/A	#N/A																	100	0.4	100	3	100	4	100	3	P	CW	P	P
#N/A	#N/A																	100	0.4	100	3	100	4	100	3	P	CW	P	P
#N/A	#N/A																	100	0.4	100	3	100	4	100	3	P	CW	P	P
#N/A	#N/A																	100	0.4	100	3	100	4	100	3	P	CW	P	P

Point Number		Peak Deflection (mm x 100)										Rad.of Curve								Rut Depth (mm)	
		LH Wheelpath				RH Wheelpath						LH Wheelpath									
		Initial	Maximum	Final	Deflection	Initial	Maximum	Final	Deflection	Max Corrected	Wheel Path	Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	LHS	RHS
11	L	2 1	27 26	3 4	49 47	2 2	32 33	3 3	59 61	77	IWP	2 0	20 20	-3 0	68 70	69	1.2	104	128	18	4
12	L	1 1	28 27	0 1	55 52	1 3	32 34	1 4	62 61	79	IWP	0 0	22 25	0 0	64 56	60	1.1	95	109	13	5
13	L	0 1	20 21	0 1	40 40	3 3	26 27	2 3	47 48	61	IWP	2 0	28 25	4 -3	56 53	54	0.5	155	79	25	0
14	L	0 1	36 36	11 11	61 60	6 4	50 49	6 5	88 89	114	IWP	0 0	22 20	-2 0	61 70	65	1.8	75	135	19	0
15	L	0 1	20 18	4 2	36 33	3 3	20 22	2 5	35 36	46	IWP	0	10	-4	117	117	1.9	130	243	8	0
16	L	1 1	21 19	4 3	37 34	0 0	30 32	4 4	56 60	75	IWP	0	12	0	117	117	2.0	124	247	11	0
17	L	1 3	19 18	3 1	34 32	2 1	13 14	2 3	22 24	43	OWP	0 -2	18 19	0 0	78 70	74	0.6	177	114	17	7
18	L	2 4	18 19	4 2	30 32	0 0	16 15	3 2	29 28	40	OWP	0 0	16 18	4 0	100 78	89	0.8	177	148		
19	L	0 1	11 10	2 1	20 18	0 0	15 16	0 1	30 31	39	IWP	0 0	14 12	0 -1	100 112	106	0.4	341	147		
20	L	0 0	8 9	1 1	15 17	4 4	14 14	6 5	18 19	24	IWP									13	5
21	L	1 3	13 14	3 1	22 24	3 4	14 17	1 5	24 25	32	IWP	0 0	14 10	0 1	100 147	124	0.9	234	210	13	8

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International
in association with **Jatula Partners**

Road Name: Zomba - Blantyre | Road Code: 15 | Sample Length No.: #N/A | Truck Axle Load - LHS: 3175 kg | Date: 8-Aug-98

Chainage (km) #N/A to #N/A | Sample Length Code: 152 | Width: 6.1 m | RHS: 3175 kg | Operator: RI/MOWS

Averages and Totals

Area Cracked	#N/A	m^2	#N/A
Wide Cracks	#N/A	m^2	#N/A
Average Condition Index	22.6		
Minimum Condition Index	22.6		
Maximum Condition Index	22.8		

Area to be patched	820	m^2	#N/A
Area already patched	30	m^2	#N/A
Area Ravelled	#N/A	m^2	#N/A
Area patched during shoulder repair	#N/A	m^2	#N/A

Average Deflection	δ_p	0.57	mm	
Standard Deviation	σ	0.27	mm	
Calibration Correction Factor	F_c	0.993	0.99	
Seasonal Correction Factor	F_w	1.300		
Design Deflection	δ_d	0.98	mm	
Percentile to equal the Design Deflection	96%	1.00	mm	
Predicted Design Axles	No.	13.16	$x10^6$	Axles
Residual Equivalent Standard Axles	No.	2.42	$x10^6$	ESAs

OWP	2	18%
IWP	9	82%

Average Rut Depth		8.9 mm
Standard Deviation of Rut Depth		6.9 mm
Avg.Radius of Curvature		84 m
Avg.M_r Upper Layers		156 MPa
M_r Base	80%	216 MPa
M_r Subbase	20%	113 MPa
Avg.M_r of the Foundation		161 MPa
M_r Selected Subgrade	80%	189 MPa
M_r Subgrade	20%	102 MPa

Percentile of the Road that will Require Reconstruction 4% of the road

Percentile of the Road that will not Require Strengthening d= 1.00 mm 96%

Target Deflection: 0.7 mm

Existing Base Material: CM

Crushed Rock Granular Overlay Thickness	=	180	mm
Stabilised Natural Gravel Overlay Thickness	=	180	mm
Natural Gravel Granular Overlay Thickness	=	180	mm
Asphalt Overlay Thickness	=	90	mm

Deflection for HDM model $\delta_{(80kN)} =$ 1.50 mm

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International
in association with **Jatula Partners**

Road Name: Zomba - Blantyre | Road Code: 15 | Sample Length No.: S3 | Truck Axle Load - LHS: 3175 kg | Date: 8-Aug-98

Chainage (km) 24.18 to 25.18 | Sample Length Code: 153 | Width: 6.1 m | RHS: 3175 kg | Operator: RI/MOWS

Chainage (km)		Surface Condition																											
		Primary Cracking						Secondary Cracking						Pothole		Patch		Edge		Ravel		Bleed		Skid		Deform			
From	To	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Number	Av.Area (m^2)	Number	Av.Area (m^2)	Length	Av.Width (m)	Extent (%)	Degree	Extent (%)	Degree	Extent (%)	Degree	Condition	Position	Shoulder Condition	Drainage Condition
24.18	24.28	C	CW	2	20	✓	✓											100	0.3	100	3	100	3	100	2	P	CW	P	P
24.28	24.38	C	CW	2	20	✓	✓											100	0.4	100	3	100	3	100	2	P	CW	P	P
24.38	24.48	C	CW	3	30	✓	✓											100	0.4	100	3	100	3	100	2	P	CW	P	P
24.48	24.58	C	CW	3	40	✓	✓											100	0.5	100	3	100	3	100	2	P	CW	P	P
24.58	24.68	C	CW	3	60	✓	✓											100	0.5	100	3	100	3	100	2	P	CW	P	P
24.68	24.78	C	CW	3	50	✓	✓											100	0.4	100	3	100	3	100	2	P	CW	P	P
24.78	24.88	C	CW	3	50	✓	✓											100	0.4	100	3	100	3	100	2	P	CW	P	P
24.88	24.98	C	CW	3	50	✓	✓											100	0.4	100	3	100	3	100	2	P	CW	P	P
24.98	25.08	C	CW	2	20	✓	✓											100	0.4	100	3	100	3	100	2	P	CW	P	P
25.08	25.18	C	CW	2	10	✓	✓											100	0.4	100	3	100	3	100	2	P	CW	P	P

Chainage (km)		Point Number		Peak Deflection (mm x 100)										Rad.of Curve								Rut Depth (mm)	
				LH Wheelpath				RH Wheelpath						LH Wheelpath									
From	To			Initial	Maximum	Final	Deflection	Initial	Maximum	Final	Deflection	Max Corrected	Wheel Path	Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	LHS	RHS
		22	R	1	38	2	73	4	32	3	57	88	OWP	5	30	5	56	50	1.3	71	95	20	5
				3	34	1	64	3	30	0	57			0	32	1	44						
24.18	24.28	23	R	0	17	1	33	3	19	1	34	44	IWP	0	25	4	61	55	0.3	222	71	19	20
				2	16	0	30	3	20	3	34			3	28	-3	50						
24.28	24.38	24	R	2	18	1	33	2	20	1	37	48	IWP	0	17	1	85	81	0.8	172	132	20	0
				1	17	1	32	2	21	2	38			2	20	2	78						
24.38	24.48	25	R	2	40	11	67	2	30	2	56	86	OWP	0	32	0	44	44	0.9	80	75	22	0
				4	40	10	66	3	30	0	57												
24.48	24.58	26	R	1	41	3	78	4	45	8	78	103	IWP	0	35	3	42	42	1.1	66	76	20	13
				1	39	2	75	4	45	4	82												
24.58	24.68	27	R	3	18	4	29	3	12	5	16	37	OWP									17	5
				1	16	2	29	4	14	6	18												
24.68	24.78	28	R	1	38	2	73	2	16	3	27	93	OWP	0	40	-1	35	34	0.6	81	52	21	6
				3	37	0	71	0	14	0	28			-1	42	0	33						
24.78	24.88	29	R	0	17	0	34	1	17	2	31	45	OWP	0	20	0	70	58	0.4	188	81	22	10
				0	18	1	35	1	15	2	27			0	30	0	47						
24.88	24.98	30	R	2	24	7	39	0	52	1	103	135	IWP	0	22	0	64	60	0.6	156	91	20	9
				0	23	8	38	0	53	0	106			0	24	-1	57						
24.98	25.08	31	R	2	20	3	35	2	20	2	36	46	OWP	0	20	0	70	66	0.6	168	100	27	5
				1	20	3	36	3	20	3	34			0	21	-3	62						
25.08	25.18	32	R	1	9	1	16	2	12	2	20	26	IWP	0	12	0	117	125	0.5	387	175	5	8
				2	12	5	17	2	12	2	20			-1	10	0	133						

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International
in association with **Jatula Partners**

Road Name:	Zomba - Blantyre	Road Code:	15	Sample Length No.:	S3	Truck Axle Load - LHS:	3175 kg
Chainage (km)	24.18 to 25.18	Sample Length Code:	153	Width:	6.1 m	RHS:	3175 kg

Date: 8-Aug-98

Operator: RI/MOWS

Averages and Totals

Area Cracked	2135	m^2	35.0%
Wide Cracks	2135	m^2	35.0%
Average Condition Index	20.4		
Minimum Condition Index	20.1		
Maximum Condition Index	20.8		

Area to be patched	920	m^2	15.1%
Area already patched	0	m^2	0.0%
Area Ravelled	6100	m^2	100.0%
Area patched during shoulder repair	300	m^2	4.9%

Average Deflection	δ_p	0.68	mm	
Standard Deviation	σ	0.34	mm	
Calibration Correction Factor	F_c	0.993	0.99	
Seasonal Correction Factor	F_w	1.300		
Design Deflection	δ_d	1.20	mm	
Percentile to equal the Design Deflection	96%	1.22	mm	
Predicted Design Axles	No.	13.16	$x10^6$	Axles
Residual Equivalent Standard Axles	No.	2.42	$x10^6$	ESAs

Percentile of the Road that will Require Reconstruction 4% of the road

Percentile of the Road that will not Require Strengthening d= 1.22 mm 96%

OWP	6	55%
IWP	5	45%

Average Rut Depth		13.4 mm
Standard Deviation of Rut Depth		8.2 mm
Avg.Radius of Curvature		64 m
Avg.M_r Upper Layers		95 MPa
M_r Base	80%	106 MPa
M_r Subbase	20%	74 MPa
Avg.M_r of the Foundation		159 MPa
M_r Selected Subgrade	80%	195 MPa
M_r Subgrade	20%	78 MPa

Target Deflection: 0.7 mm

Existing Base Material: CM

Crushed Rock Granular Overlay Thickness	=	250 mm
Stabilised Natural Gravel Overlay Thickness	=	250 mm
Natural Gravel Granular Overlay Thickness	=	250 mm
Asphalt Overlay Thickness	=	125 mm

Deflection for HDM model $\delta_{(80kN)} =$ 1.85 mm

Road Maintenance and Rehabilitation Project - Malawi

Roughton International

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

in association with **Jatula Partners**

Road Name: Zomba - Blantyre | Road Code: 15 | Sample Length No.: S4 | Truck Axle Load - LHS: 3175 kg | Date: 8-Aug-98

Chainage (km) 51.65 to 52.65 | Sample Length Code: 154 | Width: 6.1 m | RHS: 3175 kg | Operator: RI/MOWS

Chainage (km)		Surface Condition																									
		Primary Cracking						Secondary Cracking						Pothole		Patch		Edge		Ravel		Bleed		Skid		Deform			
From	To	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Number	Av.Area (m^2)	Number	Av.Area (m^2)	Length	Av.Width (m)	Extent (%)	Degree	Extent (%)	Degree	Extent (%)	Degree	Condition	Position	Shoulder Condition	Drainage Condition
51.65	51.75	C	CW	4	50	✓	✓											100	0.5	100	2	100	3	100	3	P	CW	P	P
51.75	51.85	L	CW	4	40	✓	✓	T	CW	4	40	✓	✓			5	7	100	0.5	100	2	100	3	100	3	P	CW	P	P
51.85	51.95	C	CW	4	50	✓	✓	T	CW	4	50	✓	✓					100	0.5	100	2	100	3	100	3	P	CW	P	P
51.95	52.05	C	CW	4	40	✓	✓									5	4	100	0.5	100	2	100	3	100	3	P	CW	P	P
52.05	52.15	C	CW	4	50	✓	✓									5	10	100	0.5	100	2	100	3	100	3	P	CW	P	P
52.15	52.25	C	CW	4	30	✓	✓											100	0.4	100	2	100	3	100	3	P	CW	P	P
52.25	52.35	C	CW	4	40	✓	✓											100	0.5	100	2	100	3	100	3	P	CW	P	P
52.35	52.45	C	CW	4	50	✓	✓											100	0.5	100	2	100	3	100	3	P	CW	P	P
52.45	52.55	C	CW	4	40	✓	✓							5	10			100	0.5	100	2	100	3	100	3	P	CW	P	P
52.55	52.65	C	CW	4	35	✓	✓							5	12			100	0.2	100	2	100	3	100	3	P	CW	P	P

Point Number		Peak Deflection (mm x 100)										Rad.of Curve								Rut Depth (mm)	
		LH Wheelpath				RH Wheelpath						LH Wheelpath									
		Initial	Maximum	Final	Deflection	Initial	Maximum	Final	Deflection	Max Corrected	Wheel Path	Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	LHS	RHS
33	R	1	29	1	56	3	56	2	107	138	IWP	0	26	1	55	55	1.1	90	99	40	0
		0	32	6	58	2	55	1	107												
34	R	1	40	10	69	4	32	5	55	92	OWP	0	28	1	51	48	1.3	69	90	23	0
		1	38	1	74	3	31	4	55			0	32	1	44						
35	R	2	24	3	43	5	37	6	63	84	IWP	0	30	4	50	49	0.5	140	70	26	0
		2	24	0	46	2	36	3	67			2	32	3	47						
36	R	2	22	2	40	2	32	3	59	77	IWP	2	28	4	56	55	0.5	155	80	22	6
		2	22	2	40	2	33	3	61			0	26	0	54						
37	R	2	43	13	71	5	40	4	71	94	IWP	0	32	1	44	46	1.2	72	83	20	10
		2	38	4	70	4	41	4	74			0	30	0	47						
38	R	2	46	6	84	3	42	5	76	104	OWP	3	31	0	47	47	1.6	58	93	18	11
		0	40	3	77	4	41	4	74			0	32	3	46						
39	R	4	29	4	50	2	33	3	61	79	IWP	1	28	0	51	51	0.8	108	83	17	6
		2	29	2	54	3	34	3	62												
40	R	2	45	14	74	3	41	4	75	99	IWP	0	43	2	33	33	0.7	78	52	17	8
		2	40	3	75	2	41	2	78												
41	R	1	20	1	38	4	25	4	42	50	OWP	0	18	0	78	71	0.8	143	117	10	3
		1	20	0	39	3	20	3	34			0	22	0	64						
42	R	2	32	1	61	3	39	3	72	94	IWP	0	34	0	41	41	0.8	87	67	18	12
		2	36	2	68	3	40	3	74												
43	R	0	35	0	70	4	37	4	66	90	OWP	0	30	0	47	44	1.0	75	78	23	5
		0	35	1	69	4	38	4	68			0	34	0	41						

Road Maintenance and Rehabilitation Project - Malawi
Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International
in association with **Jatula Partners**

Road Name: Zomba - Blantyre | Road Code: 15 | Sample Length No.: S4 | Truck Axle Load - LHS: 3175 kg | Date: 8-Aug-98

Chainage (km) 51.65 to 52.65 | Sample Length Code: 154 | Width: 6.1 m | RHS: 3175 kg | Operator: RI/MOWS

Averages and Totals

Area Cracked	2593	m^2	42.5%
Wide Cracks	2593	m^2	42.5%
Average Condition Index	20.9		
Minimum Condition Index	20.5		
Maximum Condition Index	21.2		

Area to be patched	1163	m^2	19.1%
Area already patched	79	m^2	1.3%
Area Ravelled	6100	m^2	100.0%
Area patched during shoulder repair	300	m^2	4.9%

Average Deflection	δ_p	0.91	mm	
Standard Deviation	σ	0.21	mm	
Calibration Correction Factor	F_c	0.993	0.99	
Seasonal Correction Factor	F_w	1.300		
Design Deflection	δ_d	1.23	mm	
Percentile to equal the Design Deflection	96%	1.24	mm	
Predicted Design Axles	No.	13.16	$x10^6$	Axles
Residual Equivalent Standard Axles	No.	2.42	$x10^6$	ESAs

OWP	4	36%
IWP	7	64%

Average Rut Depth		13.4 mm
Standard Deviation of Rut Depth		10.1 mm
Avg.Radius of Curvature		50 m
Avg.M_r Upper Layers		83 MPa
M_r Base	80%	93 MPa
M_r Subbase	20%	70 MPa
Avg.M_r of the Foundation		98 MPa
M_r Selected Subgrade	80%	140 MPa
M_r Subgrade	20%	72 MPa

Percentile of the Road that will Require Reconstruction 4% of the road

Percentile of the Road that will not Require Strengthening d= 1.24 mm 96%

Target Deflection: 0.7 mm

Existing Base Material: CM

Crushed Rock Granular Overlay Thickness	=	260 mm
Stabilised Natural Gravel Overlay Thickness	=	260 mm
Natural Gravel Granular Overlay Thickness	=	260 mm
Asphalt Overlay Thickness	=	130 mm

Deflection for HDM model $\delta_{(80kN)} =$ 1.90 mm

Road Maintenance and Rehabilitation Project - Malawi
Roughton International
in association with **Jatula Partners**

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Road Name: Zomba - Blantyre | Road Code: 15 | Sample Length No.: S5 | Truck Axle Load - LHS: 3175 kg | Date: 8-Aug-98

Chainage (km) 56.04 to 58.04 | Sample Length Code: 155 | Width: 6.1 m | RHS: 3175 kg | Operator: RI/MOWS

Chainage (km)		Surface Condition																														
		Primary Cracking						Secondary Cracking						Pothole		Patch		Edge		Ravel		Bleed		Skid		Deform				
From	To	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Type	Position	Degree	Extent (%)	Width >3mm	Pumping	Number	Av.Area (m^2)	Number	Av.Area (m^2)	Length	Av.Width (m)	Extent (%)	Degree	Extent (%)	Degree	Extent (%)	Degree	Condition	Position	Shoulder Condition	Drainage Condition	Point Number
																														44
56.04	56.14	C	CW	3	30	✓	✓									1	700	100	0.5	100	2	100	3	100	3	P	CW	P	P	45
56.14	56.24	L	CW	3	35	✓	✓	T	CW	3	35	✓	✓					100	0.5	100	2	100	3	100	3	P	CW	P	P	46
56.24	56.34	L	CW	3	40	✓	✓	T	CW	3	40	✓	✓					100	0.5	100	2	100	3	100	3	P	CW	P	P	47
56.34	56.44																	100	0.5	100	2	100	3	100	3	P	CW	P	P	48
56.44	56.54																	100	0.5	100	2	100	3	100	3	P	CW	P	P	49
56.54	56.64	C	CW	3	30	✓	✓	L	CW	3	30	✓	✓					100	0.5	100	2	100	3	100	3	P	CW	P	P	50
56.64	56.74	L	CW	3	10	✓	✓	T	CW	3	10	✓	✓					100	0.3	100	2	100	3	100	3	P	CW	P	P	51
56.74	56.84	C	CW	3	15	✓	✓	T	CW	3	15	✓	✓					100	0.5	100	2	100	3	100	3	P	CW	P	P	52
56.84	56.94	C	CW	3	50	✓	✓											100	0.4	100	2	100	3	100	3	P	CW	P	P	53
56.94	57.04	C	CW	3	30	✓	✓											100	0.5	100	2	100	3	100	3	P	CW	P	P	54
57.04	57.14	C	CW	3	35	✓	✓											100	0.5	100	2	100	3	100	3	P	CW	P	P	55
57.14	57.24	L	CW	3	40	✓	✓	T	CW	3	40	✓	✓					100	0.5	100	2	100	3	100	3	P	CW	P	P	56
57.24	57.34	L	CW	2	10	✓	✓	T	CW	2	10	✓	✓					100	0.5	100	2	100	3	100	3	P	CW	P	P	57
57.34	57.44	L	CW	2	5	✓	✓	T	CW	2	5	✓	✓					100	0.5	100	2	100	3	100	3	P	CW	P	P	58
57.44	57.54	L	CW	2	15	✓	✓	T	CW	2	15	✓	✓					100	0.5	100	2	100	3	100	3	P	CW	P	P	59
57.54	57.64	L	CW	2	10	✓	✓	T	CW	2	10	✓	✓					100	0.5	100	2	100	3	100	3	P	CW	P	P	60
57.64	57.74	L	CW	2	5	✓	✓	T	CW	2	5	✓	✓					100	0.5	100	2	100	3	100	3	P	CW	P	P	61
57.74	57.84	L	CW	2	10	✓	✓	T	CW	2	10	✓	✓					100	0.5	100	2	100	3	100	3	P	CW	P	P	62
57.84	57.94	L	CW	2	10	✓	✓	T	CW	2	10	✓	✓					100	0.5	100	2	100	3	100	3	P	CW	P	P	63
57.94	58.04	L	CW	2	10	✓	✓	T	CW	2	10	✓	✓					100	0.5	100	2	100	3	100	3	P	CW	P	P	64

Point Number		Peak Deflection (mm x 100)										Rad.of Curve								Rut Depth (mm)	
		LH Wheelpath				RH Wheelpath						LH Wheelpath									
		Initial	Maximum	Final	Deflection	Initial	Maximum	Final	Deflection	Max Corrected	Wheel Path	Initial	Maximum	Final	R_c	Average	MR	E_{SG}	E_B	LHS	RHS
44	R	1	31	3	58	3	62	1	120	156	IWP	0	19	-1	72	71	1.9	79	148	7	4
		0	30	4	56	5	65	4	121			0	20	0	70						
45	R	2	31	0	60	2	32	0	62	80	IWP	0	19	0	74	72	2.3	69	159	24	5
		0	32	0	64	0	30	-2	62			0	20	0	70						
46	R	2	30	1	57	0	26	0	52	74	OWP	0	20	0	70	70	1.9	78	146	12	8
		0	29	0	58	0	27	0	54												
47	R	1	10	1	18	2	23	-3	47	61	IWP	0	12	-3	104	88	0.3	377	109	19	0
		1	11	1	20	0	23	-1	47			2	22	3	72						
48	R	0	20	8	32	2	22	1	41	52	IWP	0	13	0	108	115	1.4	155	222	12	0
		1	17	3	30	2	21	1	39			0	10	-3	122						
49	R	2	11	3	17	0	16	-1	33	42	IWP	0	10	0	140	128	0.5	349	189	6	0
		0	9	0	18	0	16	0	32			0	12	0	117						
50	R	1	31	0	61	3	11	-2	21	80	OWP	0	15	0	93	90	3.8	61	229	18	0
		0	31	-1	63	3	11	-2	21			0	16	0	88						
51	R	0	20	1	39	3	29	0	55	70	IWP	0	19	0	74	72	0.9	132	123	13	5
		0	20	-2	42	0	27	0	54			0	20	0	70						
52	R	1	7	0	13	2	19	0	36	45	IWP	2	10	2	175	175	1.5	224	345	4	5
		0	15	1	29	1	15	-5	34												
53	R	2	49	4	92	3	72	5	136	177	IWP	0	10	-2	127	127	17.6	28	494	14	0
		0	44	-2	90	2	68	-4	138			0	11	0	127						
54	R	2	24	7	39	2	28	0	54	70	IWP	0	28	0	50	53	0.4	174	73	15	10
		2	20	2	36	2	29	1	55			0	25	0	56						
55	R	0	17	1	33	3	23	2	41	52	IWP	0	17	0	82	76	0.7	170	121	11	5
		0	19	4	34	1	21	1	40			0	20	0	70						
56	R	1	14	1	26	2	24	1	45	57	IWP	0	19	0	74	74	0.4	256	99	6	0
		0	13	0	26	0	22	0	44												
57	R	0	22	0	44	0	21	0	42	59	OWP									13	0
		0	25	2	48	1	22	2	41												
58	R	2	20	4	34	2	25	1	47	61	IWP									5	8
		1	20	5	34	2	26	2	48												
59	R	1	32	-1	64	2	46	0	90	116	IWP	1	20	1	74	74	2.7	64	169	17	7
		0	32	-1	65	2	46	1	89			0	20	2	74						
60	R	2	30	2	56	1	29	-2	59	73	IWP	0	22	1	65	68	1.7	83	138	10	5
		2	30	3	55	2	30	4	54			3	23	4	72						
61	R	0	20	2	38	2	28	2	52	66	IWP	0	29	0	48	52	0.5	162	73	11	14
		0	21	1	41	2	29	6	50			0	25	0	56						
62	R	2	35	10	58	2	20	0	38	77	OWP	0	20	-2	67	59	1.4	81	114		
		3	39	14	61	2	19	1	35			6	30	0	52						
63	R	1	29	9	48	2	24	2	44	61	OWP	0	30	-2	45	52	0.7	124	82	10	5
		1	24	1	46	3	25	0	47			-2	20	-5	60						
64	R	2	33	13	51	2	19	1	35	65	OWP	0	30	0	47	54	0.8	111	88	28	
		0	25	1	49	2	18	3	31			0	23		61						

Road Maintenance and Rehabilitation Project - Malawi

Detailed Visual Condition Survey and Deflection Survey for Sample Lengths

Roughton International
in association with **Jatula Partners**

Road Name:	Zomba - Blantyre	Road Code:	15	Sample Length No.:	S5	Truck Axle Load - LHS:	3175 kg
Date:	8-Aug-98						
Chainage (km)	56.04 to 58.04	Sample Length Code:	155	Width:	6.1 m	RHS:	3175 kg
Operator:	RI/MOWS						

Averages and Totals

Area Cracked	2379	m^2	19.5%
Wide Cracks	2379	m^2	19.5%
Average Condition Index	20.6		
Minimum Condition Index	20.1		
Maximum Condition Index	23.6		

Area to be patched	2350	m^2	19.3%
Area already patched	525	m^2	4.3%
Area Ravelled	12200	m^2	100.0%
Area patched during shoulder repair	600	m^2	4.9%

Average Deflection	δ_p	0.76	mm	OWP	6	29%
Standard Deviation	σ	0.34	mm	IWP	15	71%
Calibration Correction Factor	F_c	0.993	0.99			
Seasonal Correction Factor	F_w	1.300				
Design Deflection	δ_d	1.27	mm			
Percentile to equal the Design Deflection	96%	1.59	mm			
Predicted Design Axles	No.	13.16	$x10^6$ Axles			
Residual Equivalent Standard Axles	No.	2.42	$x10^6$ ESAs			

Percentile of the Road that will Require Reconstruction 4% of the road

Percentile of the Road that will not Require Strengthening d= 1.59 mm 96%

Average Rut Depth		8.6	mm
Standard Deviation of Rut Depth		6.7	mm
Avg.Radius of Curvature		81	m
Avg.M_r Upper Layers		164	MPa
M_r Base	80%	202	MPa
M_r Subbase	20%	95	MPa
Avg.M_r of the Foundation		146	MPa
M_r Selected Subgrade	80%	194	MPa
M_r Subgrade	20%	74	MPa

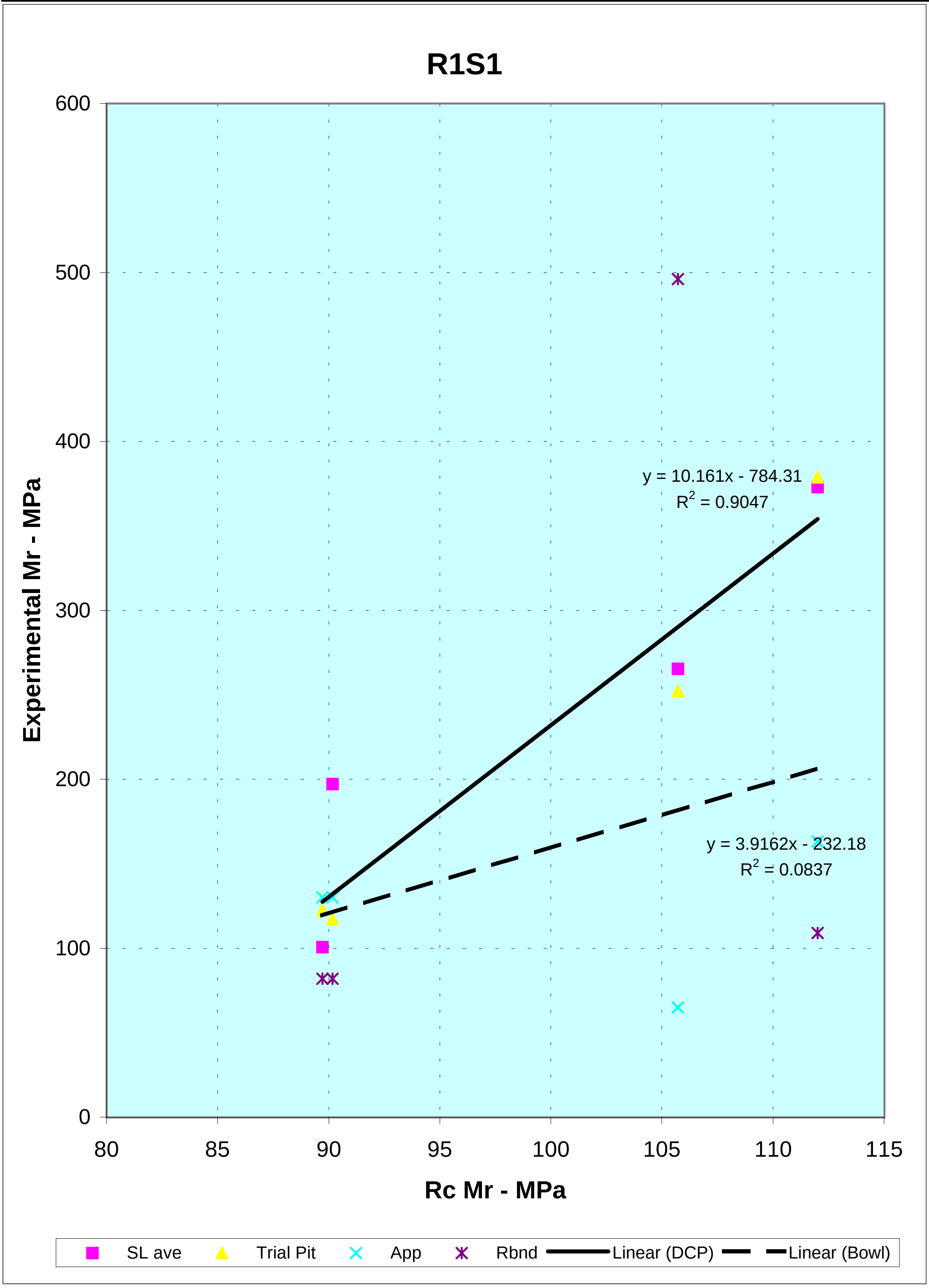
Target Deflection: 0.7 mm

Existing Base Material: CM

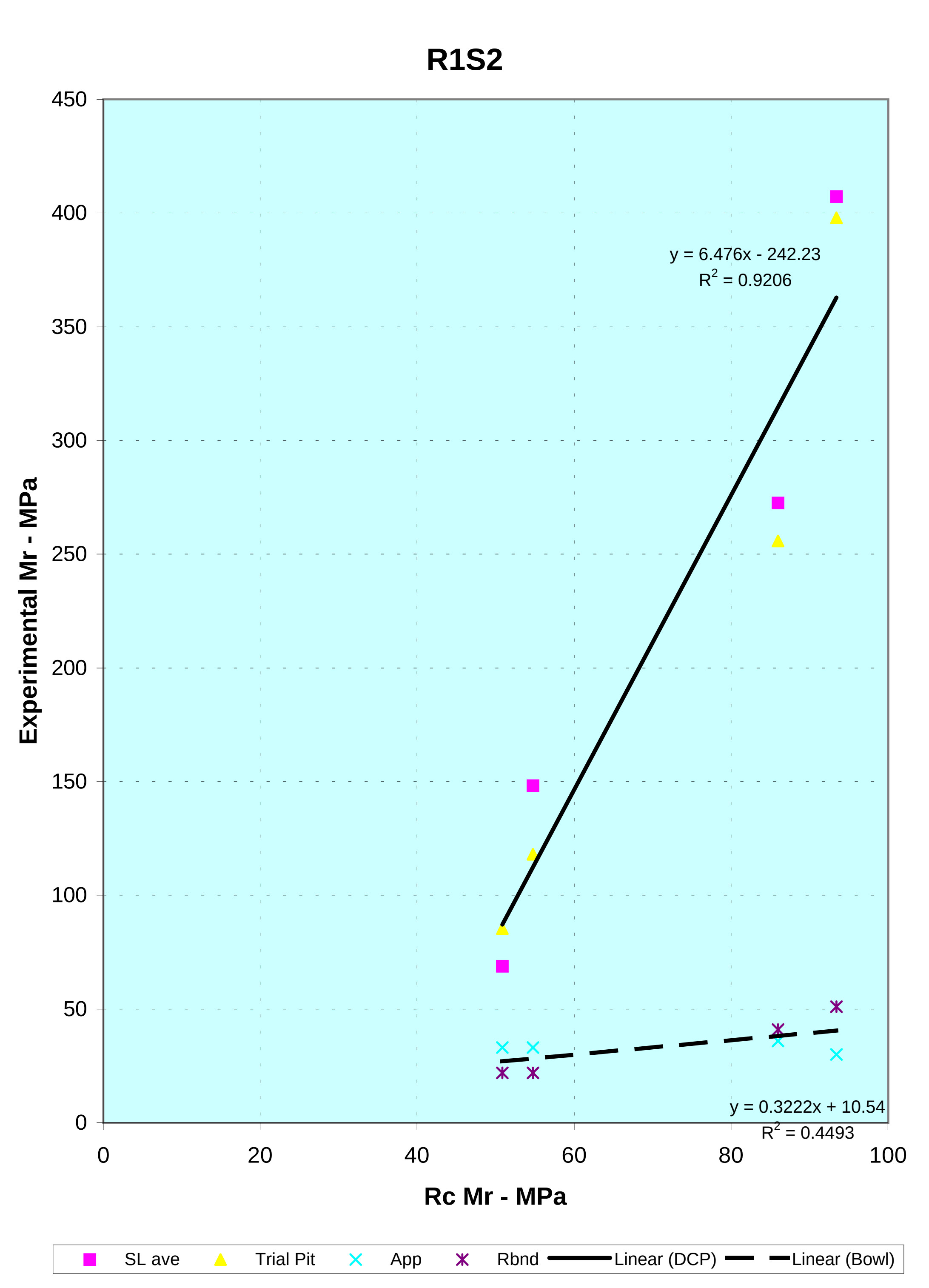
Crushed Rock Granular Overlay Thickness	=	270	mm
Stabilised Natural Gravel Overlay Thickness	=	270	mm
Natural Gravel Granular Overlay Thickness	=	270	mm
Asphalt Overlay Thickness	=	135	mm

Deflection for HDM model $\delta_{(80kN)} =$ 1.95 mm

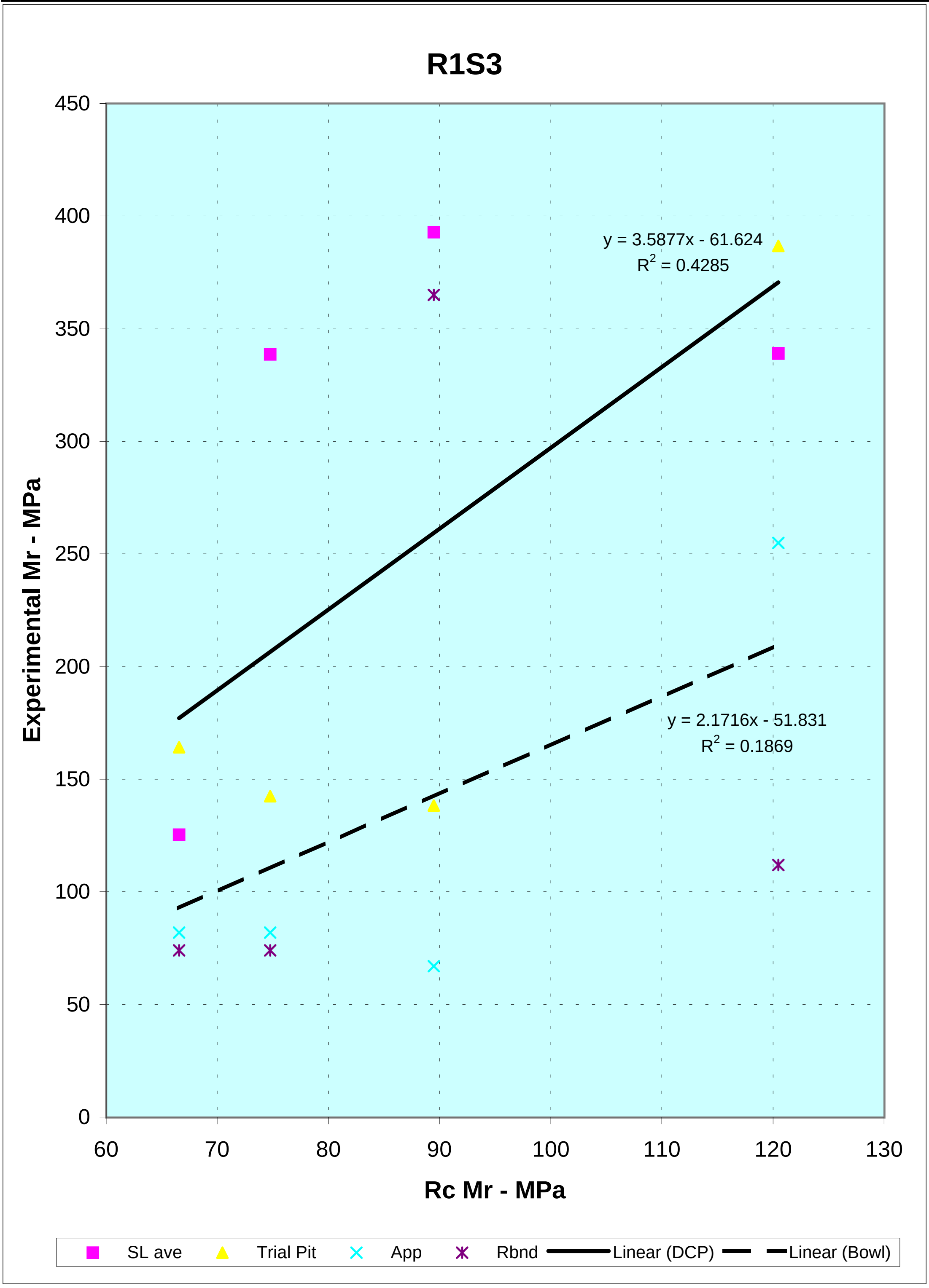
	Road No: R1S1					Karonga - Songwe					Soaked CBR %	
	Resilient Modulus (Mpa)					Soil Properties				Dry In Situ Density		
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI		%Comp	
		SL ave	Trial Pit	App	Rbnd						98	95
Base	112	373	379	163	109	Crushed Stone	7	N	NP	-	-	-
Subbase	106	265	252	65	496	Laterite/Quartz Gravel	8	N	NP	-	-	-
SSG	90	197	117	130	82	Silty ClayL1P23	52	36	16	-	-	-
SG	90	101	122	130	82							



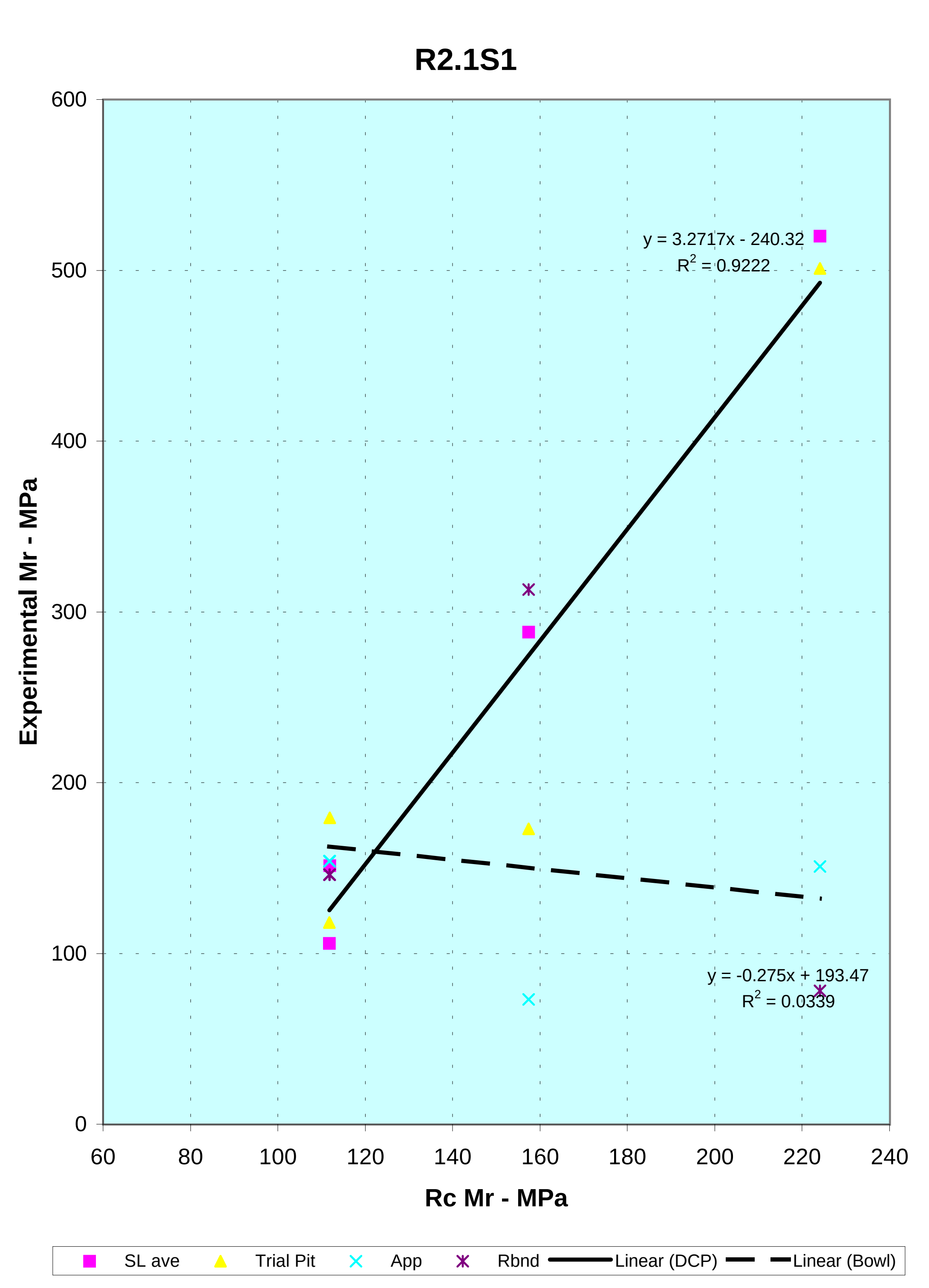
	Road No: R1S2					Karonga - Songwe					Soaked CBR %	
	Resilient Modulus (Mpa)					Soil Properties				Dry In Situ Density	%Comp	
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI		98	95
		SL ave	Trial Pit	App	Rbnd							
Base	93	407	398	30	51	Crushed Stone	6	30	13	-	-	-
Subbase	86	273	256	36	41	Laterite/Quartz Gravel	8	30	13	-	-	-
SSG	55	148	118	33	22	Silty ClayL1P23	52	36	16	-	-	-
SG	51	69	85	33	22							



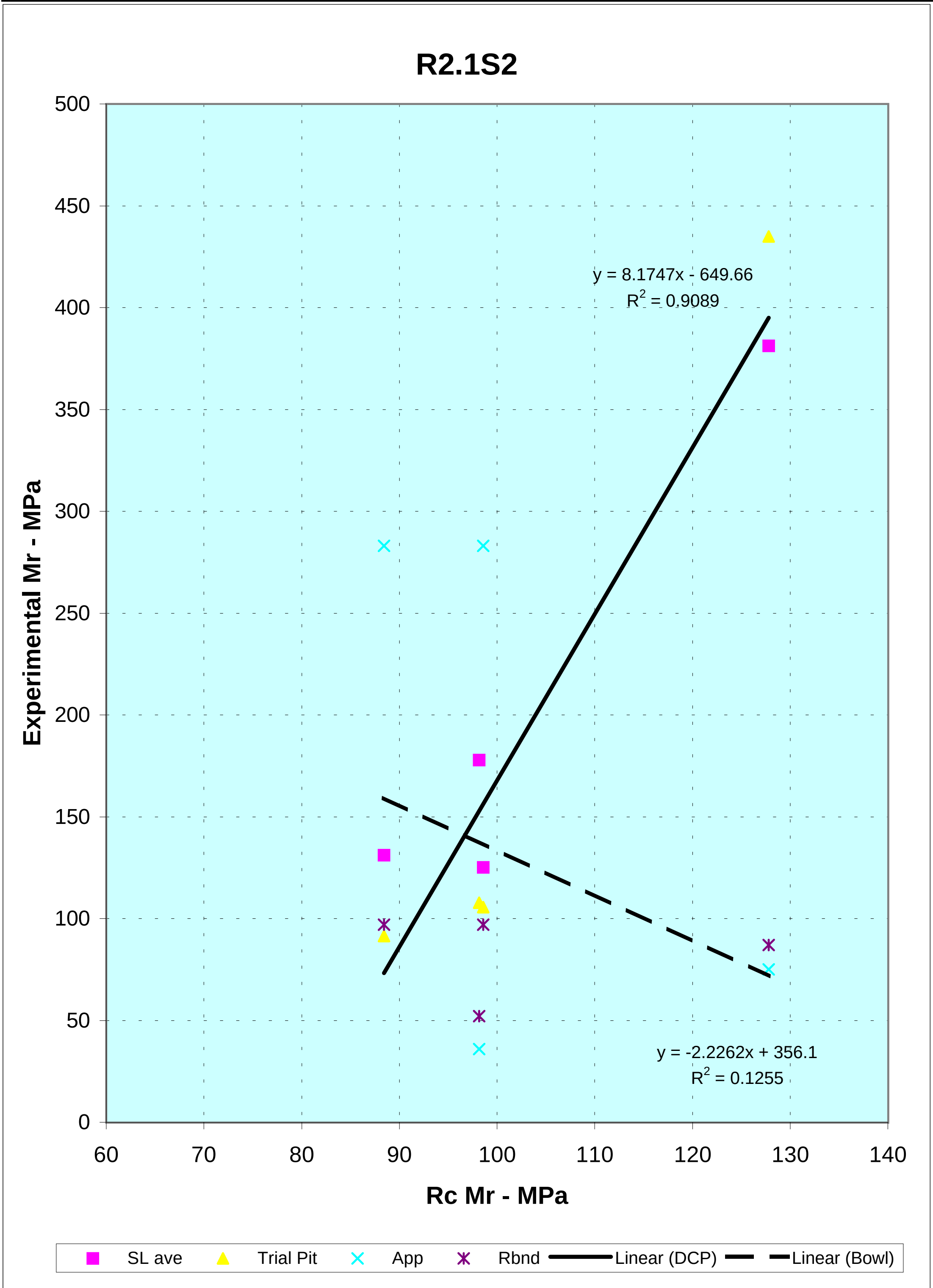
	Road No:	**R1S3**				**Karonga - Songwe**					Soaked CBR %	
	Resilient Modulus (Mpa)					Soil Properties				Dry In Situ Density		
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI		%Comp	
		SL ave	Trial Pit	App	Rbnd						98	95
Base	120	339	387	255	112	Crushed Stone	8	31	15	-	-	-
Subbase	89	393	138	67	365	Laterite/Quartz Gravel	30	60	30	-	-	-
SSG	75	339	142	82	74	Silty Clay	52	36	16	-	-	-
SG	67	125	164	82	74							



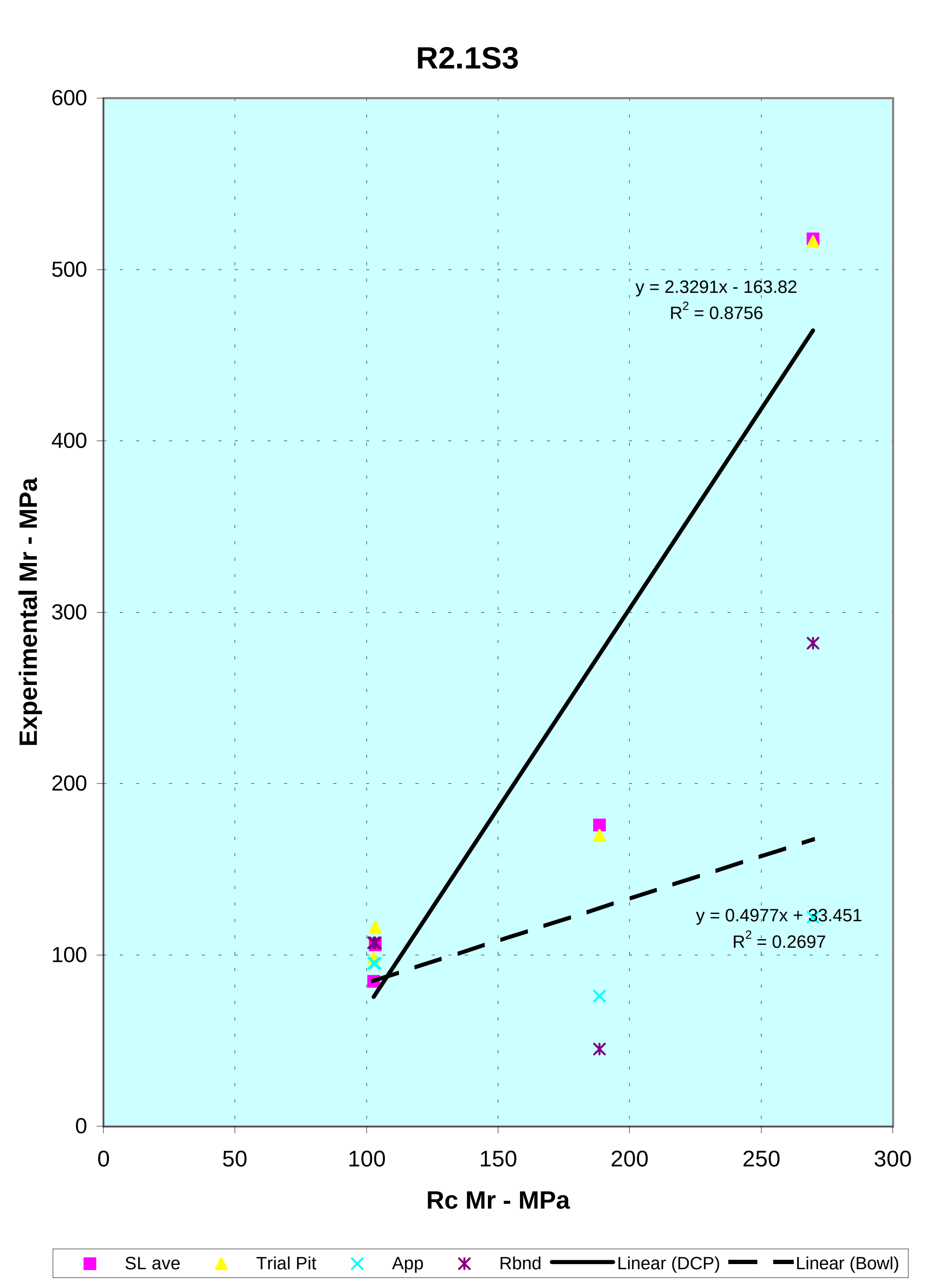
	Road No: R2.1S1					Mzuzu - Bwengu					Soaked CBR %	
	Resilient Modulus (Mpa)					Soil Properties				Dry In Situ Density	%Comp	
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI		98	95
		SL ave	Trial Pit	App	Rbnd							
Base	224	520	501	151	78	Crushed Stone	8	N	NP	1721	-	-
Subbase	157	288	173	73	313	Gravelly Clay	37	42	21	-	-	-
SSG	112	151	179	154	146	Clayey Silty Sand	46	45	23	-	-	-
SG	112	106	118	154	146							



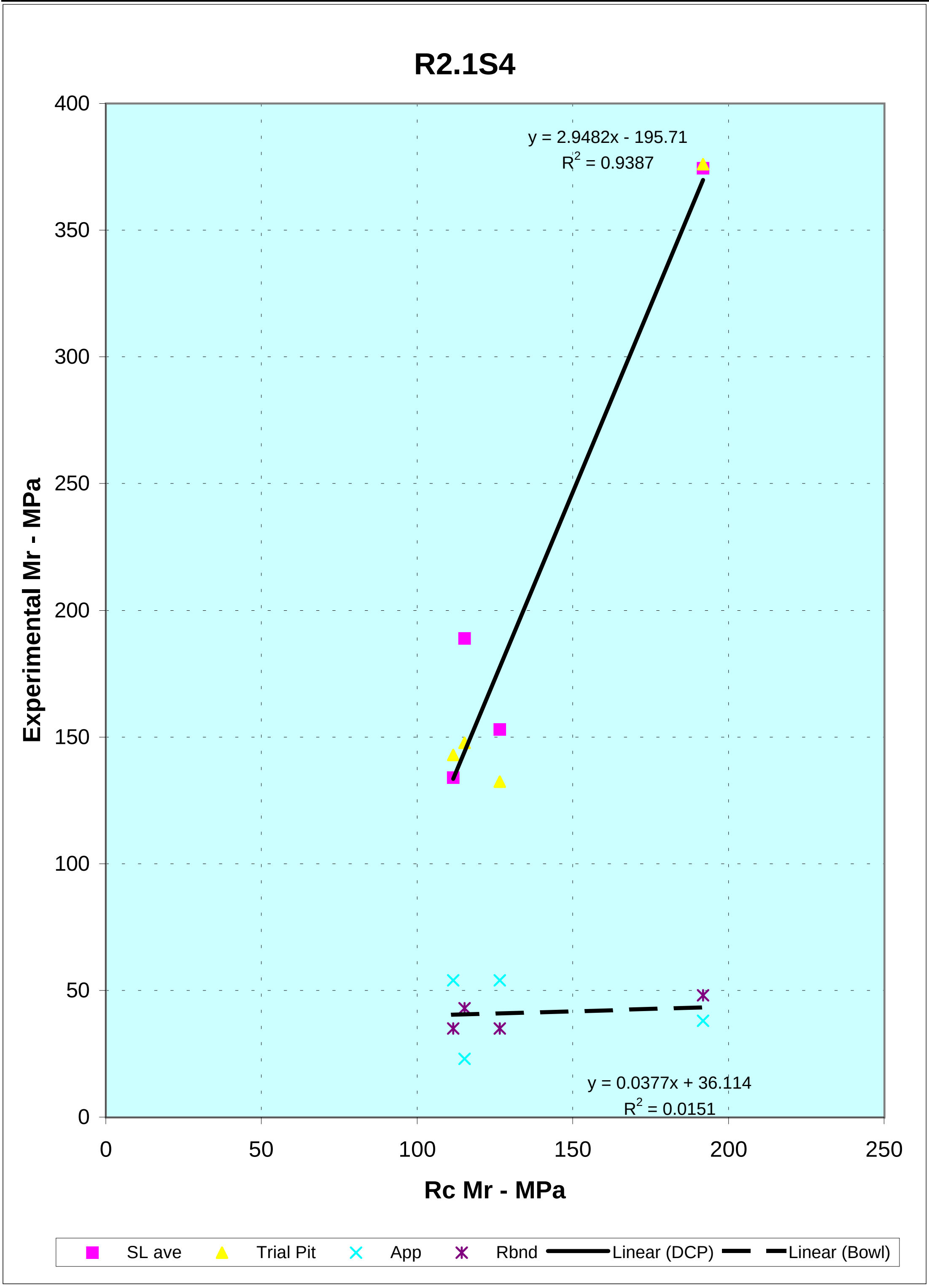
	Road No: **R2.1S2**					**Mzuzu - Bwengu**					Soaked CBR %	
	Resilient Modulus (Mpa)					Soil Properties				Dry In Situ Density	%Comp	
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI			
		SL ave	Trial Pit	App	Rbnd						98	95
Base	128	381	435	75	87	Crushed Stone	5	N	NP	1945	-	-
Subbase	98	178	108	36	52	Clayey Quartz Gravel	29	40	19	-	-	-
SSG	99	125	106	283	97	Clayey Silty Sand	24	51	27	-	-	-
SG	88	131	91	283	97							



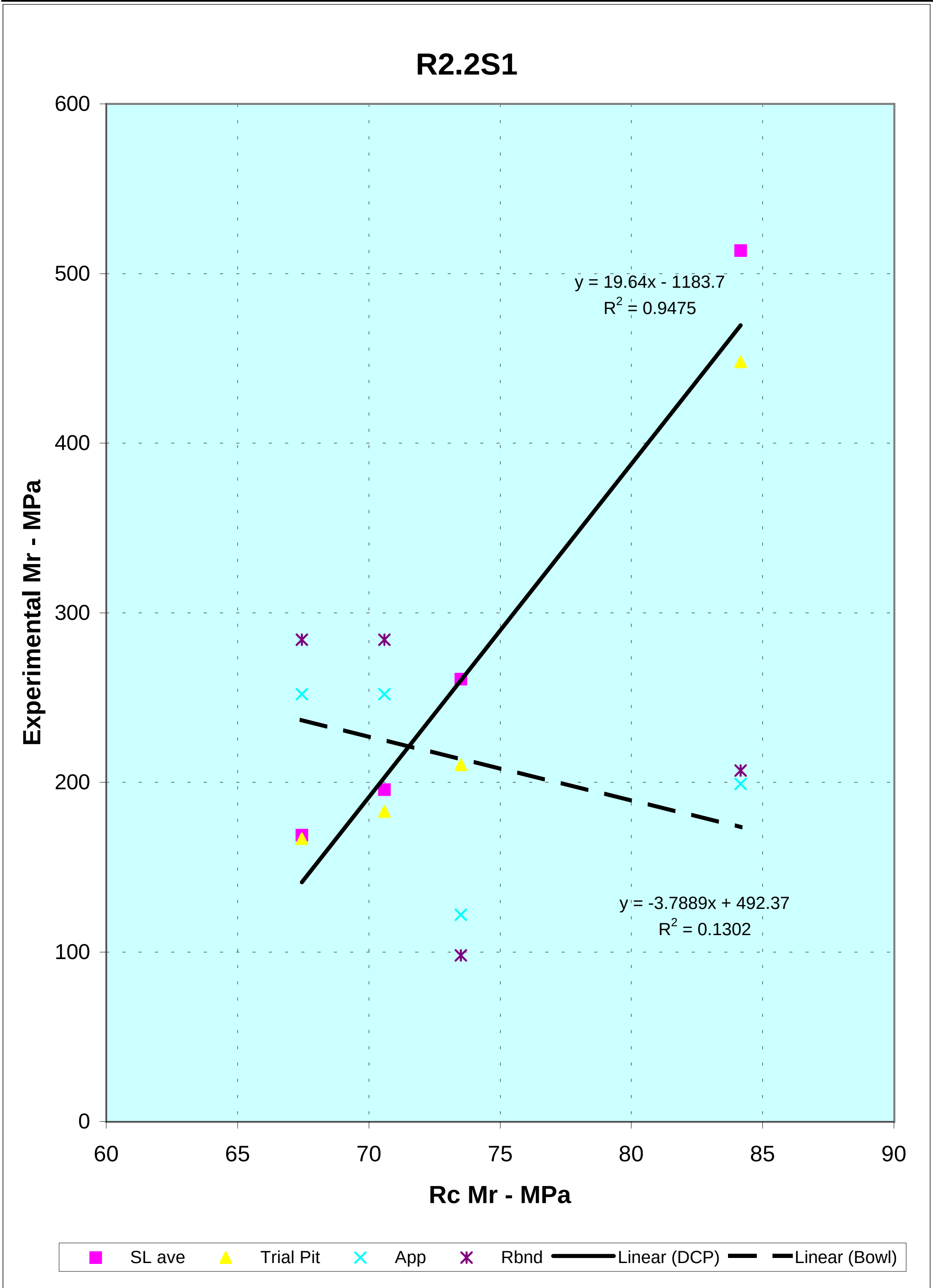
	Road No: R2.1S3					Mzuzu - Bwengu					Soaked CBR %	
	Resilient Modulus (Mpa)					Soil Properties				Dry In Situ Density		
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI		%Comp	
		SL ave	Trial Pit	App	Rbnd						98	95
Base	270	518	516	122	282	Crushed Stone	8	N	NP	2201	-	-
Subbase	189	176	170	76	45	Clayey Quartz Gravel	24	21	8	-	-	-
SSG	103	106	116	95	107	Clayey Silty Sand	58	55	31	-	-	-
SG	103	84	98	95	107							



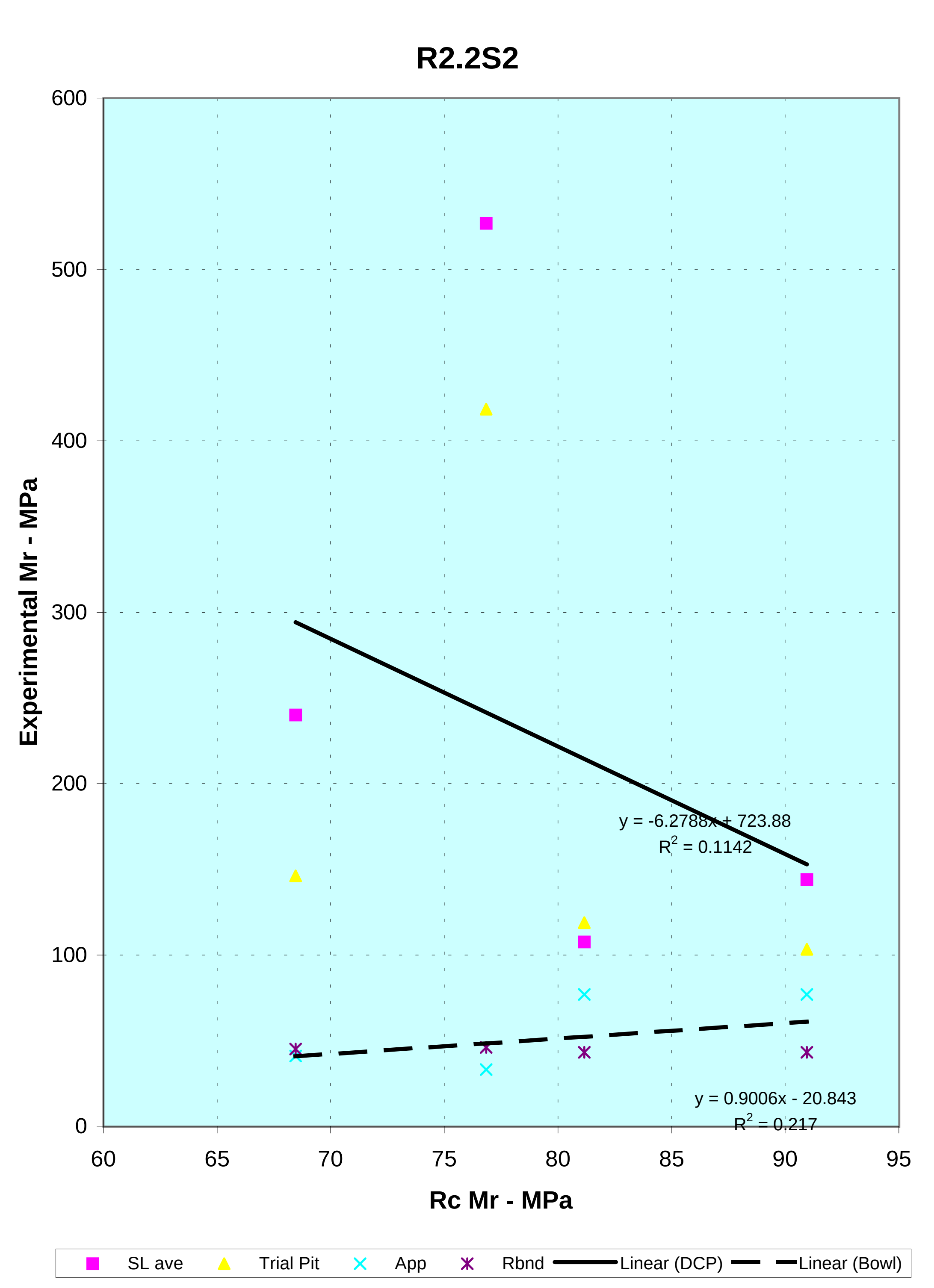
	Road No:	R2.1S4				Mzuzu - Bwengu						Soaked CBR %	
	Resilient Modulus (Mpa)					Soil Properties					Dry In Situ Density		
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI			%Comp	
		SL ave	Trial Pit	App	Rbnd							98	95
Base	192	374	376	38	48	Crushed Stone	12	27	11		1999	-	-
Subbase	115	189	148	23	43	Gravelly Clay	44	36	21		-	-	-
SSG	127	153	132	54	35	Clayey Silty Sand	-	-	-		-	-	-
SG	112	134	143	54	35								



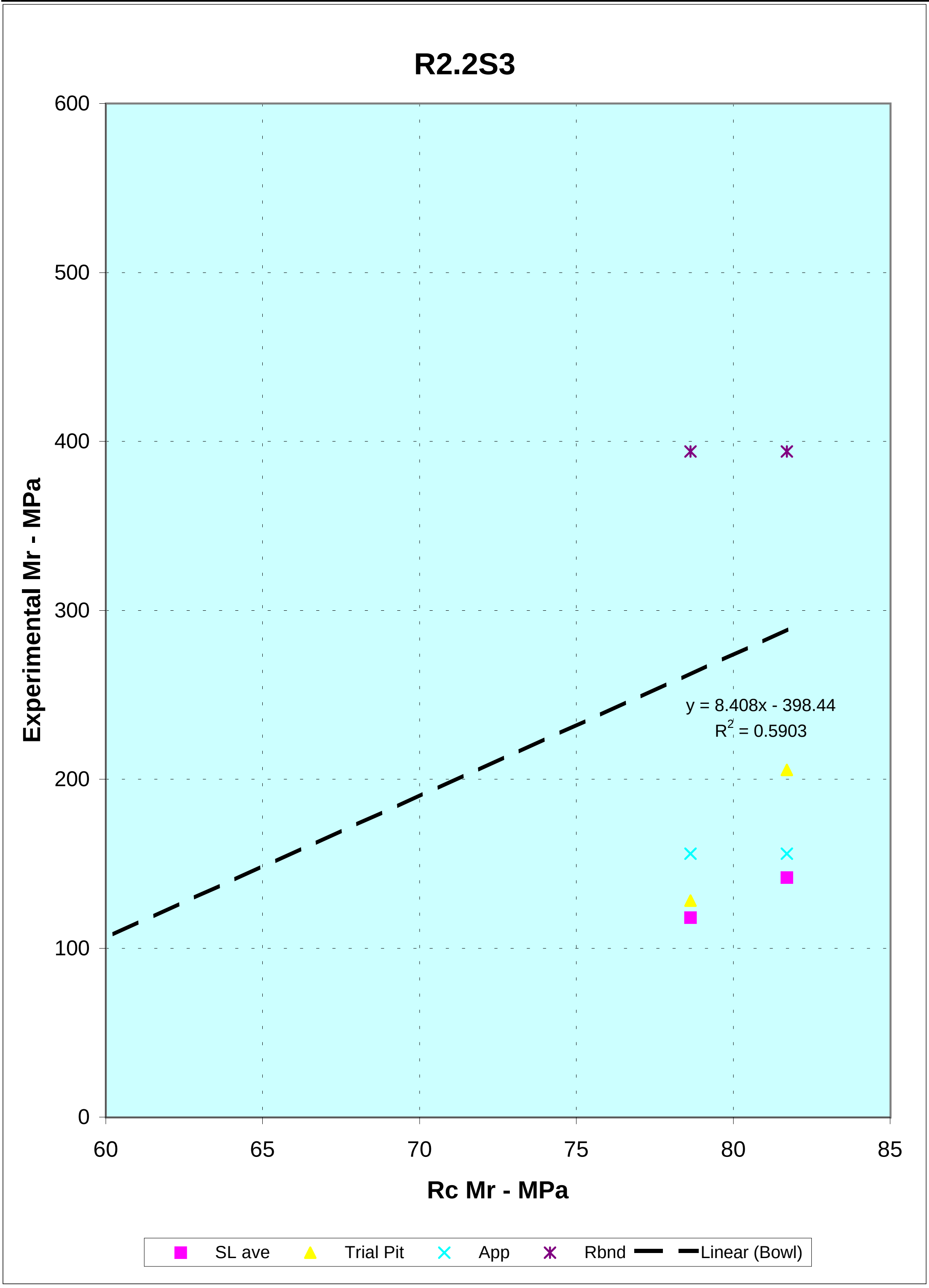
	Road No: **R2.2S1**					**Bwengu - Chiweta**					Soaked CBR %	
	Resilient Modulus (Mpa)					Soil Properties				Dry In Situ Density	%Comp	
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI			
		SL ave	Trial Pit	App	Rbnd						98	95
Base	84	514	448	199	207	Crushed Stone	18	28	13	2230	-	-
Subbase	74	261	210	122	98	Gravelly Clay	33	24	12	-	-	-
SSG	71	196	183	252	284	Clayey Silty Sand	34	32	16	-	-	-
SG	67	169	167	252	284							



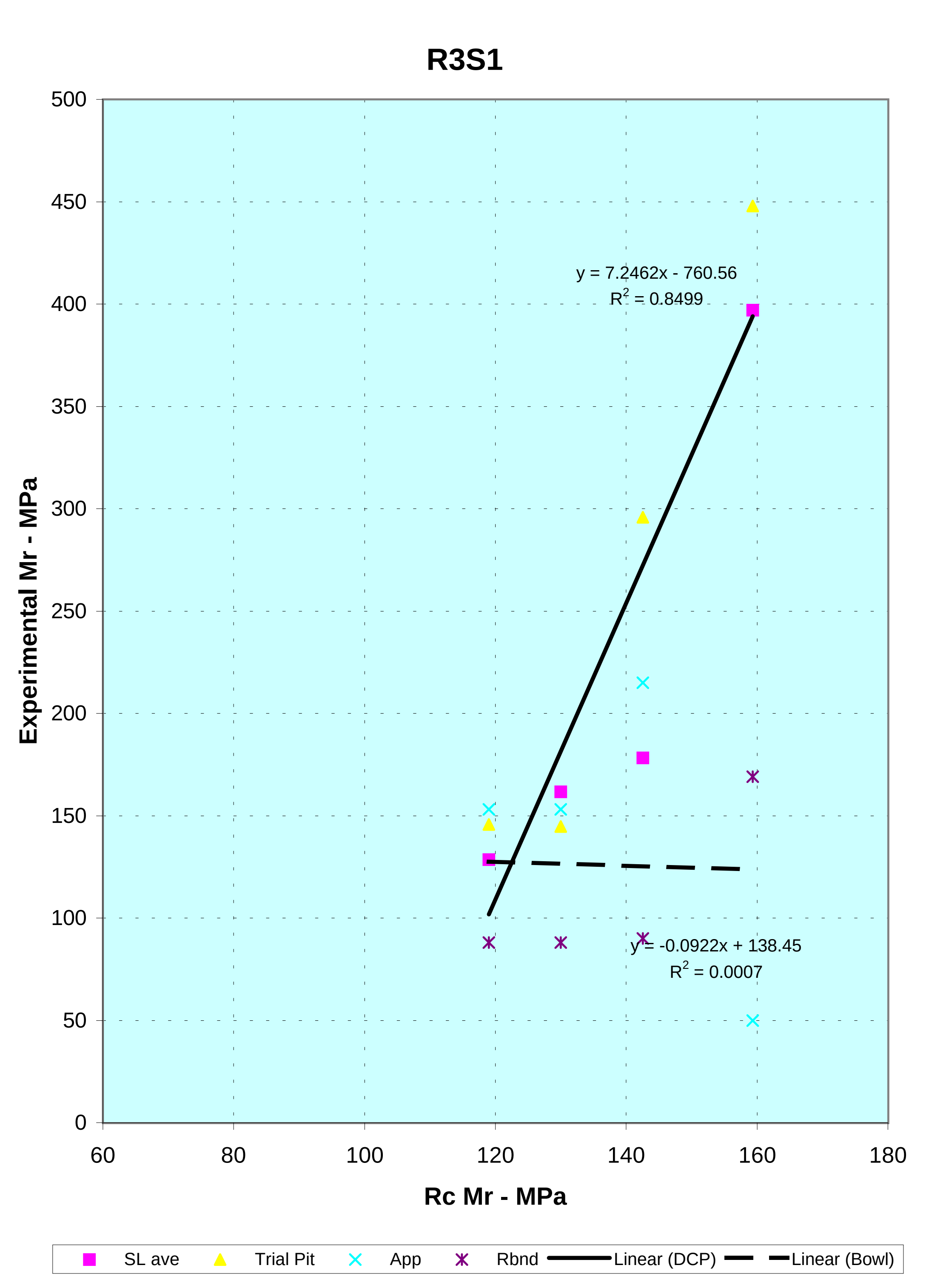
	Road No:	R2.2S2				Bwengu - Chiweta					Soaked CBR %	
	Resilient Modulus (Mpa)					Soil Properties				Dry In Situ Density		
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI		%Comp	
		SL ave	Trial Pit	App	Rbnd						98	95
Base	77	527	418	33	46	Crushed Stone	18	28	13	2230	-	-
Subbase	68	240	146	41	45	Gravelly Clay	33	24	12	-	-	-
SSG	91	144	103	77	43	Clayey Silty Sand	34	32	16	-	-	-
SG	81	108	119	77	43							



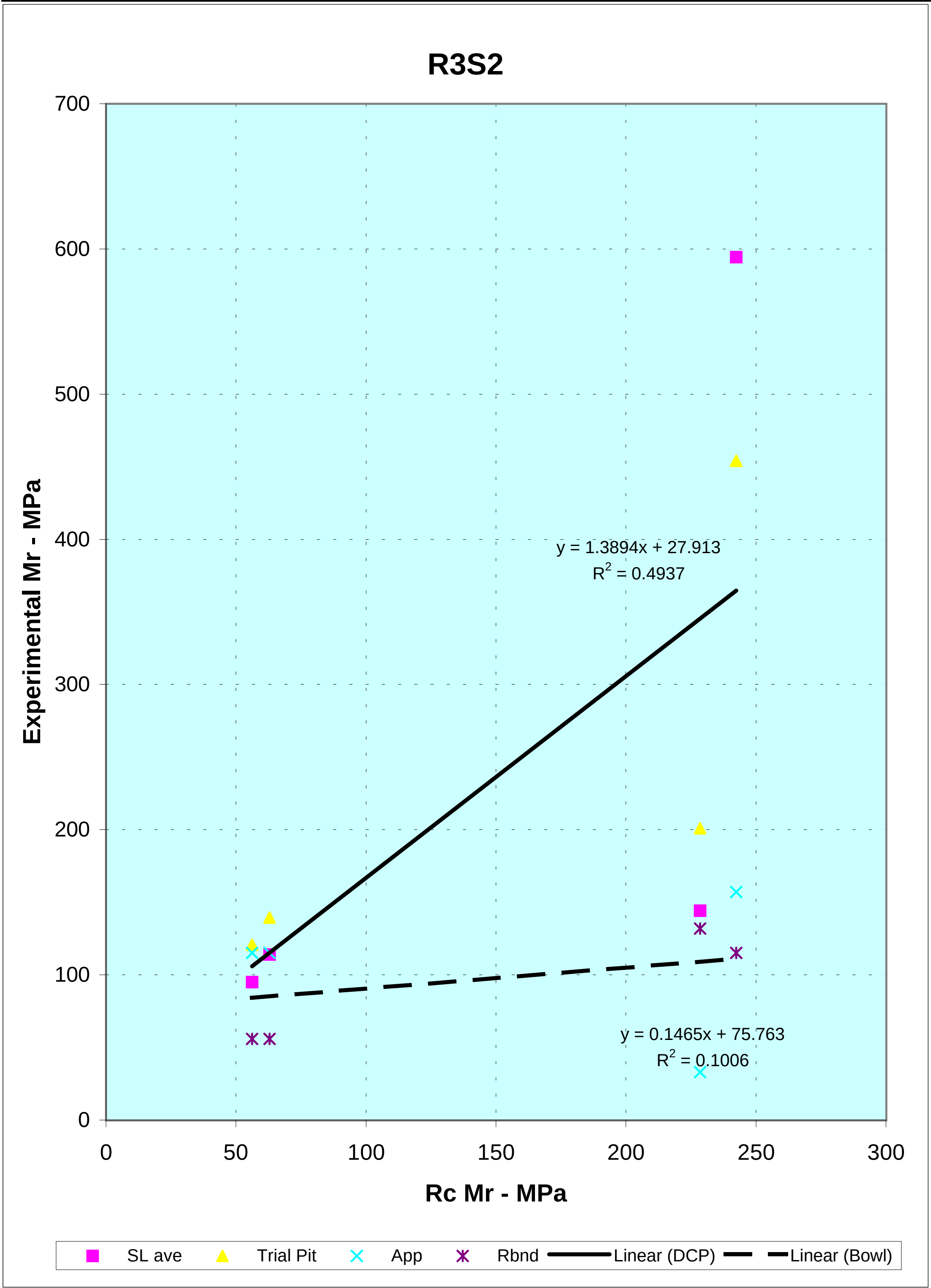
	Road No:	R2.2S3				Bwengu - Chiweta					Soaked CBR %	
	Resilient Modulus (Mpa)					Soil Properties				Dry In Situ Density	%Comp	
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI		98	95
		SL ave	Trial Pit	App	Rbnd							
Base	57	491	520	75	134	Crushed Stone Macadam	8	28	12	-	-	-
Subbase	54	295	269	37	20	Clayey Quartz Gravel	26	30	14	-	-	-
SSG	82	142	206	156	394	Clayey Silty Sand	34	32	16	-	-	-
SG	79	118	128	156	394							



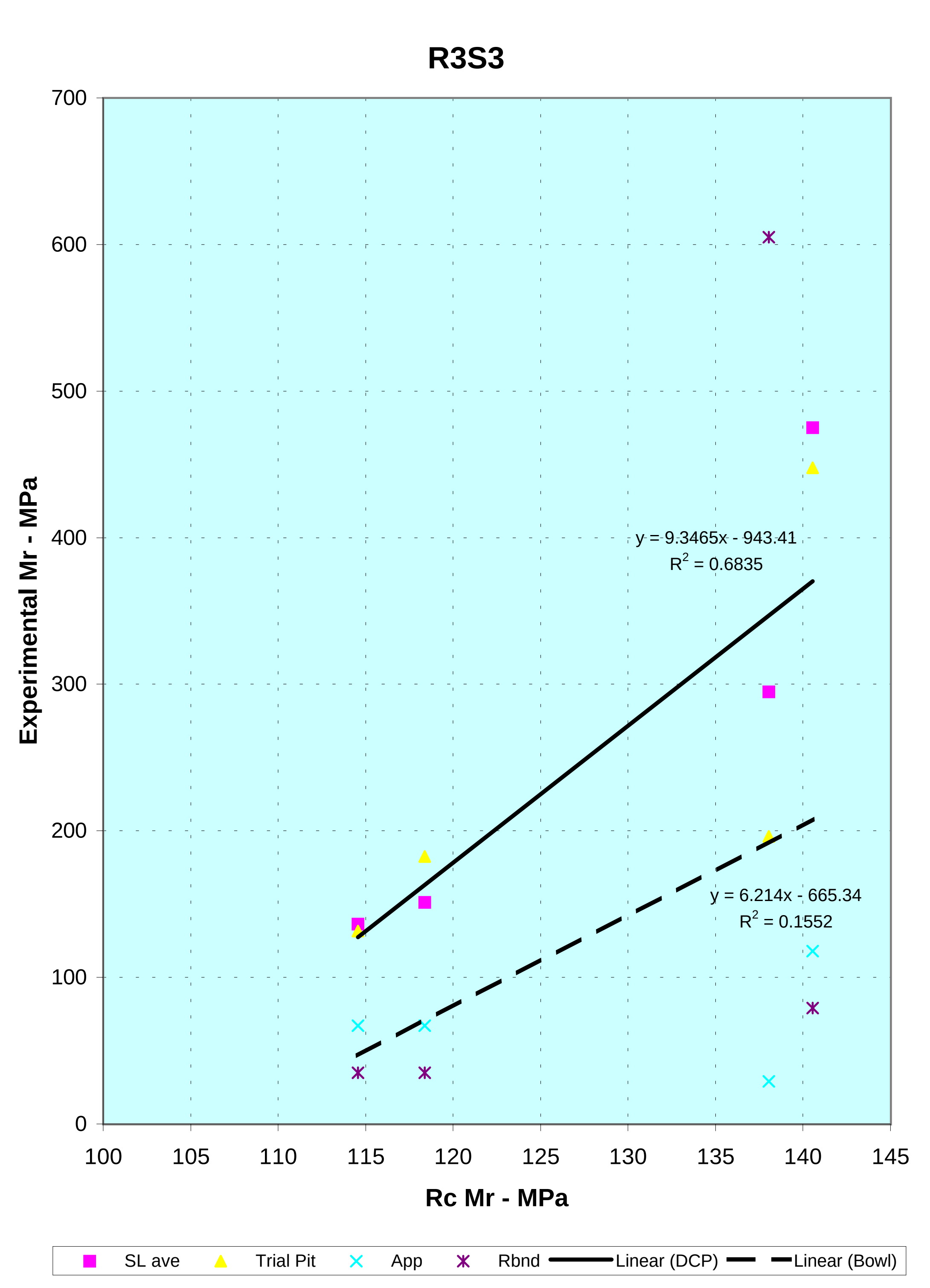
	Road No: R3S1					Jenda - Chikangawa					Soaked CBR %	
	Resilient Modulus (Mpa)					Soil Properties				Dry In Situ Density	%Comp	
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI		98	95
		SL ave	Trial Pit	App	Rbnd							
Base	159	397	448	50	169	Crushed Stone	6	N	NP	2067	90	58
Subbase	143	178	296	215	90	Clayey Quartz/Lat Gravel	23	24	9	-	-	-
SSG	130	162	145	153	88	Clayey Sand	31	50	28	-	-	-
SG	119	128	146	153	88							



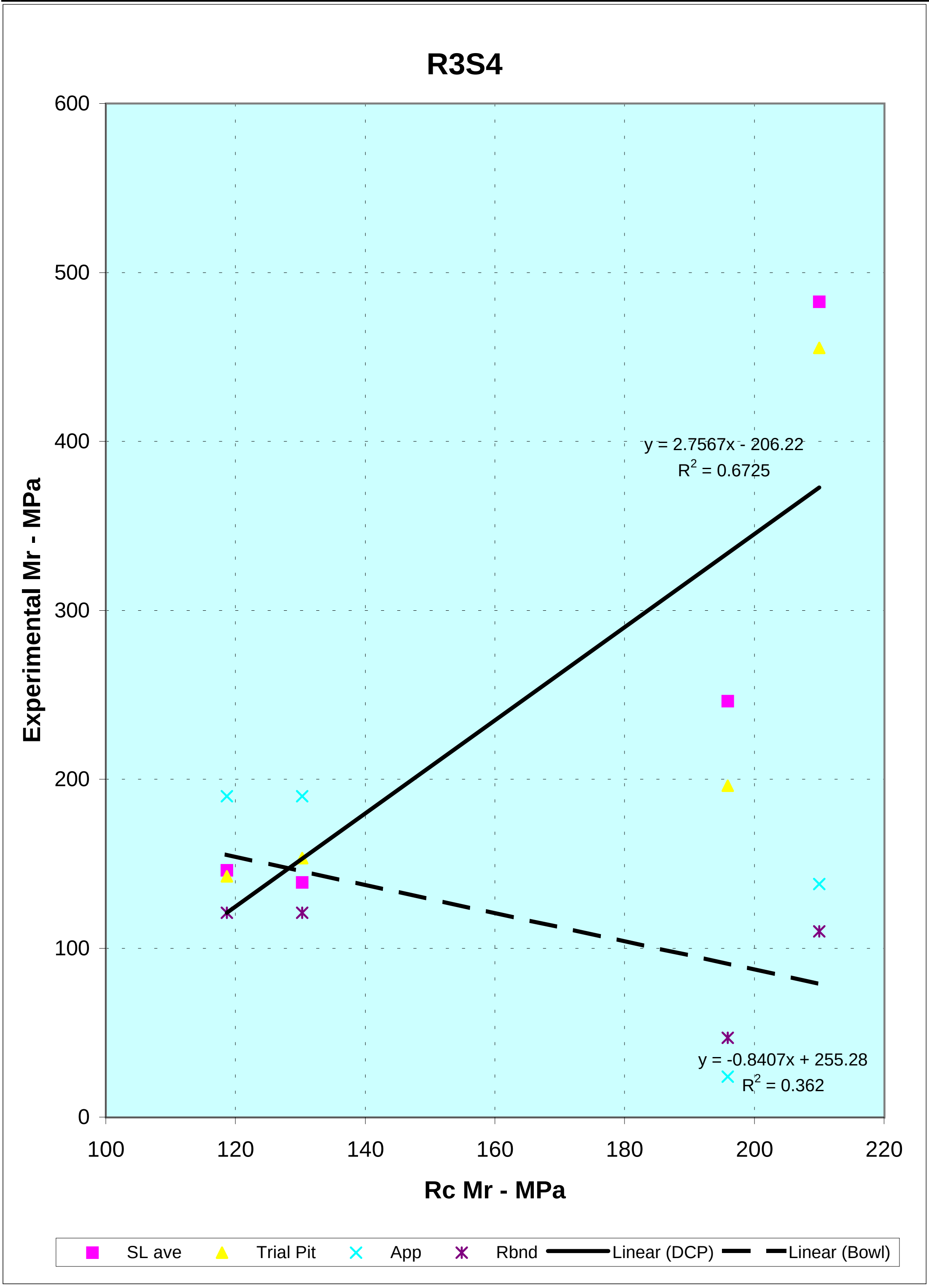
	Road No: R3S2	Jenda - Chikangawa										Soaked CBR %	
	Resilient Modulus (Mpa)					Soil Properties					Dry In Situ Density	%Comp	
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI			98	95
		SL ave	Trial Pit	App	Rbnd								
Base	242	594	454	157	115	Crushed Stone	3	N	NP		2100	-	-
Subbase	228	144	201	33	132	Clayey Quartz Gravel	24	33	17		-	-	-
SSG	63	114	139	115	56	Clayey Sand	48	48	24		-	-	-
SG	56	95	121	115	56								



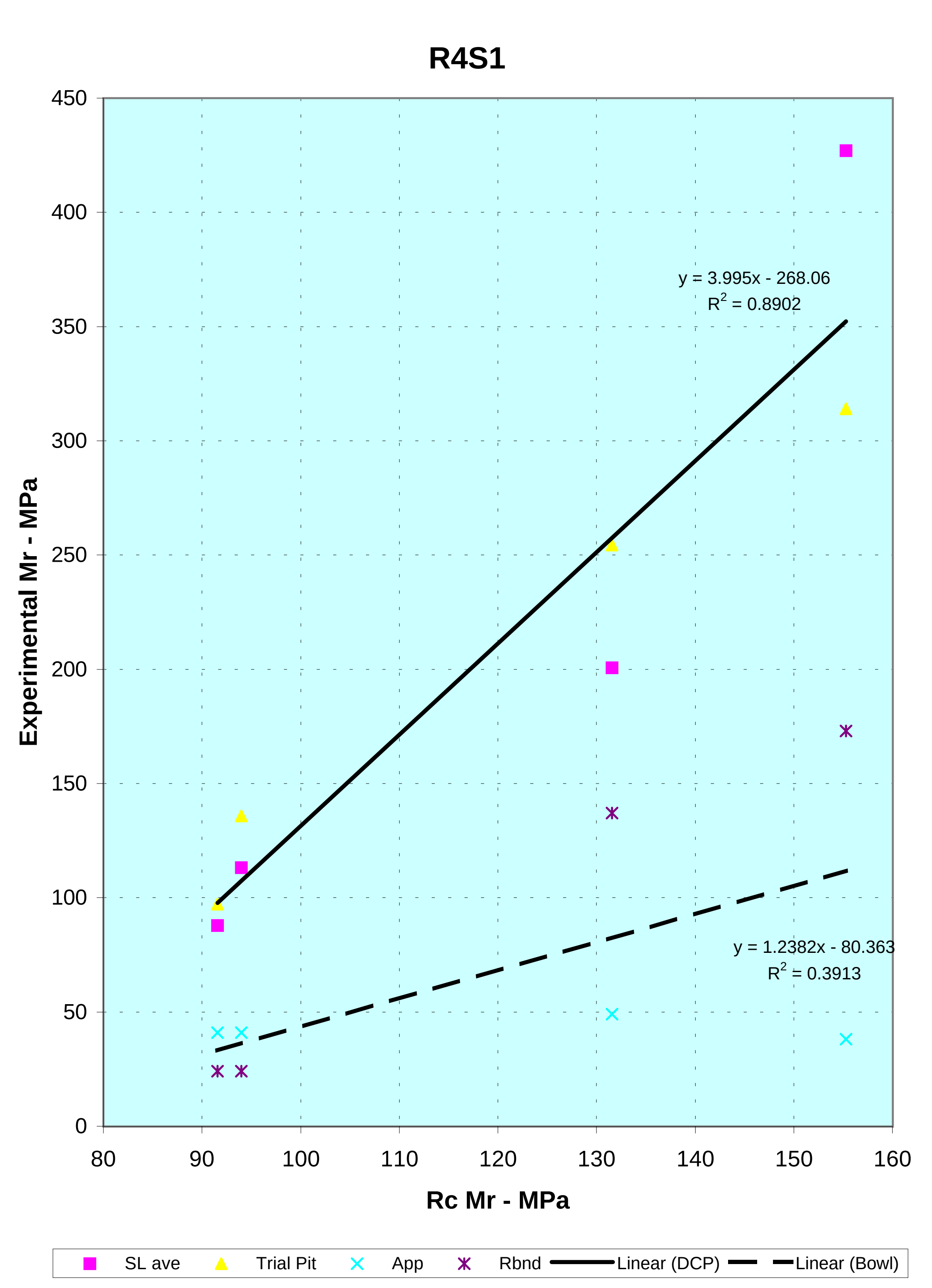
	Road No: R3S3					Jenda - Chikangawa					Soaked CBR %	
	Resilient Modulus (Mpa)					Soil Properties				Dry In Situ Density		
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI		%Comp	
		SL ave	Trial Pit	App	Rbnd						98	95
Base	141	475	448	118	79	Crushed Stone	5	N	NP	2028	-	-
Subbase	138	295	196	29	605	Gravelly Clay	43	40	20	-	-	-
SSG	118	151	183	67	35	Clayey Sand	35	54	35	-	-	-
SG	115	136	132	67	35							



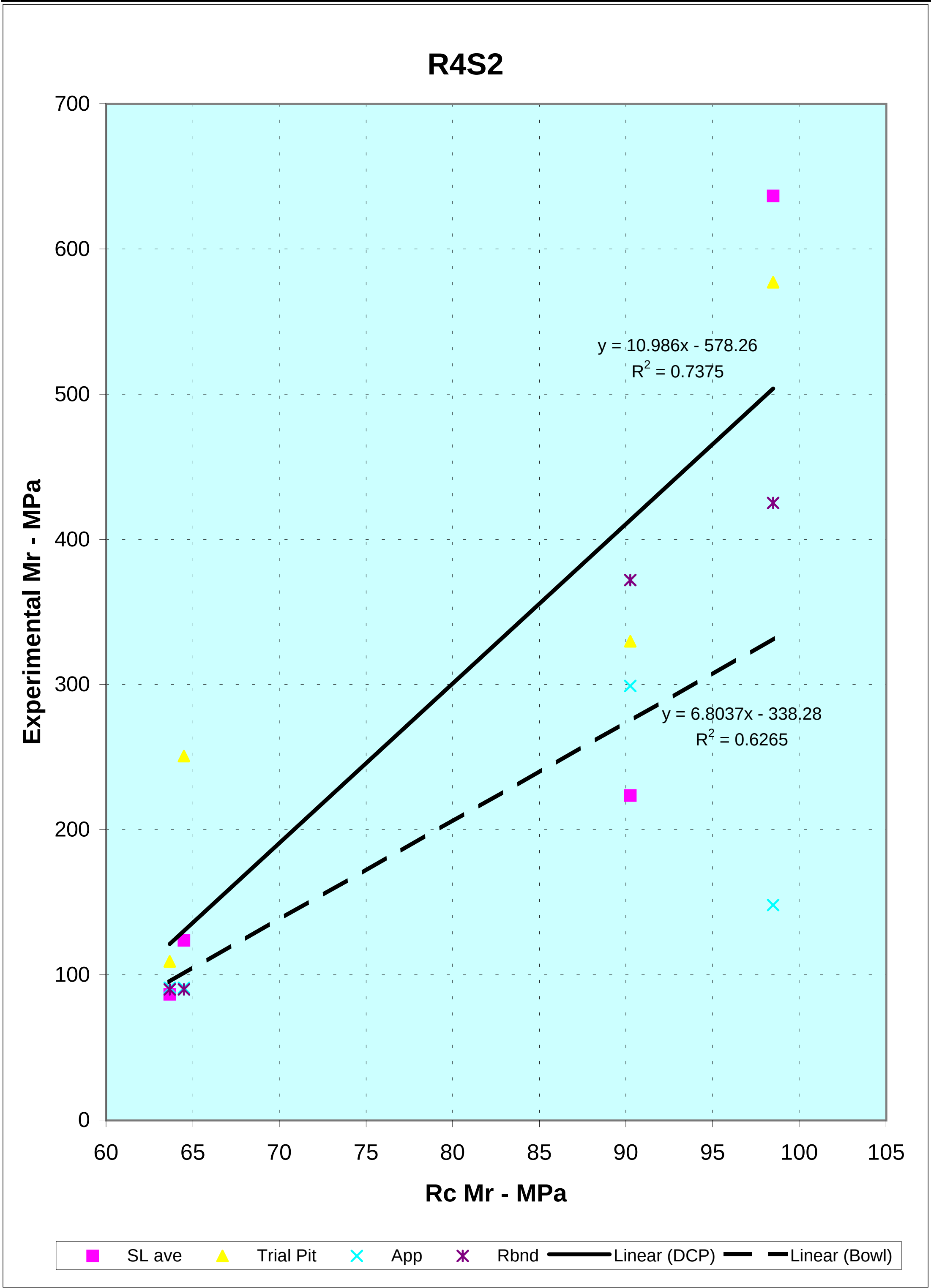
	Road No: R3S4					Jenda - Chikangawa					Soaked CBR %	
	Resilient Modulus (Mpa)					Soil Properties				Dry In Situ Density	%Comp	
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI			
		SL ave	Trial Pit	App	Rbnd						98	95
Base	210	483	455	138	110	Crushed Stone	2	N	NP	2040	-	-
Subbase	196	246	196	24	47	Clayey Quartz Gravel	32	37	18	-	-	-
SSG	130	139	153	190	121	Clayey Sand	32	52	34	-	-	-
SG	119	146	142	190	121							



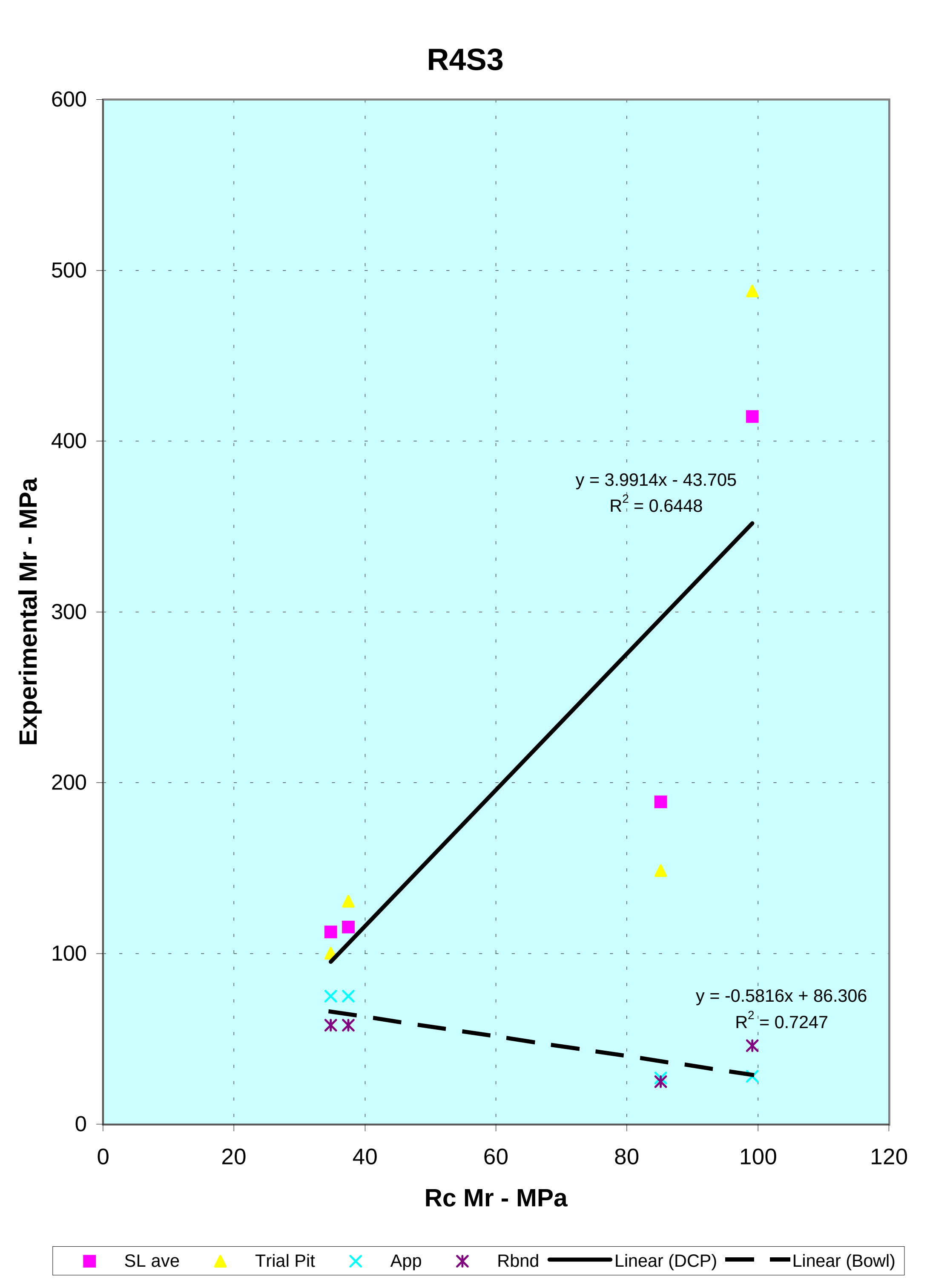
	Road No: R4S1					Mzuzu - Nkhata Bay					Soaked CBR %	
	Resilient Modulus (Mpa)					Soil Properties				Dry In Situ Density		
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI		%Comp	
		SL ave	Trial Pit	App	Rbnd						98	95
Base	155	427	314	38	173	Laterite/Quartz Gravel	32	53	31	1778	22	11
Subbase	132	201	254	49	137	Sandy Gravel	29	44	21	-	-	-
SSG	94	113	136	41	24	Sandy Clay	42	48	28	-	-	-
SG	92	88	97	41	24							



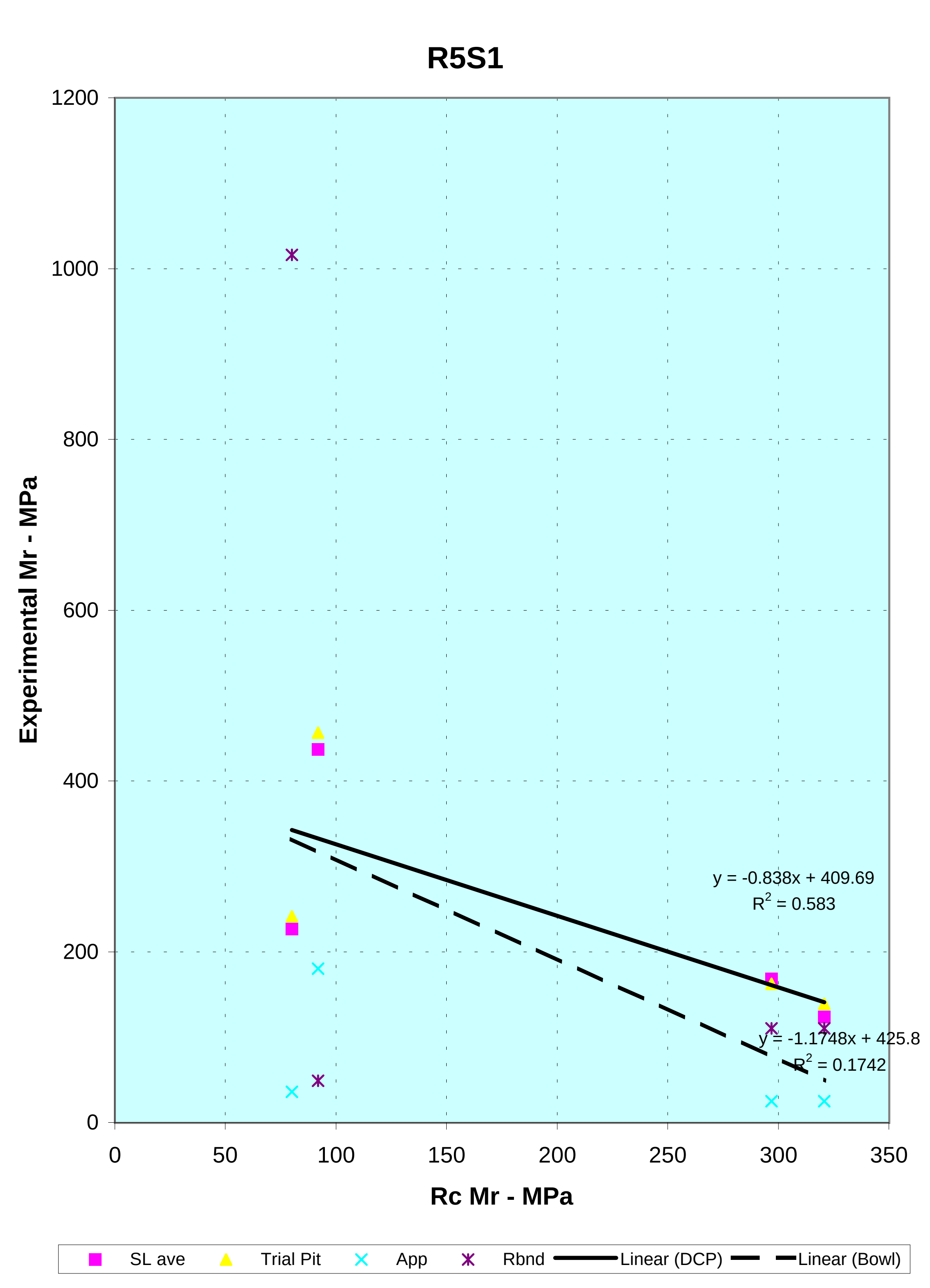
	Road No: **R4S2**					**Mzuzu - Nkhata Bay**					Soaked CBR %	
	Resilient Modulus (Mpa)					Soil Properties				Dry In Situ Density	%Comp	
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI			
		SL ave	Trial Pit	App	Rbnd						98	95
Base	99	636	577	148	425	Stab. Quartz Gravel	10	N	NP	-	-	-
Subbase	90	223	330	299	372	Gravelly Clay	48	36	16	-	-	-
SSG	64	124	251	91	90	Clayey Sand	18	36	17	-	-	-
SG	64	87	109	91	90							



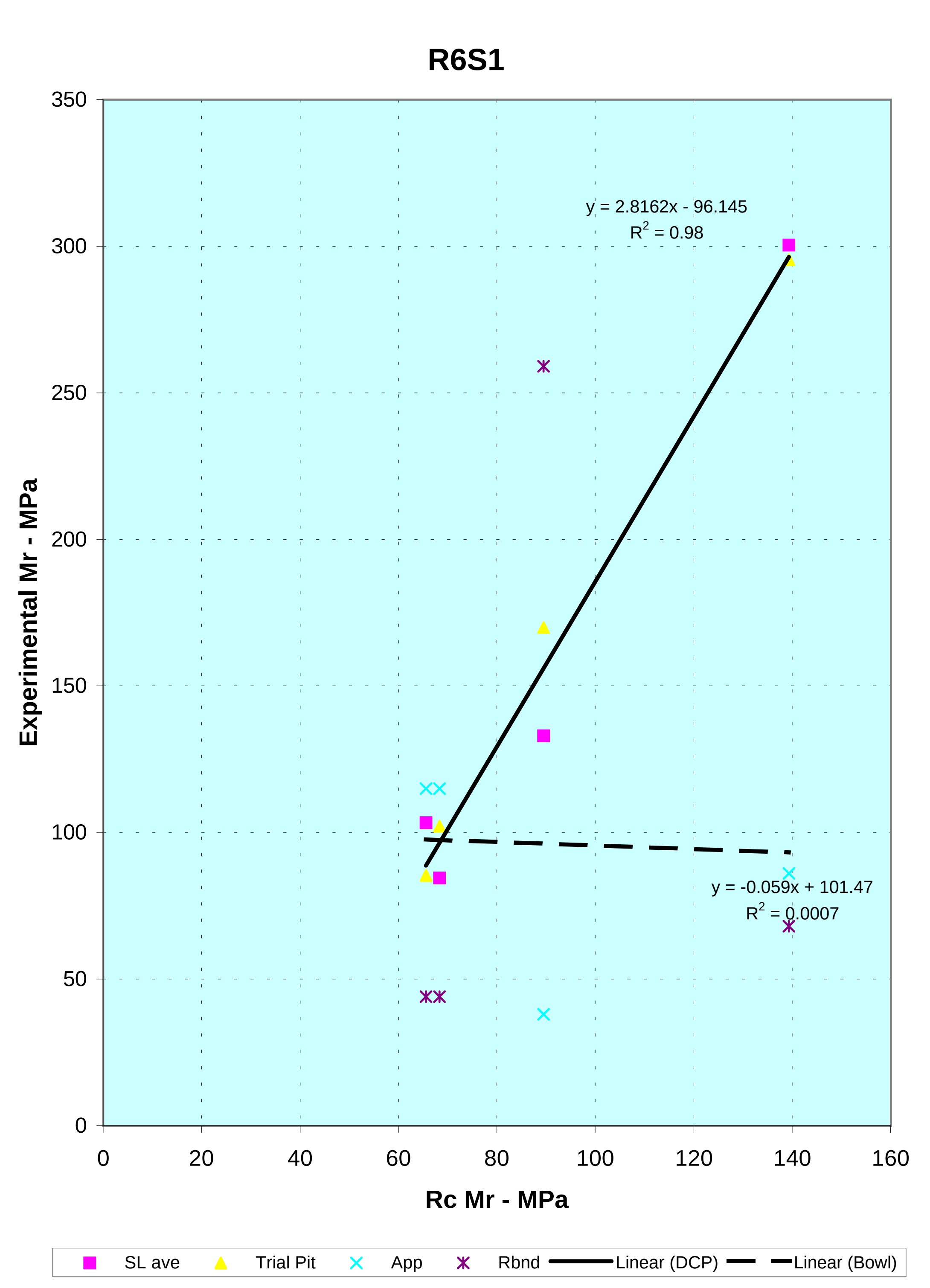
	Road No: R4S3					Mzuzu - Nkhata Bay					Soaked CBR %	
	Resilient Modulus (Mpa)					Soil Properties				Dry In Situ Density	%Comp	
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI			
		SL ave	Trial Pit	App	Rbnd						98	95
Base	99	414	488	28	46	Stab. Quartz Gravel	17	38	31	-	8	3
Subbase	85	189	148	27	25	Gravelly Clay	41	37	17	-	-	-
SSG	37	116	131	75	58	Sandy Clay	59	48	28	-	-	-
SG	35	113	100	75	58							



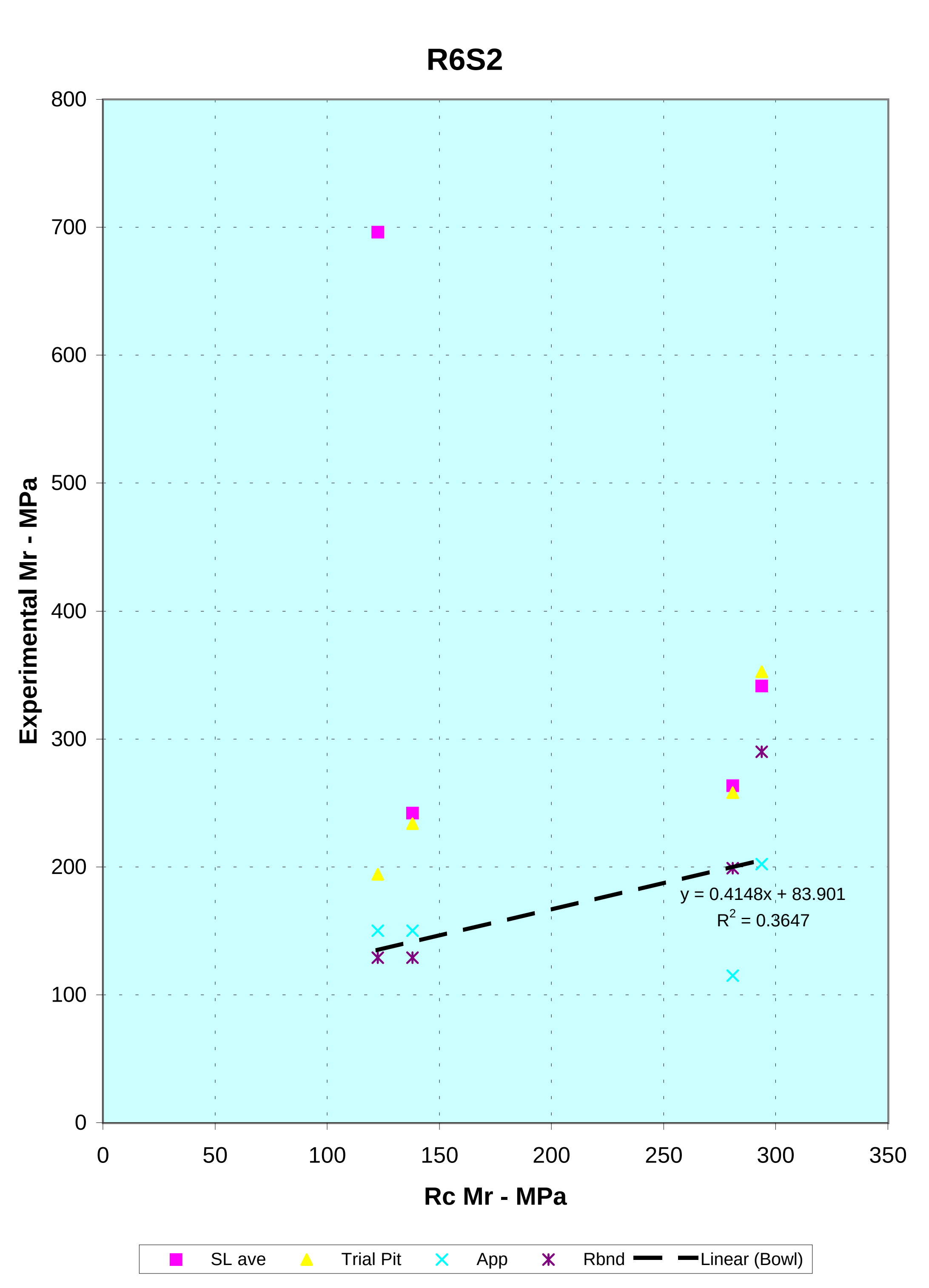
	Road No:	R5S1				Bwengu - Rumphi					Soaked CBR %	
	Resilient Modulus (Mpa)					Soil Properties				Dry In Situ Density		
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI		%Comp	
		SL ave	Trial Pit	App	Rbnd						98	95
Base	92	437	456	180	49	Crushed Stone	14	28	21	1911	-	-
Subbase	80	227	241	36	1016	Sandy Gravel	19	32	16	-	-	-
SSG	321	124	139	25	110	Sandy Clay	49	42	24	-	-	-
SG	297	168	163	25	110							



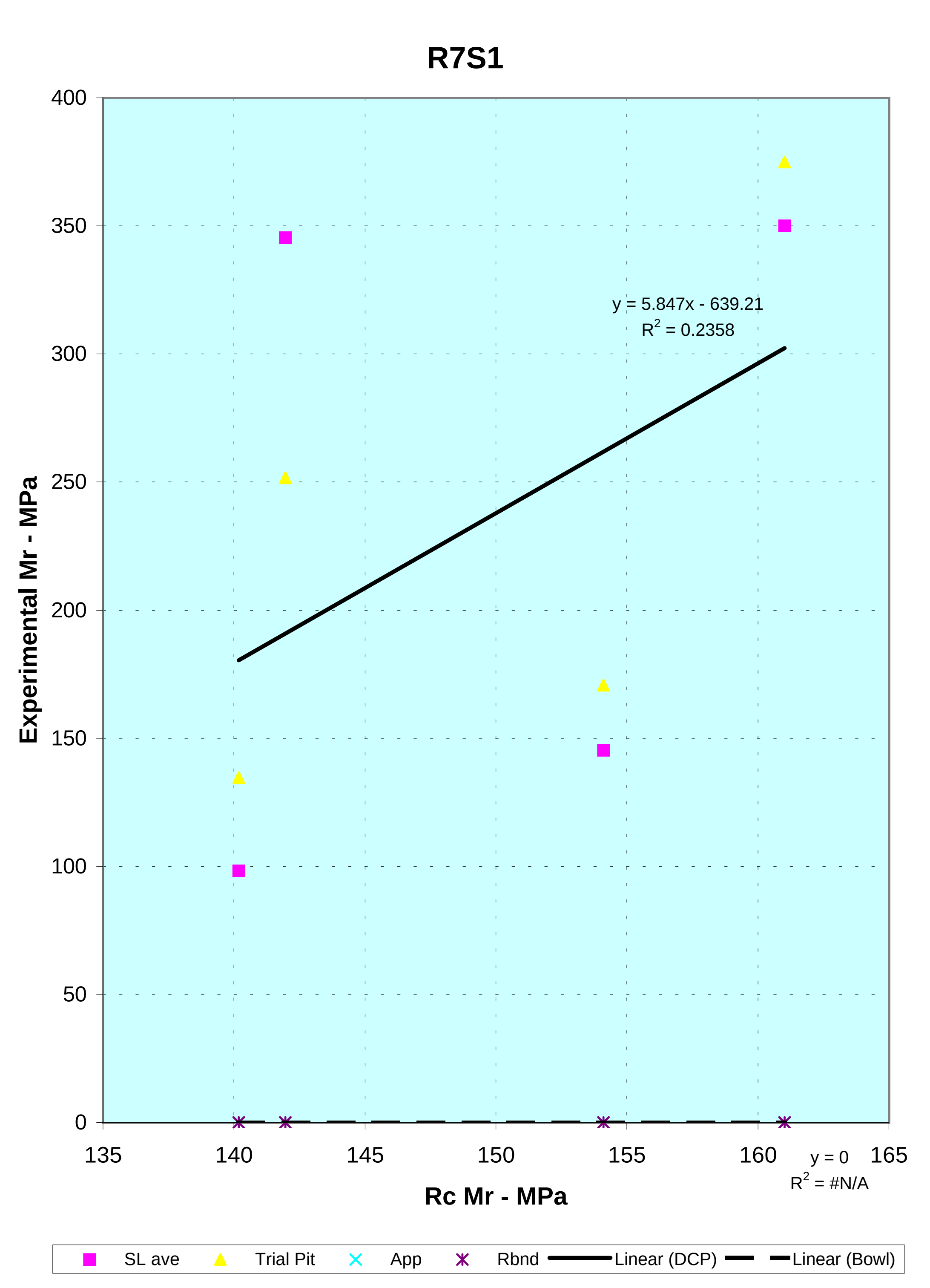
	Road No: **R6S1**					Kasungu - Dwangwa					Soaked CBR %	
	Resilient Modulus (Mpa)					Soil Properties				Dry In Situ Density		
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI		%Comp	
		SL ave	Trial Pit	App	Rbnd						98	95
Base	139	300	295	86	68	Clayey Sandy Gravel	19	29	14	1941	-	-
Subbase	89	133	170	38	259	Gravelly Sand	19	34	17	-	-	-
SSG	68	85	102	115	44	Sandy Silt	41	40	21	-	-	-
SG	66	103	85	115	44							



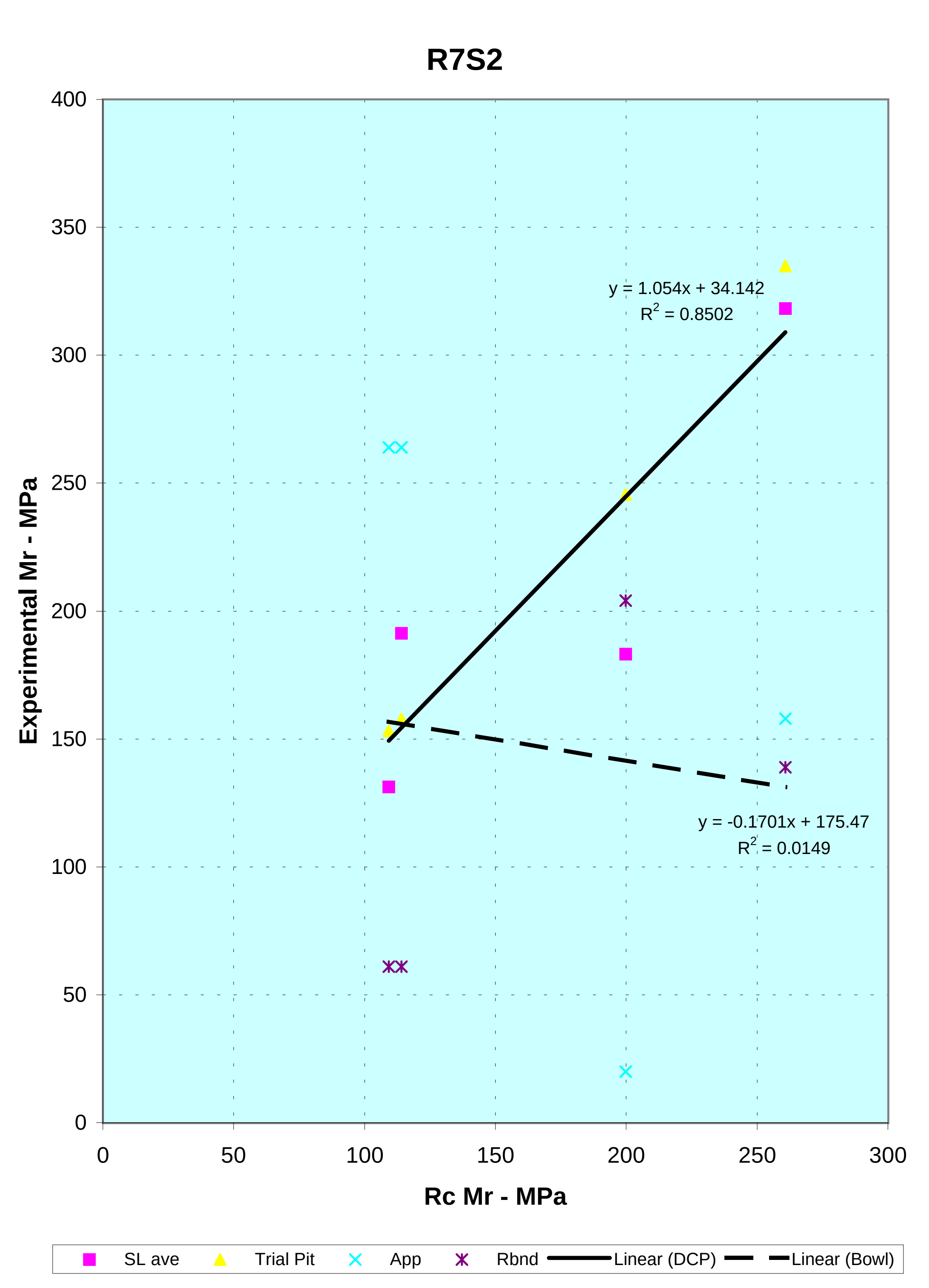
	Road No:	R6S2				Kasungu - Dwangwa					Soaked CBR %	
	Resilient Modulus (Mpa)					Soil Properties				Dry In Situ Density		
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI		%Comp	
		SL ave	Trial Pit	App	Rbnd						98	95
Base	294	341	353	202	290	"As Dug" Laterite Gravel	20	31	13	-	26	6
Subbase	281	263	258	115	199	Gravelly Sand	27	49	25	-	-	-
SSG	138	242	234	150	129	Sandy Silt	36	33	18	-	-	-
SG	123	696	194	150	129							



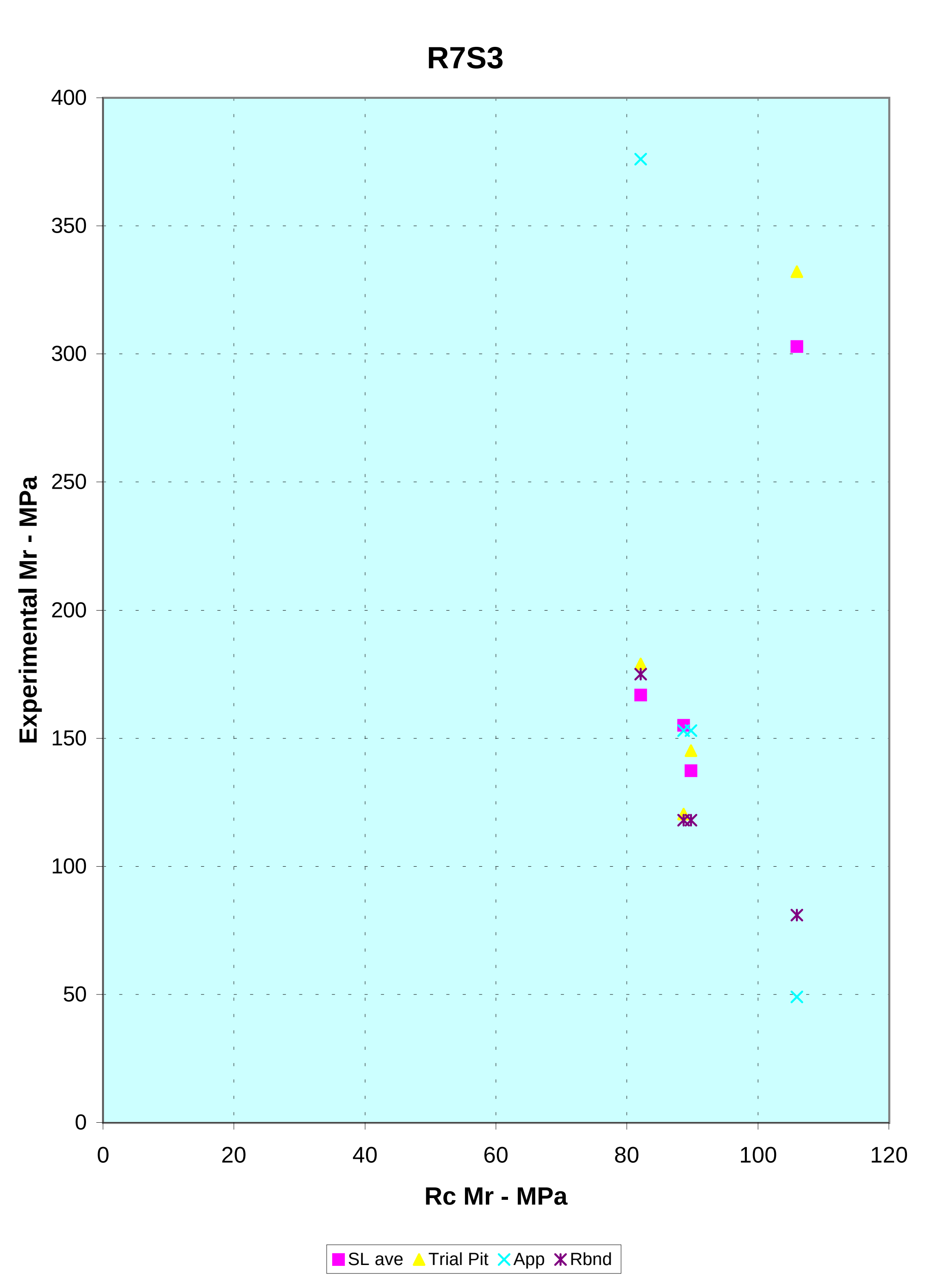
	Road No:	R7S1		Madisi - Kasungu							
	Resilient Modulus (Mpa)					Soil Properties				Dry In Situ Density	Soaked CBR %	
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI		%Comp	
		SL ave	Trial Pit	App	Rbnd						98	95
Base	161	350	375	0	0	"As Dug" Laterite Gravel	16	35	19	1969	8	4
Subbase	142	345	252	0	0	Silty Sand/Lat Gravel	20	38	19	-	-	-
SSG	154	145	171	0	0	Silty Sand	19	36	17	-	-	-
SG	140	98	135	0	0							



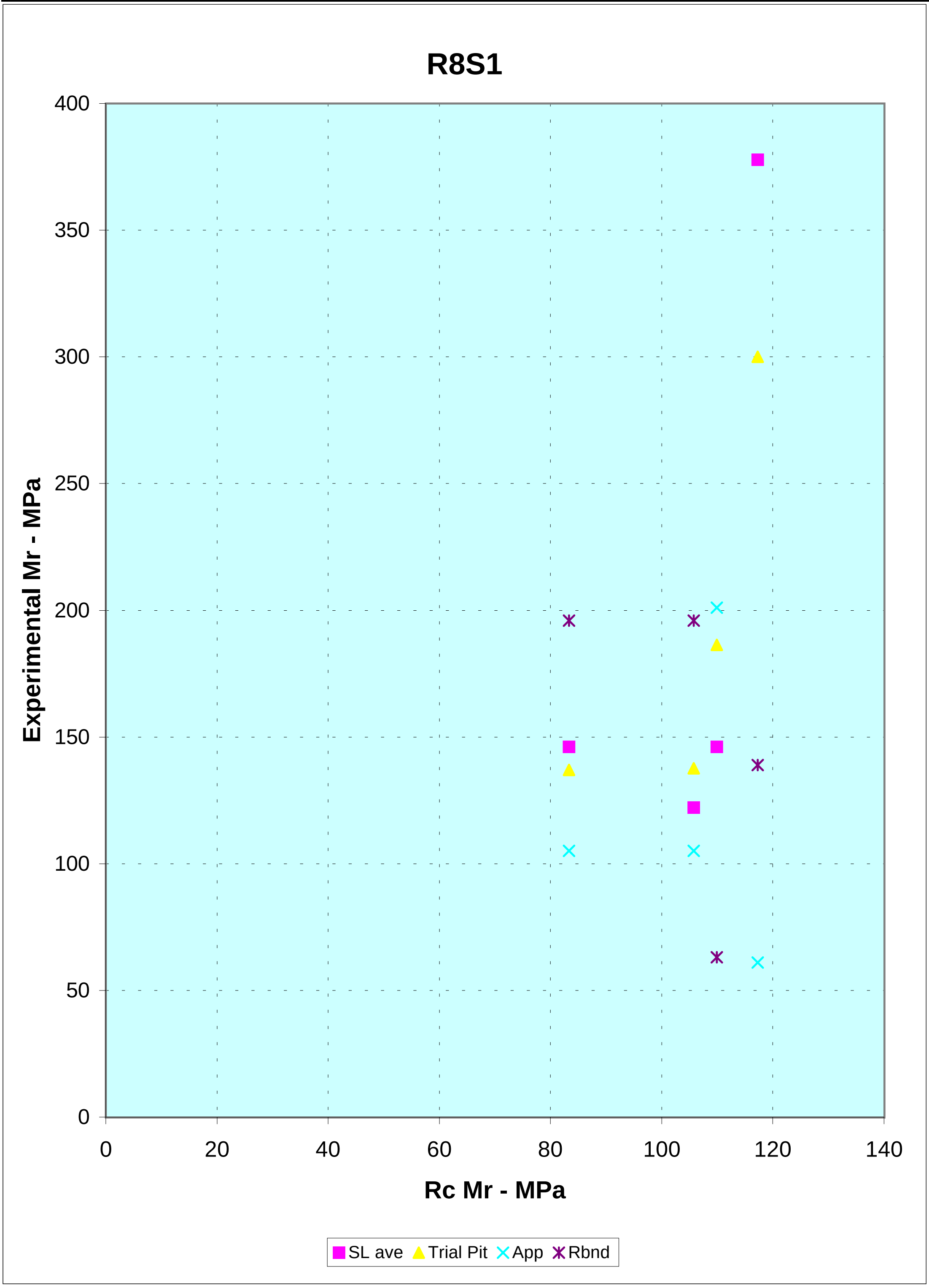
	Road No: R7S2					Madisi - Kasungu					Soaked CBR %	
	Resilient Modulus (Mpa)					Soil Properties				Dry In Situ Density		
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI		%Comp	
		SL ave	Trial Pit	App	Rbnd						98	95
Base	261	318	335	158	139	"As Dug" Laterite Gravel	15	29	16	1917	42	33
Subbase	200	183	246	20	204	Silty Sand/Lat Gravel	16	32	18	-	-	-
SSG	114	191	158	264	61	Silty Sand	22	36	17	-	-	-
SG	109	131	153	264	61							



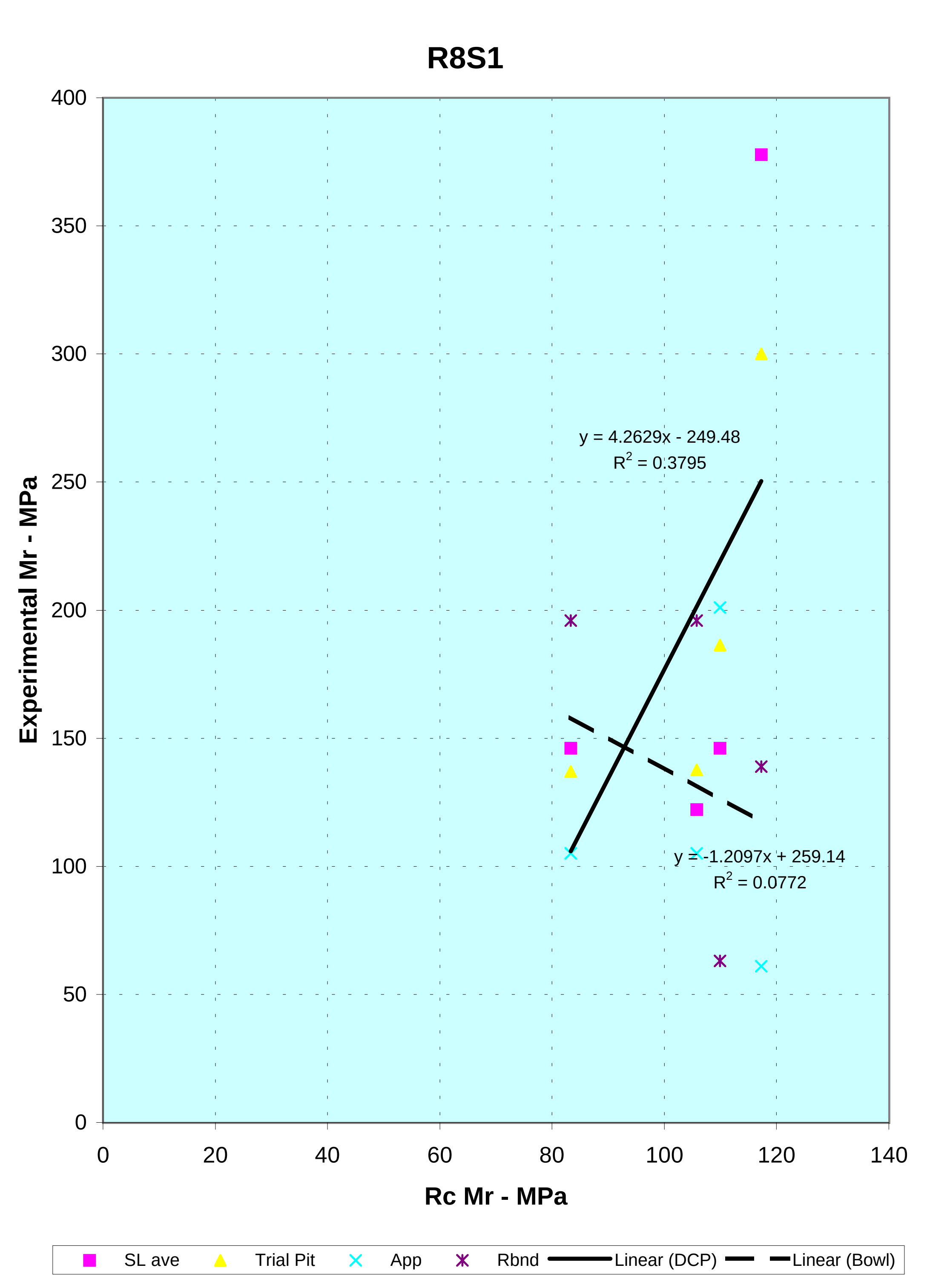
	Road No: **R7S3**					**Madisi - Kasungu**						
	Resilient Modulus (Mpa)					Soil Properties				Dry In Situ Density	Soaked CBR %	
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI		%Comp	
		SL ave	Trial Pit	App	Rbnd						98	95
Base	106	303	332	49	81	"As Dug" Laterite Gravel	12	24	13	1933	70	62
Subbase	82	167	179	376	175	Lateritic Gravel	13	36	19	-	-	-
SSG	90	137	145	153	118	Silty Sand	35	38	19	-	-	-
SG	89	155	120	153	118							



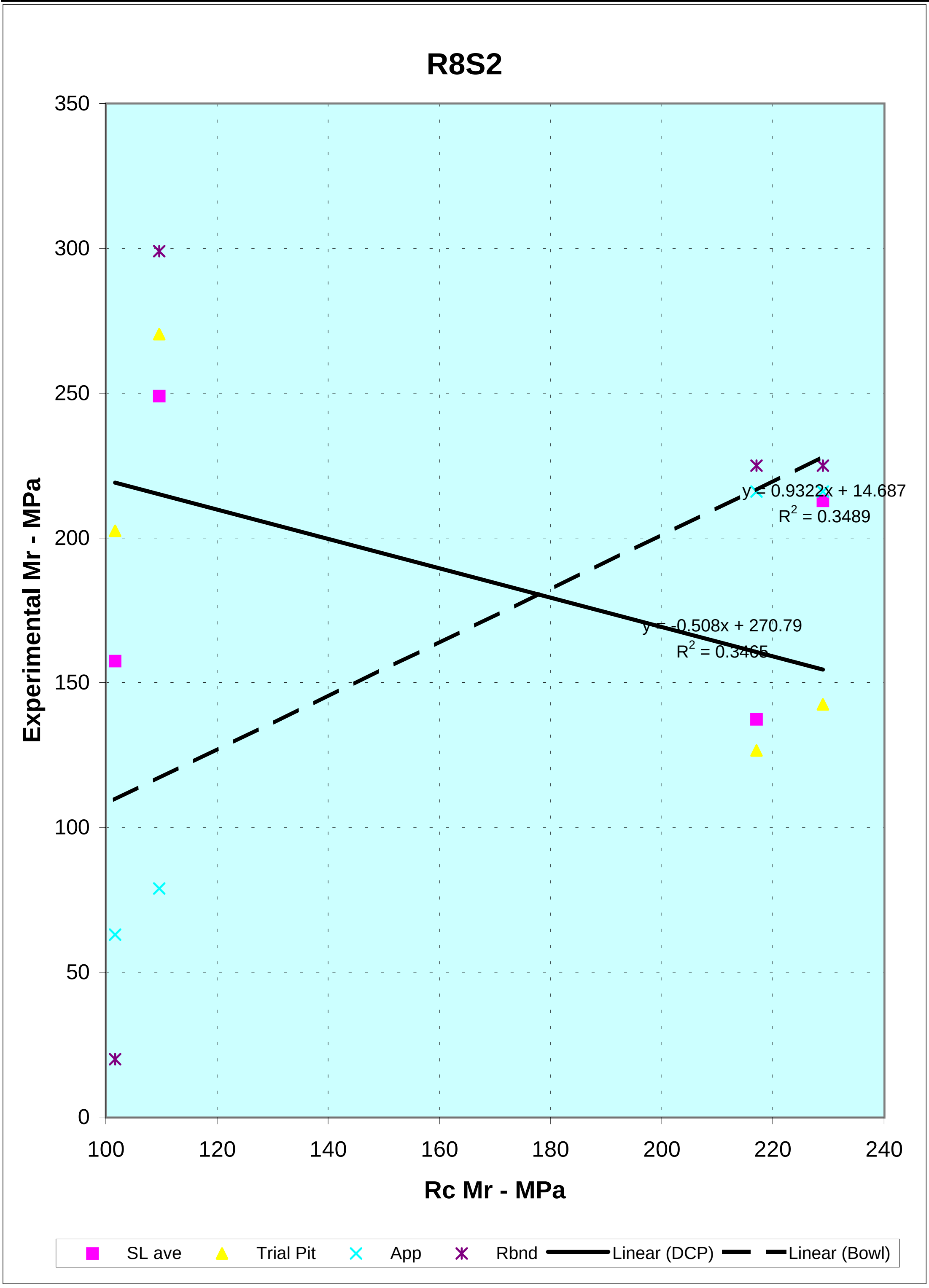
	Road No: R8S1					Lumbadzi - Mponela					Soaked CBR %	
	Resilient Modulus (Mpa)					Soil Properties				Dry In Situ Density		
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI		%Comp	
		SL ave	Trial Pit	App	Rbnd						98	95
Base	117	378	300	61	139	"As Dug" Laterite Gravel	14	26	14	-	42	17
Subbase	110	146	186	201	63	Lateritic Gravel	13	26	12	-	-	-
SSG	106	122	138	105	196	Sandy Clay	29	44	22	-	-	-
SG	83	146	137	105	196							



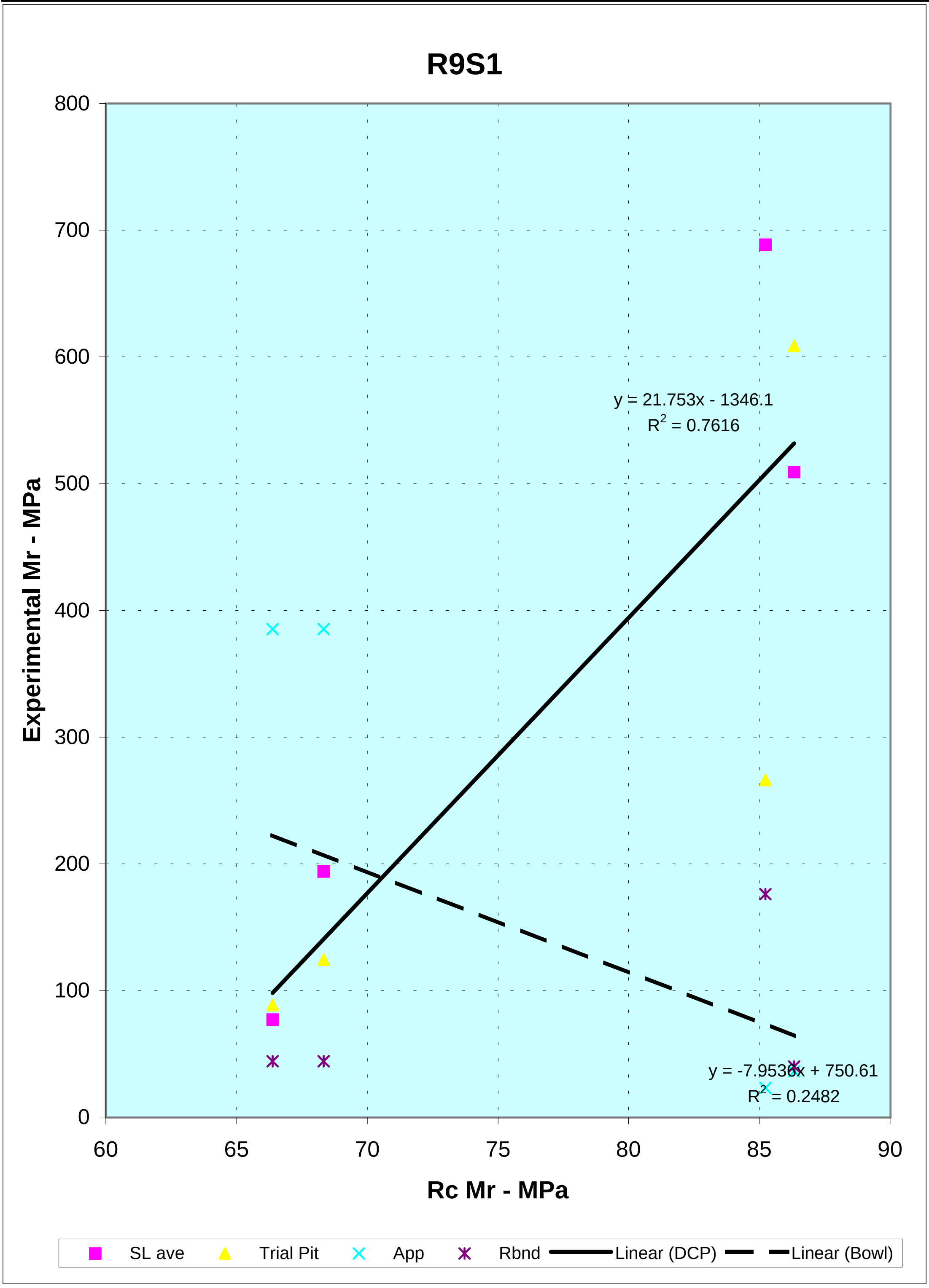
	Road No: R8S1					Lumbadzi - Mponela					Soaked CBR %	
	Resilient Modulus (Mpa)					Soil Properties				Dry In Situ Density		
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI		%Comp	
		SL ave	Trial Pit	App	Rbnd						98	95
Base	117	378	300	61	139	"As Dug" Laterite Gravel	14	26	14	-	42	17
Subbase	110	146	186	201	63	Lateritic Gravel	13	26	12	-	-	-
SSG	106	122	138	105	196	Sandy Clay	29	44	22	-	-	-
SG	83	146	137	105	196							



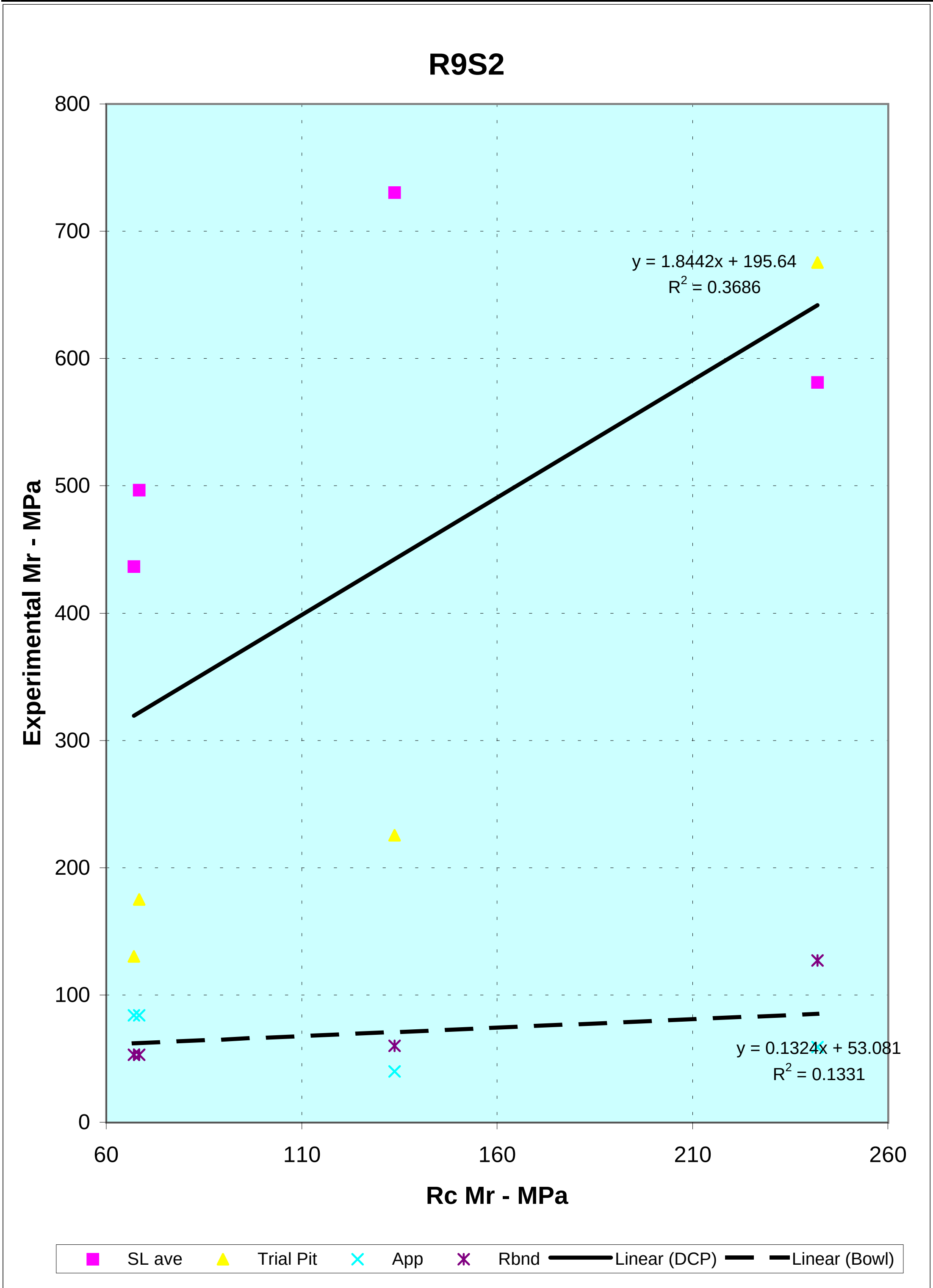
	Road No: R8S2					Lumbadzi - Mponela					Soaked CBR %	
	Resilient Modulus (Mpa)					Soil Properties				Dry In Situ Density	%Comp	
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI			
		SL ave	Trial Pit	App	Rbnd						98	95
Base	110	249	270	79	299	"As Dug" Laterite Gravel	21	35	25	-	7	-
Subbase	102	158	202	63	20	Lateritic Gravel	21	34	19	-	-	-
SSG	229	213	142	216	225	Sandy Clay	29	39	24	-	-	-
SG	217	137	127	216	225							



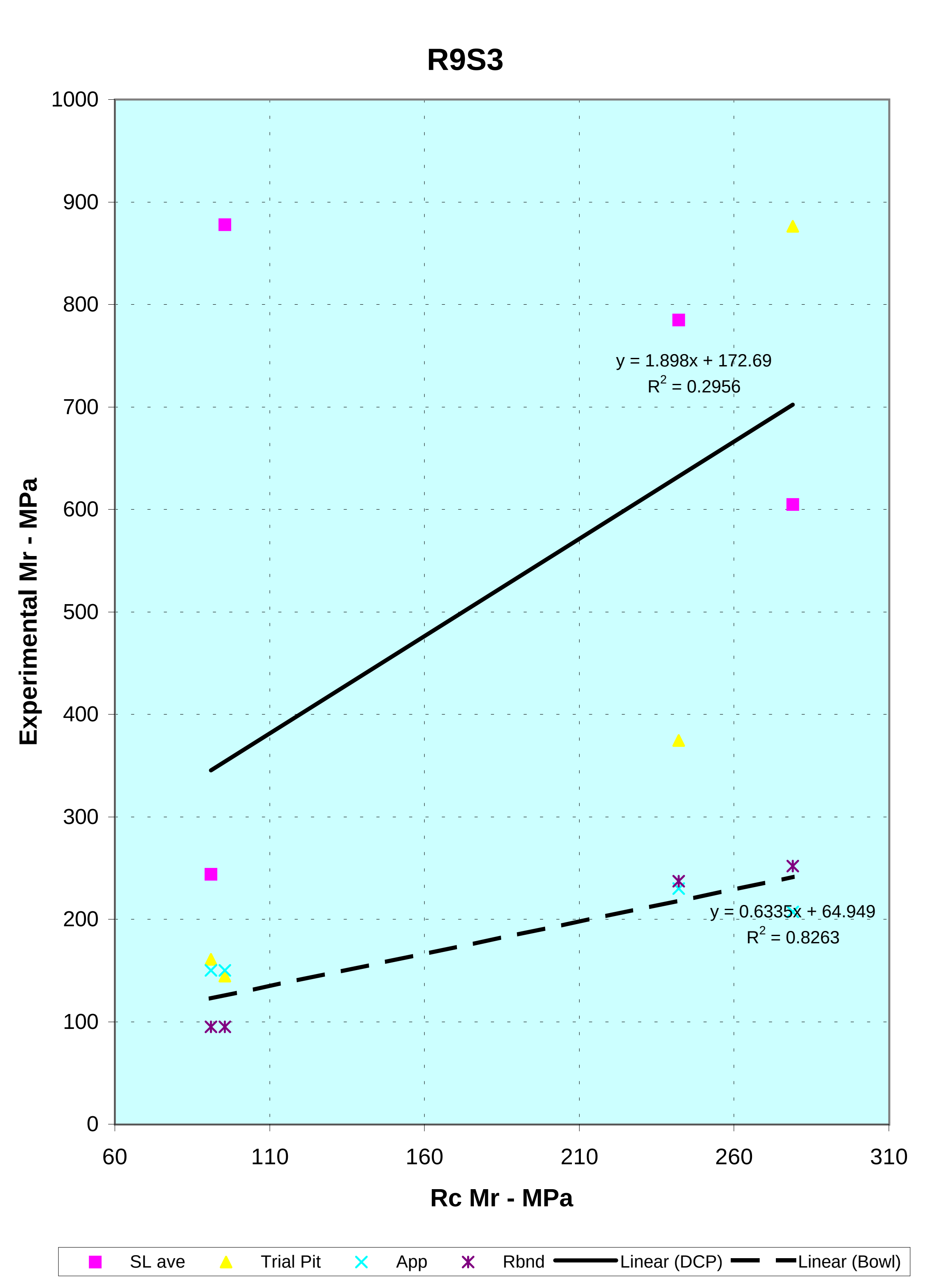
	Road No: R9S1					Bunda Turn Off - Chimbiya					Soaked CBR %	
	Resilient Modulus (Mpa)					Soil Properties				Dry In Situ Density	%Comp	
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI			
		SL ave	Trial Pit	App	Rbnd						98	95
Base	86	509	609	36	40	Crushed Stone Macadam	4	N	NP	-	-	-
Subbase	85	689	266	23	176	Silty Sand	29	32	16	-	-	-
SSG	68	194	124	385	44	Gravelly Clay	50	38	19	-	-	-
SG	66	77	88	385	44							



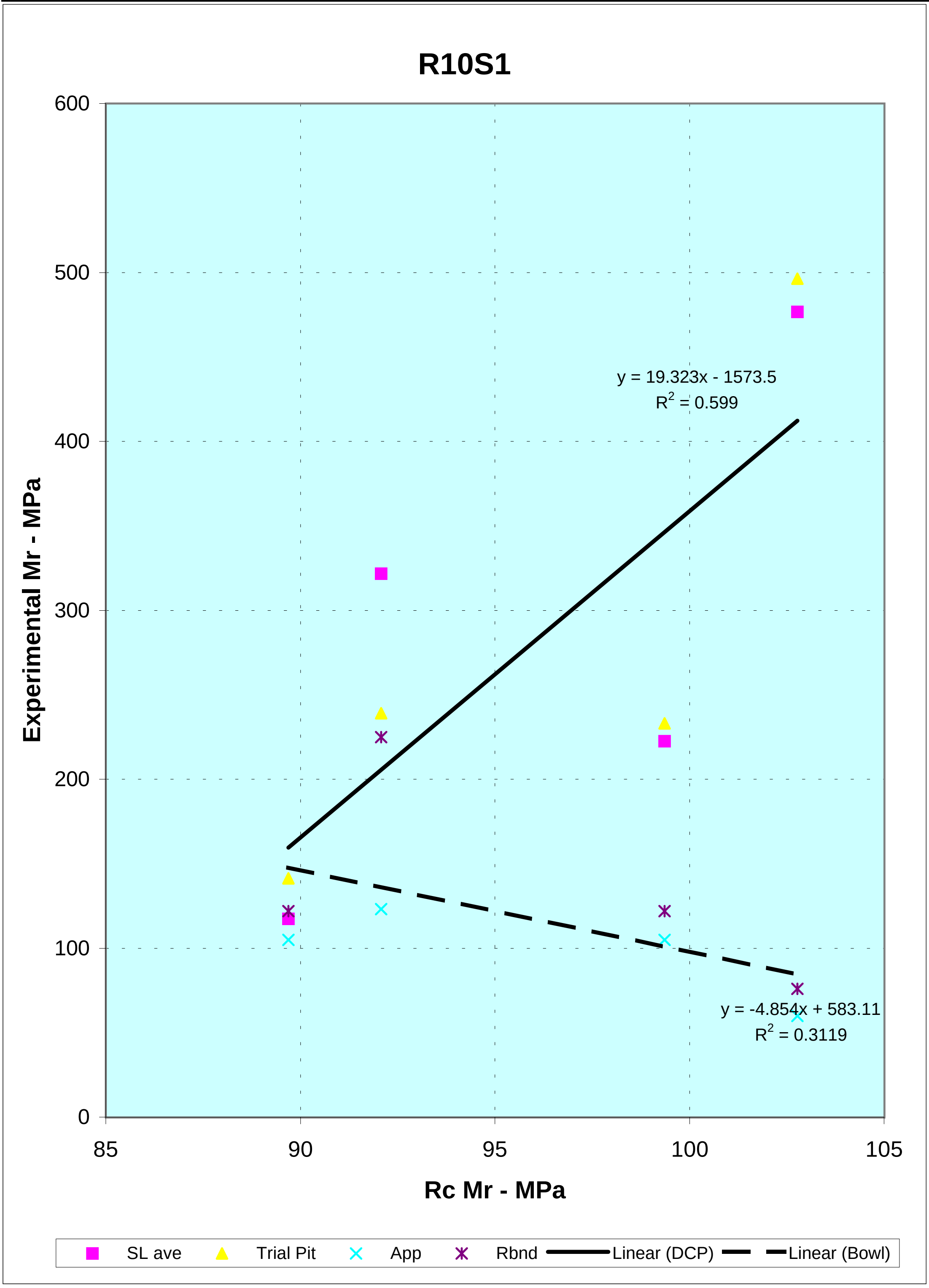
	Road No: R9S2					Bunda Turn Off - Chimbiya					Soaked CBR %	
	Resilient Modulus (Mpa)					Soil Properties				Dry In Situ Density		
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI		%Comp	
		SL ave	Trial Pit	App	Rbnd						98	95
Base	242	581	675	59	127	Crushed Stone Macadam	9	N	NP	-	-	-
Subbase	134	730	225	40	60	Silty Sand	24	38	22	-	-	-
SSG	68	497	175	84	53	Gravelly Clay	33	34	21	-	-	-
SG	67	437	130	84	53							



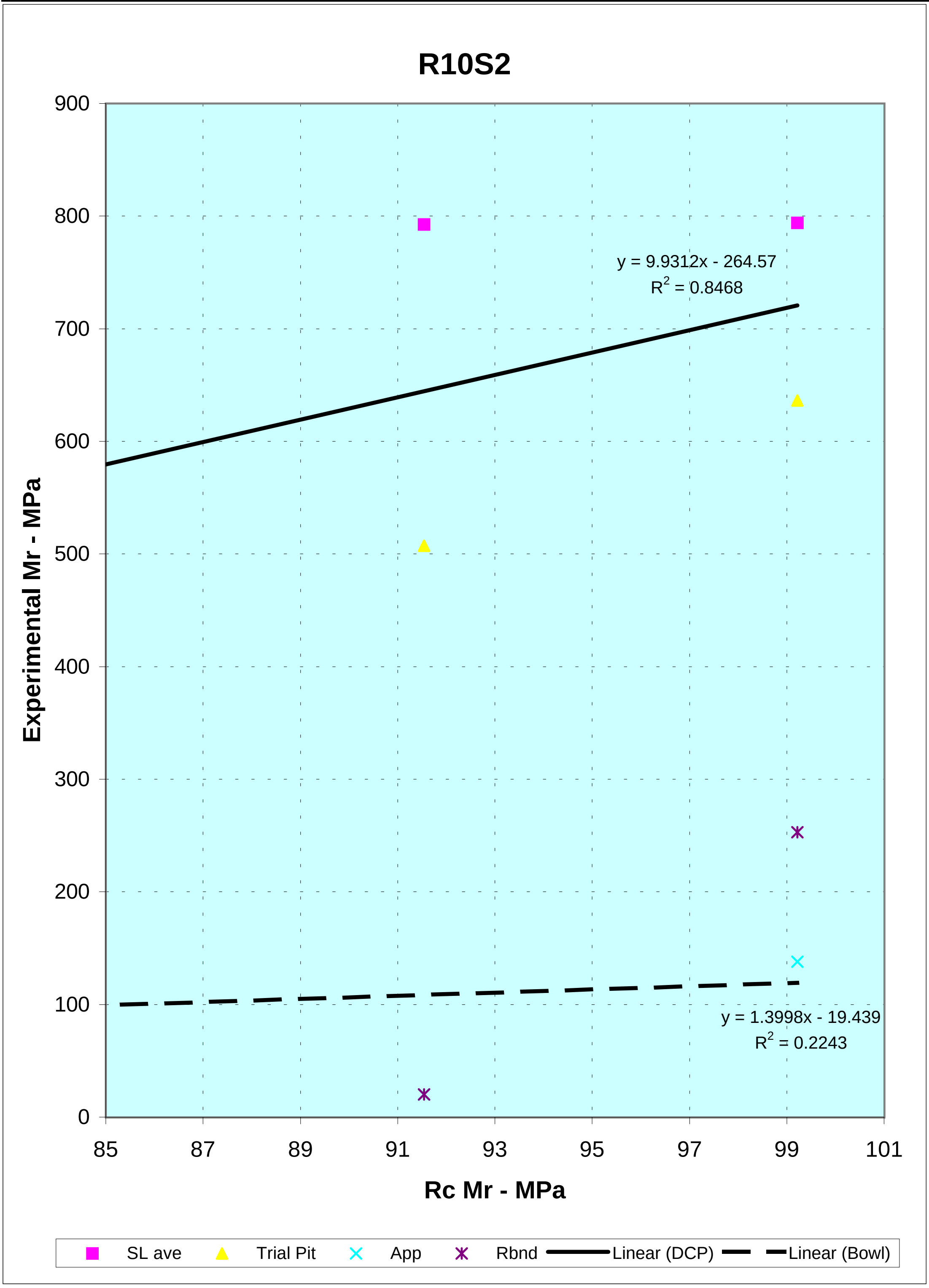
	Road No: **R9S3**					**Bunda Turn Off - Chimbiya**					Soaked CBR %	
	Resilient Modulus (Mpa)					Soil Properties				Dry In Situ Density		
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI		%Comp	
		SL ave	Trial Pit	App	Rbnd						98	95
Base	279	605	876	207	252	Crushed Stone Macadam	5	N	NP	-	-	-
Subbase	242	785	374	230	237	Quartz Gravel	25	30	15	-	-	-
SSG	96	878	145	150	95	Gravelly Clay	45	42	22	-	-	-
SG	91	244	161	150	95							



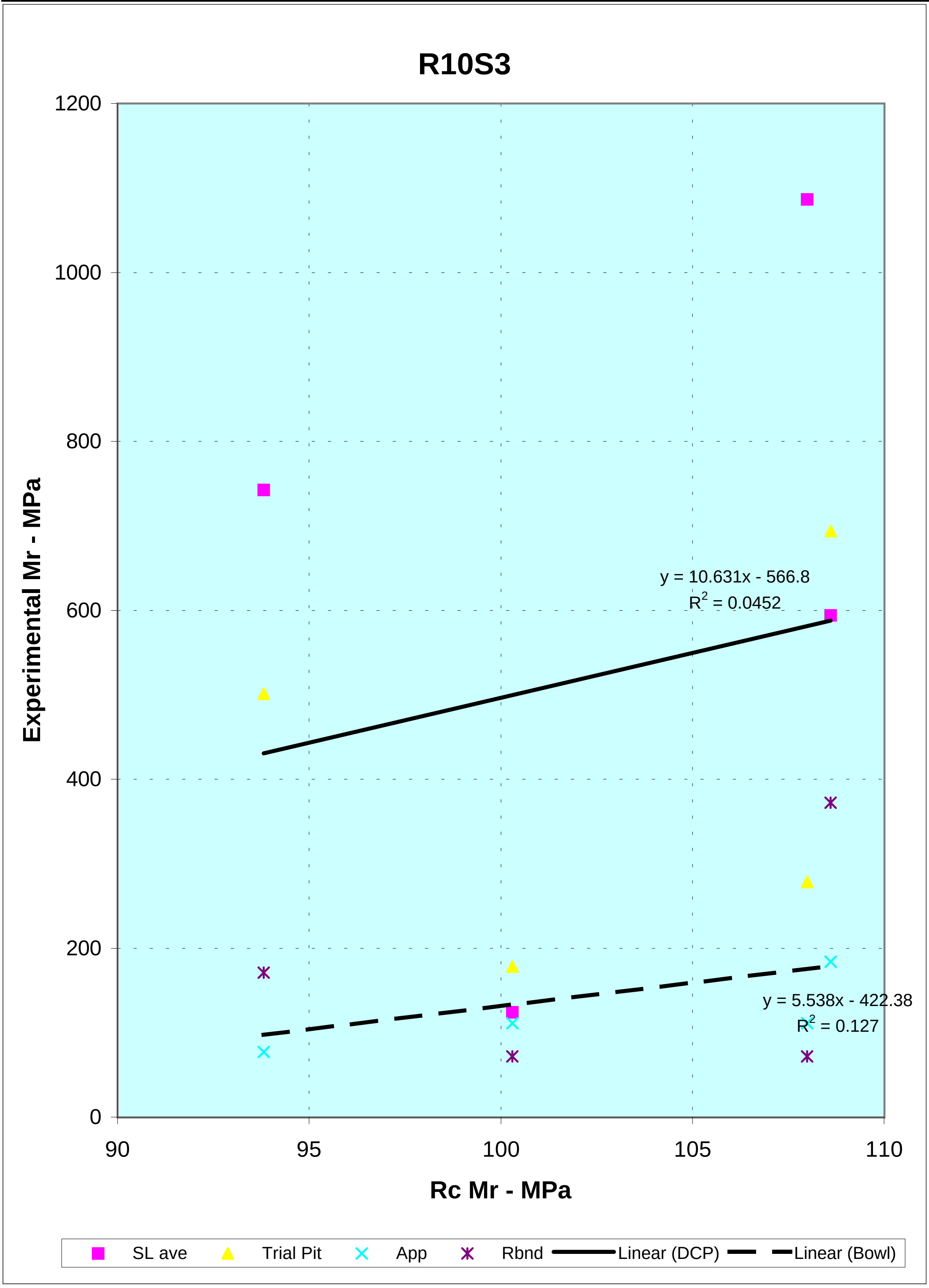
	Road No: R10S1					Dedza - Biriwiri					Soaked CBR %	
	Resilient Modulus (Mpa)					Soil Properties				Dry In Situ Density		
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI		%Comp	
		SL ave	Trial Pit	App	Rbnd						98	95
Base	103	477	496	60	76	Crushed Stone	7	N	NP	-	-	-
Subbase	92	322	239	123	225	Clayey Quartz Gravel	14	31	16	-	-	-
SSG	99	222	233	105	122	Silty Sand	33	40	22	-	-	-
SG	90	117	141	105	122							



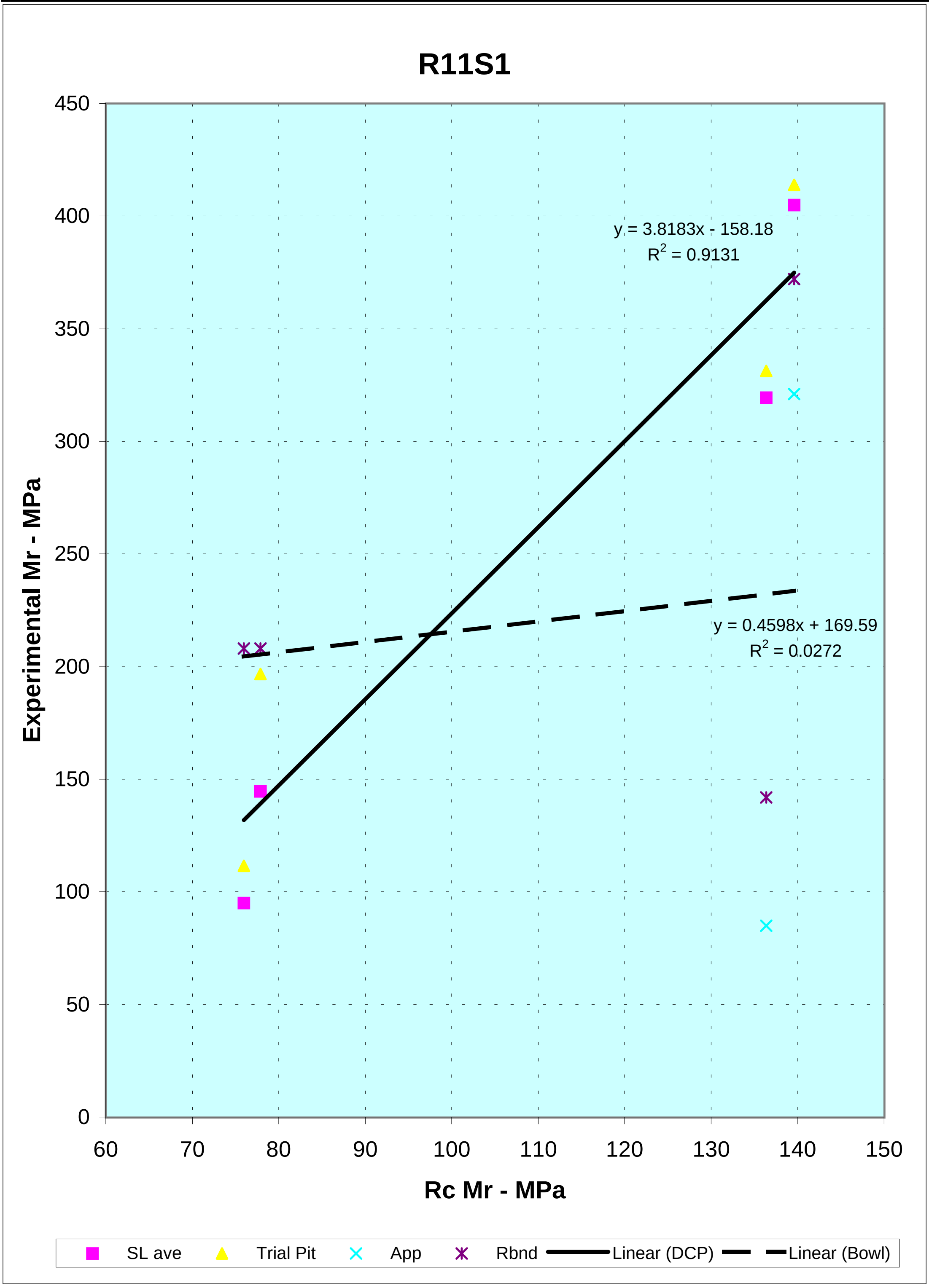
	Road No: R10S2					Dedza - Biriwiri					Soaked CBR %	
	Resilient Modulus (Mpa)					Soil Properties				Dry In Situ Density		
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI		%Comp	
		SL ave	Trial Pit	App	Rbnd						98	95
Base	99	794	636	138	253	Crushed Stone	3	27	11	-	-	-
Subbase	92	792	507	20	20	Sandy Gravel	20	37	16	-	-	-
SSG	46	347	187	56	45	Silty Sand	10	50	28	-	-	-
SG	45	87	126	56	45							



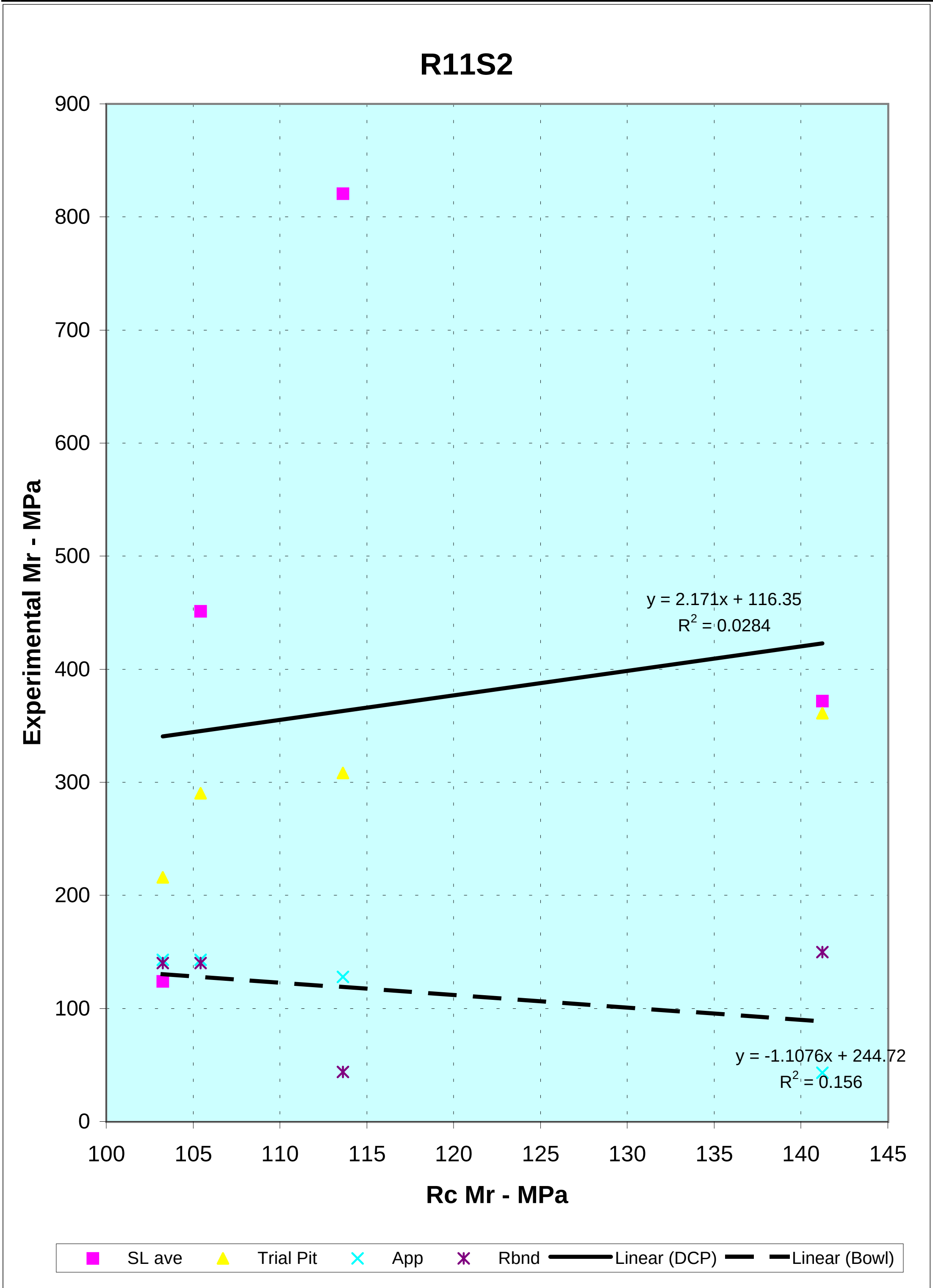
	Road No:	R10S3				Dedza - Biriwiri					Soaked CBR %	
	Resilient Modulus (Mpa)					Soil Properties				Dry In Situ Density		
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI		%Comp	
		SL ave	Trial Pit	App	Rbnd						98	95
Base	109	594	694	184	372	Crushed Stone	10	N	15	-	-	-
Subbase	94	743	501	77	171	Clayey Quartz Gravel	15	41	17	-	-	-
SSG	108	1087	278	111	72	Silty Clay	17	41	18	-	-	-
SG	100	124	178	111	72							



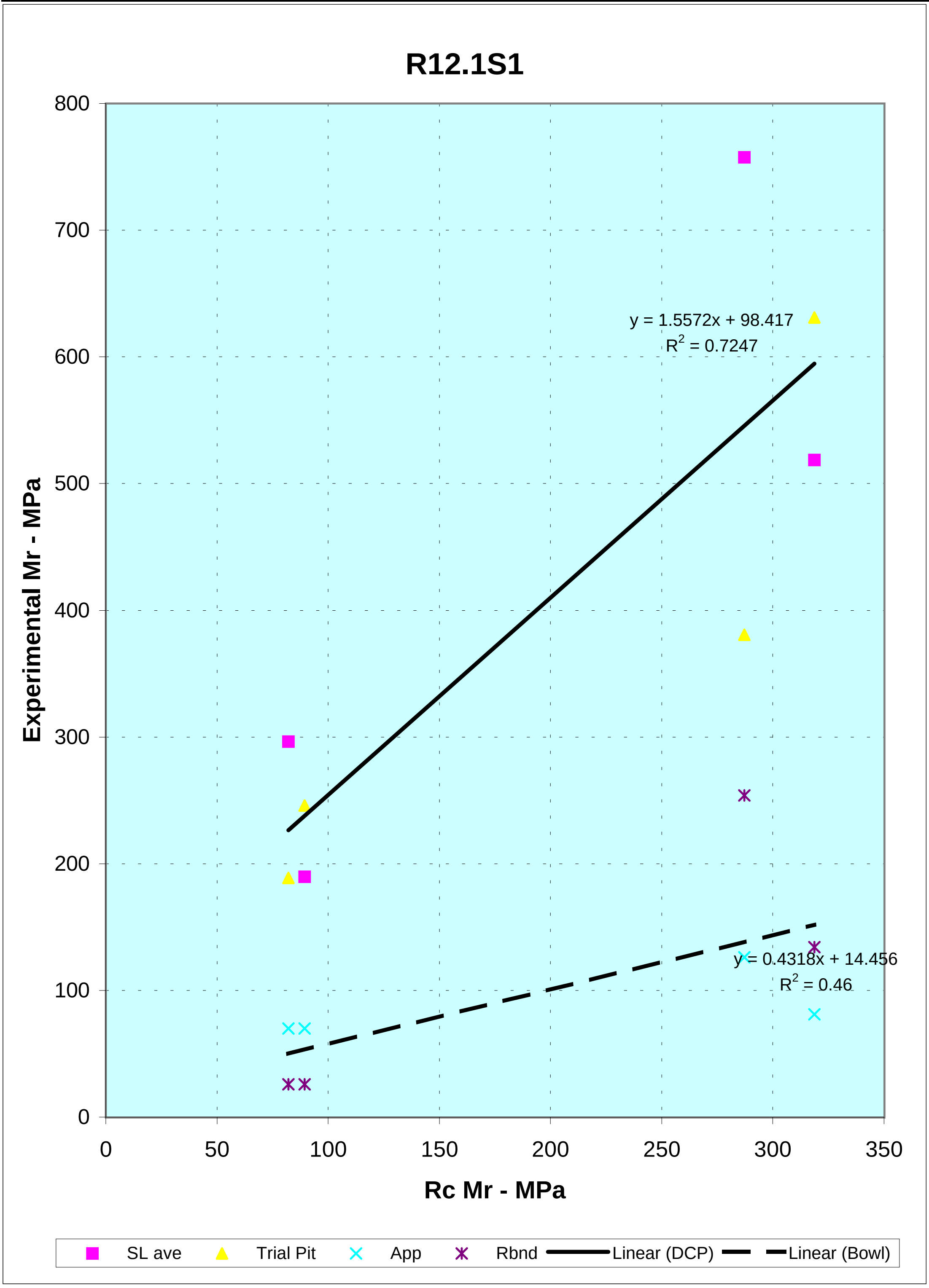
	Road No:	R11S1			Salima - Senga Bay					Soaked CBR %	
	Resilient Modulus (Mpa)				Soil Properties				Dry In Situ Density		
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI		%Comp	
		SL ave	Trial Pit	App	Rbnd						98	95
Base	140	405	414	321	372	Laterite Gravel	28	38	19	-	15	14
Subbase	136	319	331	85	142	Gravelly Sand	17	23	15	-	-	-
SSG	78	145	197	208	208	Clayey Sand	28	33	19	-	-	-
SG	76	95	111	208	208							



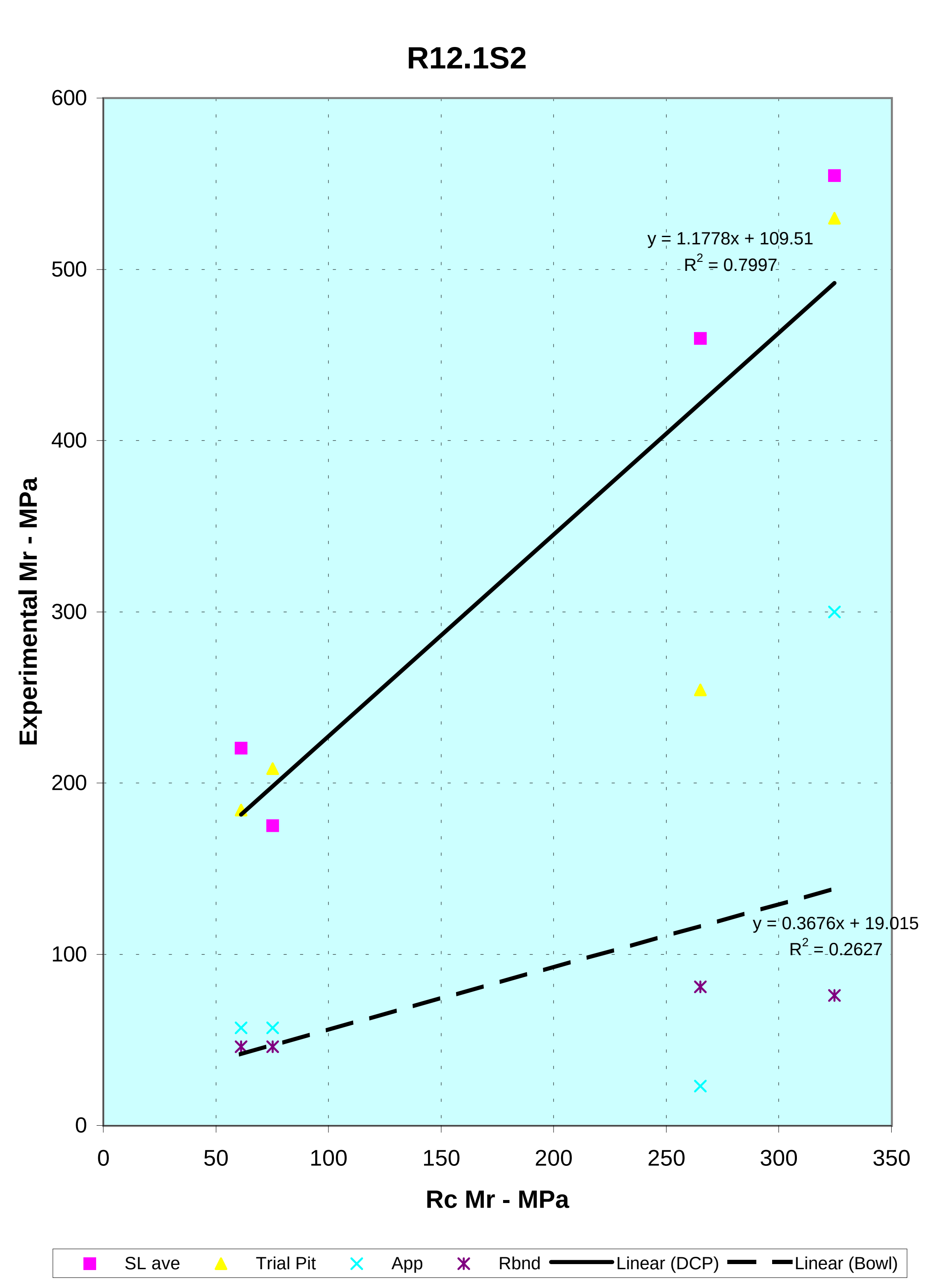
	Road No: R11S2					Salima - Senga Bay					Soaked CBR %	
	Resilient Modulus (Mpa)					Soil Properties				Dry In Situ Density		
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI		%Comp	
		SL ave	Trial Pit	App	Rbnd						98	95
Base	141	372	361	43	150	Sandy Clay	17	23	13	-	30	40
Subbase	114	821	308	128	44	-	-	0	-	-	-	-
SSG	105	451	290	143	140	-	-	0	-	-	-	-
SG	103	124	216	143	140							



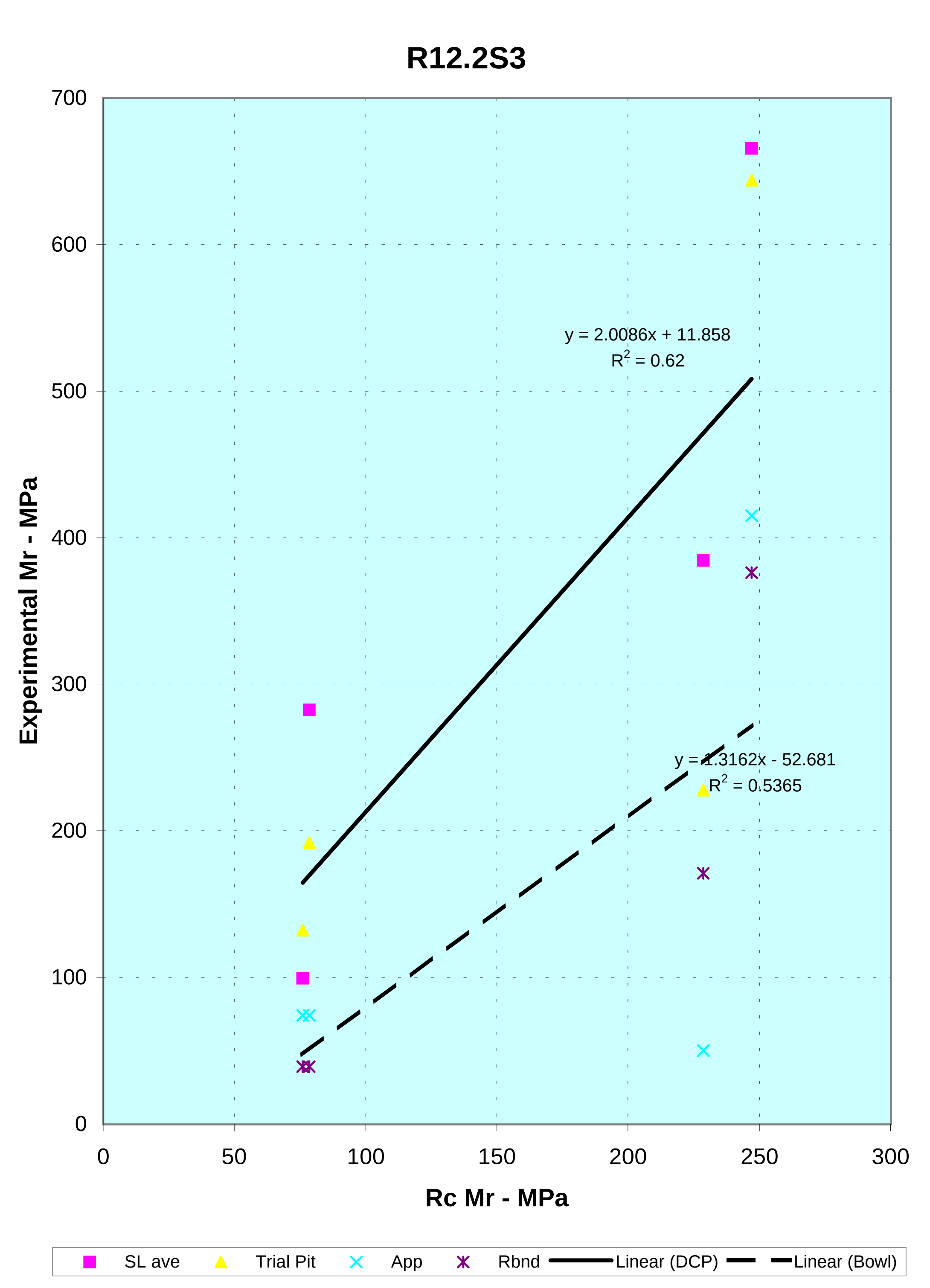
	Road No:	R12.1S1				Benga - Nkhotakota					Soaked CBR %	
	Resilient Modulus (Mpa)					Soil Properties				Dry In Situ Density		
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI		%Comp	
		SL ave	Trial Pit	App	Rbnd						98	95
Base	319	519	631	81	134	Crushed Stone	19	N	NP	-	-	-
Subbase	287	758	381	126	254	Clayey Lat Gravel	10	41	22	-	-	-
SSG	89	190	246	70	26	Clayey Sand	25	N	NP	-	-	-
SG	82	296	189	70	26							



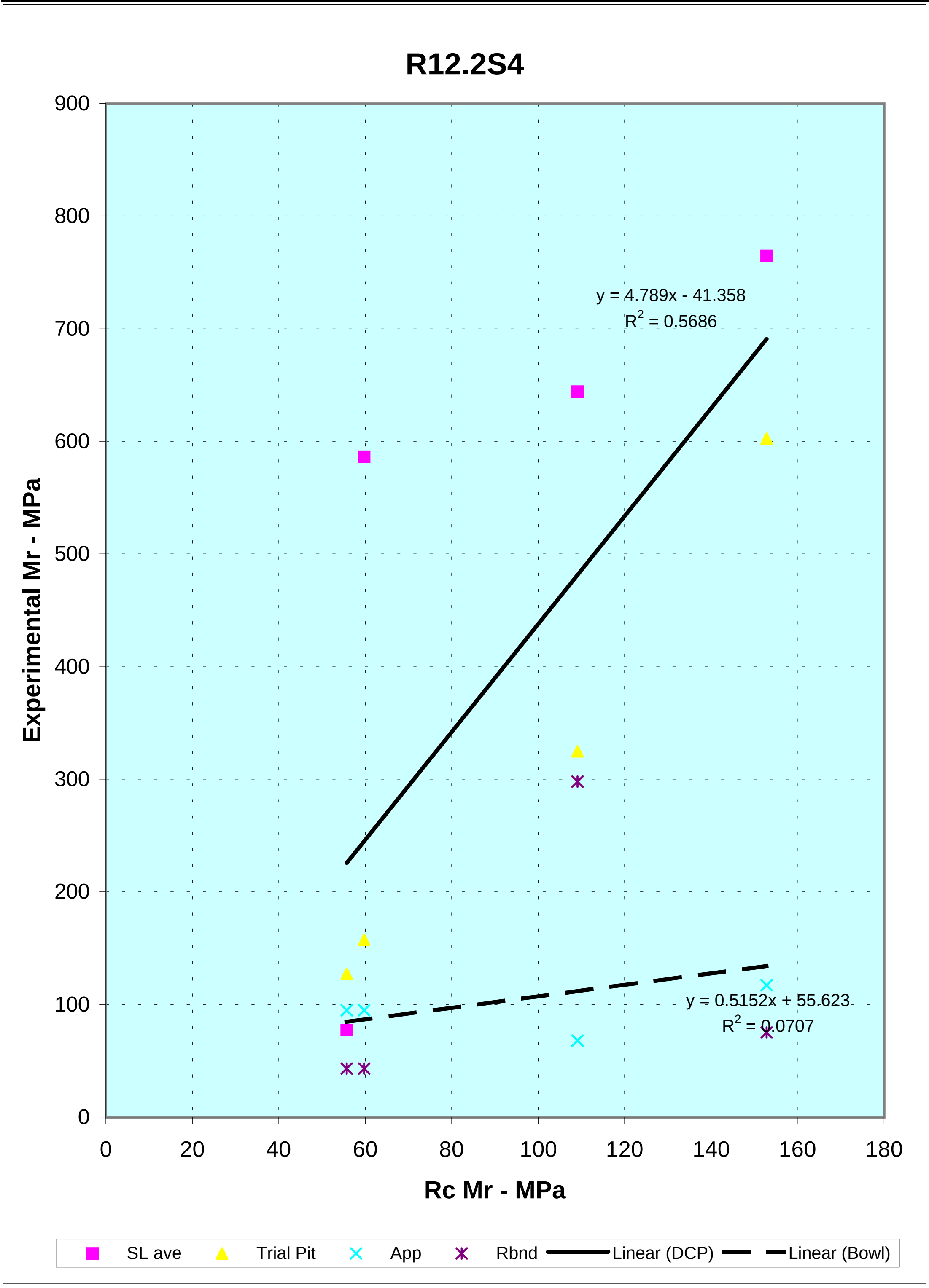
	Road No: R12.1S2					Benga - Nkhotakota					Soaked CBR %	
	Resilient Modulus (Mpa)					Soil Properties				Dry In Situ Density		
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI		%Comp	
		SL ave	Trial Pit	App	Rbnd						98	95
Base	325	555	530	300	76	Stab Crushed Stone	5	N	NP	-	-	-
Subbase	265	460	254	23	81	Clayey Lat Gravel	18	44	28	-	-	-
SSG	75	175	208	57	46	Clayey Lat Gravel	10	41	22	-	-	-
SG	61	220	184	57	46							



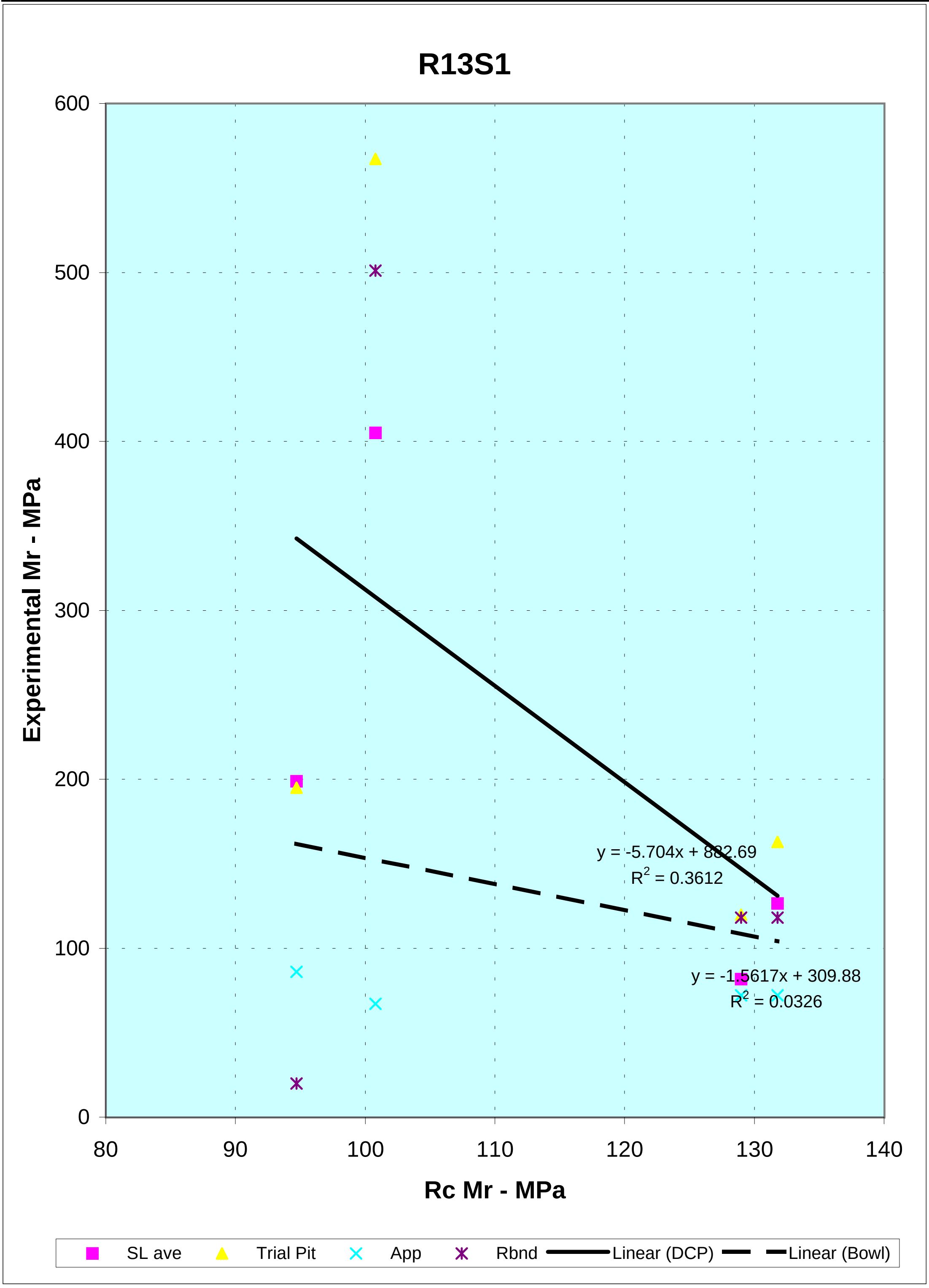
	Road No: R12.2S3				Nkhotakota - Dwangwa						Soaked CBR %	
	Resilient Modulus (Mpa)					Soil Properties				Dry In Situ Density		
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI		%Comp	
		SL ave	Trial Pit	App	Rbnd						98	95
Base	247	666	644	415	376	-	-	0	-	-	-	-
Subbase	229	384	228	50	171	-	-	0	-	-	-	-
SSG	79	282	192	74	39	-	-	0	-	-	-	-
SG	76	99	132	74	39							



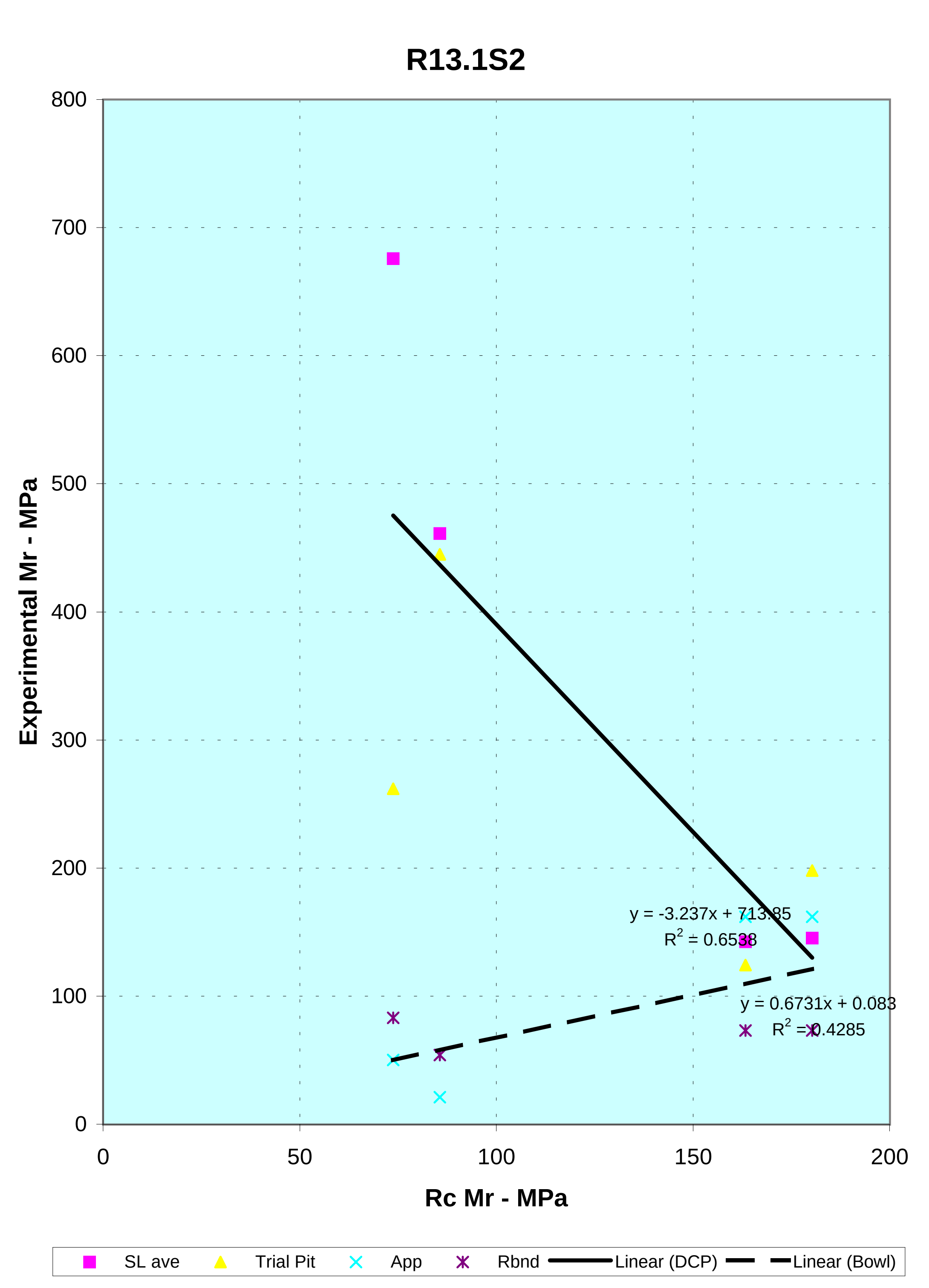
	Road No:	R12.2S4				Nkhotakota - Dwangwa					Soaked CBR %	
	Resilient Modulus (Mpa)					Soil Properties				Dry In Situ Density		
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI		%Comp	
		SL ave	Trial Pit	App	Rbnd						98	95
Base	153	765	603	117	75	Stab Sandy Gravel	16	30	15	-	44	38
Subbase	109	644	325	68	298	Clayey Lat Gravel	10	41	22	-	-	-
SSG	60	587	157	95	43	-	-	0	-	-	-	-
SG	56	77	127	95	43							



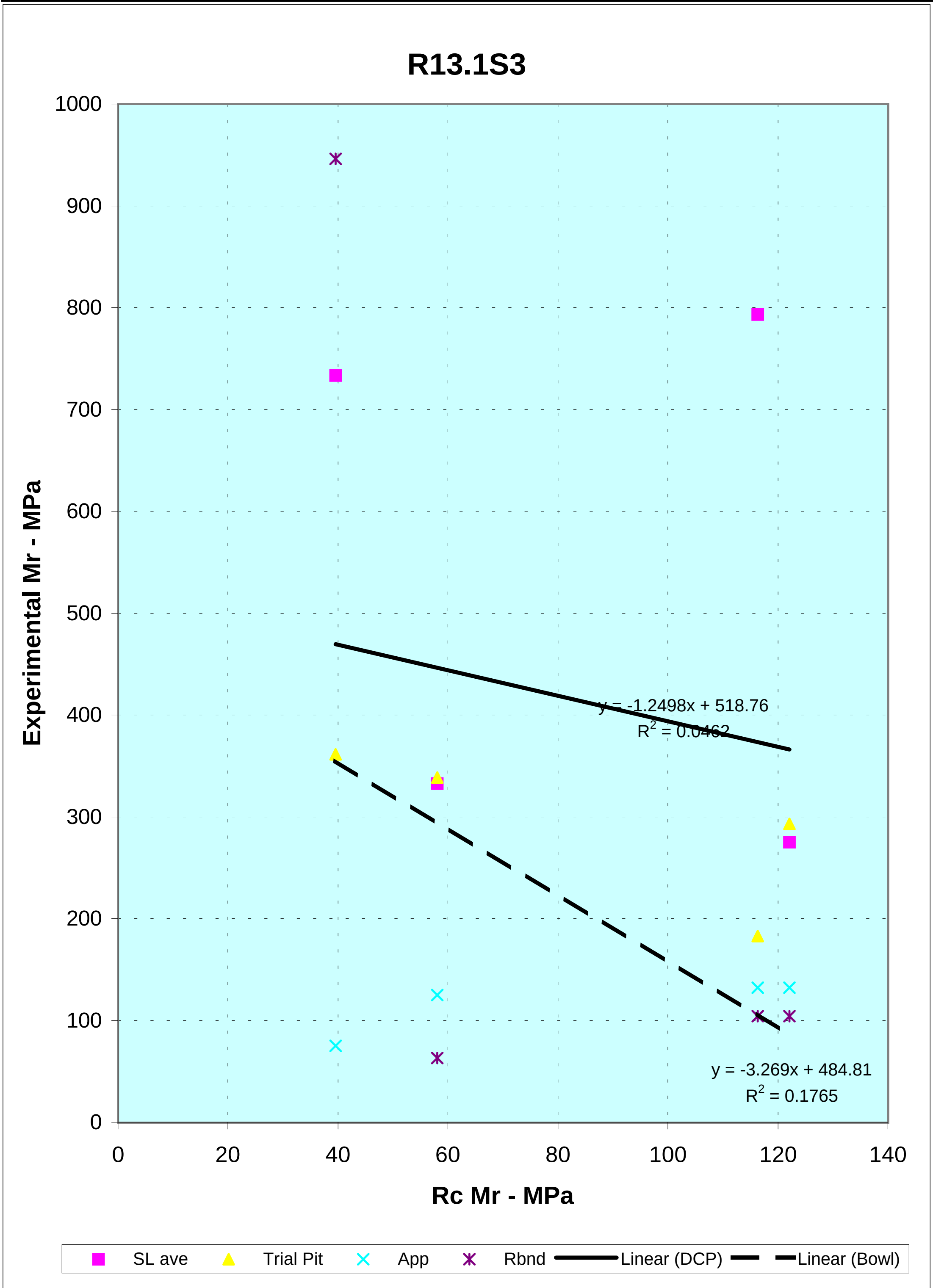
	Road No: R13S1					Chingeni - Liwonde					Soaked CBR %	
	Resilient Modulus (Mpa)					Soil Properties				Dry In Situ Density		
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI		%Comp	
		SL ave	Trial Pit	App	Rbnd						98	95
Base	101	405	567	67	501	Stab Gravel	5	N	NP	-	60	###
Subbase	95	199	195	86	20	Quartz Gravel	29	32	16	-	-	-
SSG	132	126	163	72	118	Clayey Sand	28	34	17	-	-	-
SG	129	82	120	72	118							



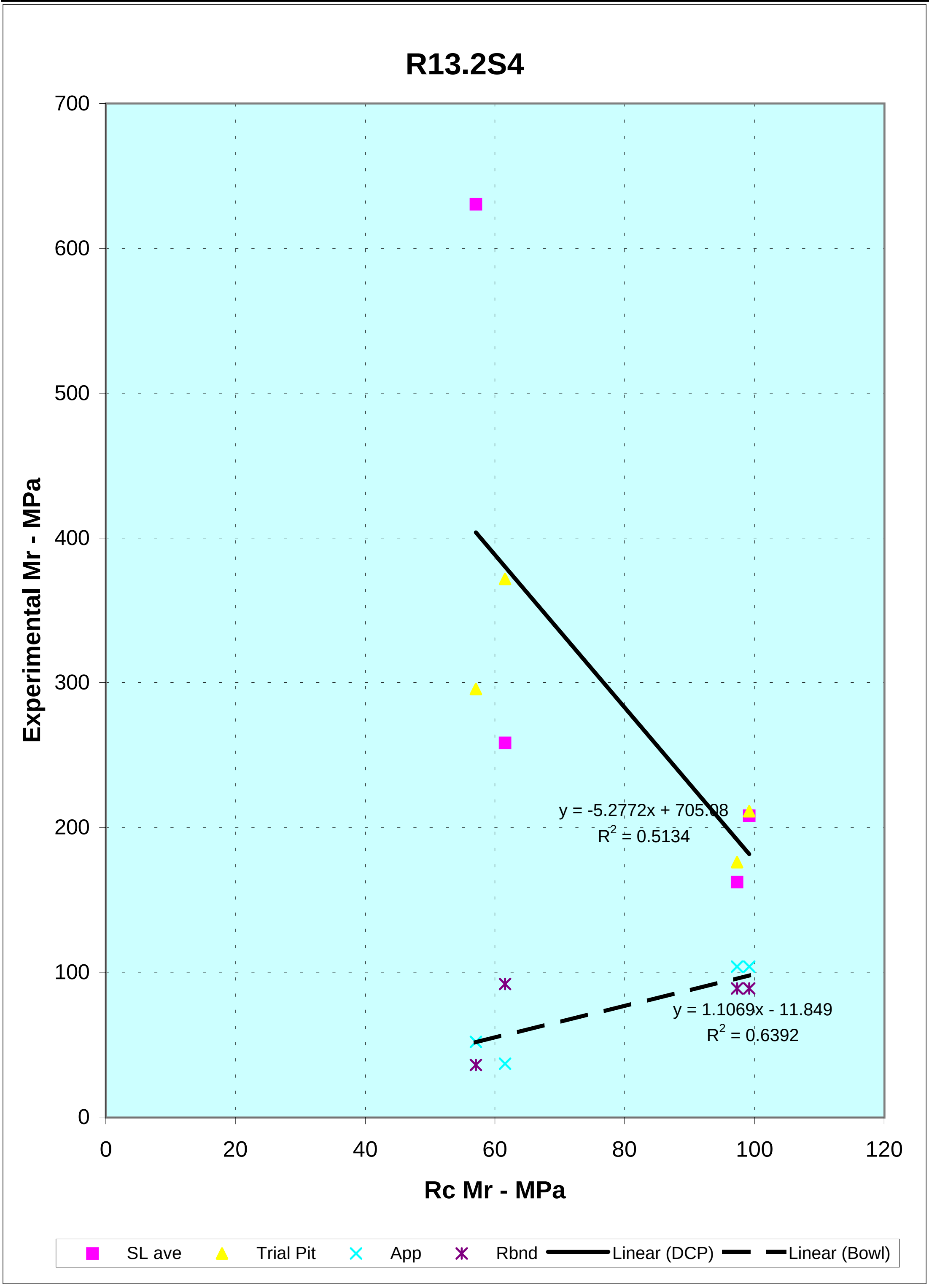
	Road No: R13.1S2					Chingeni - Liwonde						Soaked CBR %	
	Resilient Modulus (Mpa)					Soil Properties					Dry In Situ Density		
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI			%Comp	
		SL ave	Trial Pit	App	Rbnd							98	95
Base	86	461	445	21	54	Stab Gravel	18	36	18		-	-	-
Subbase	74	676	262	50	83	Sandy Gravel	23	N	NP		-	-	-
SSG	180	145	198	162	73	Clayey Sand	32	34	15		-	-	-
SG	163	142	124	162	73								



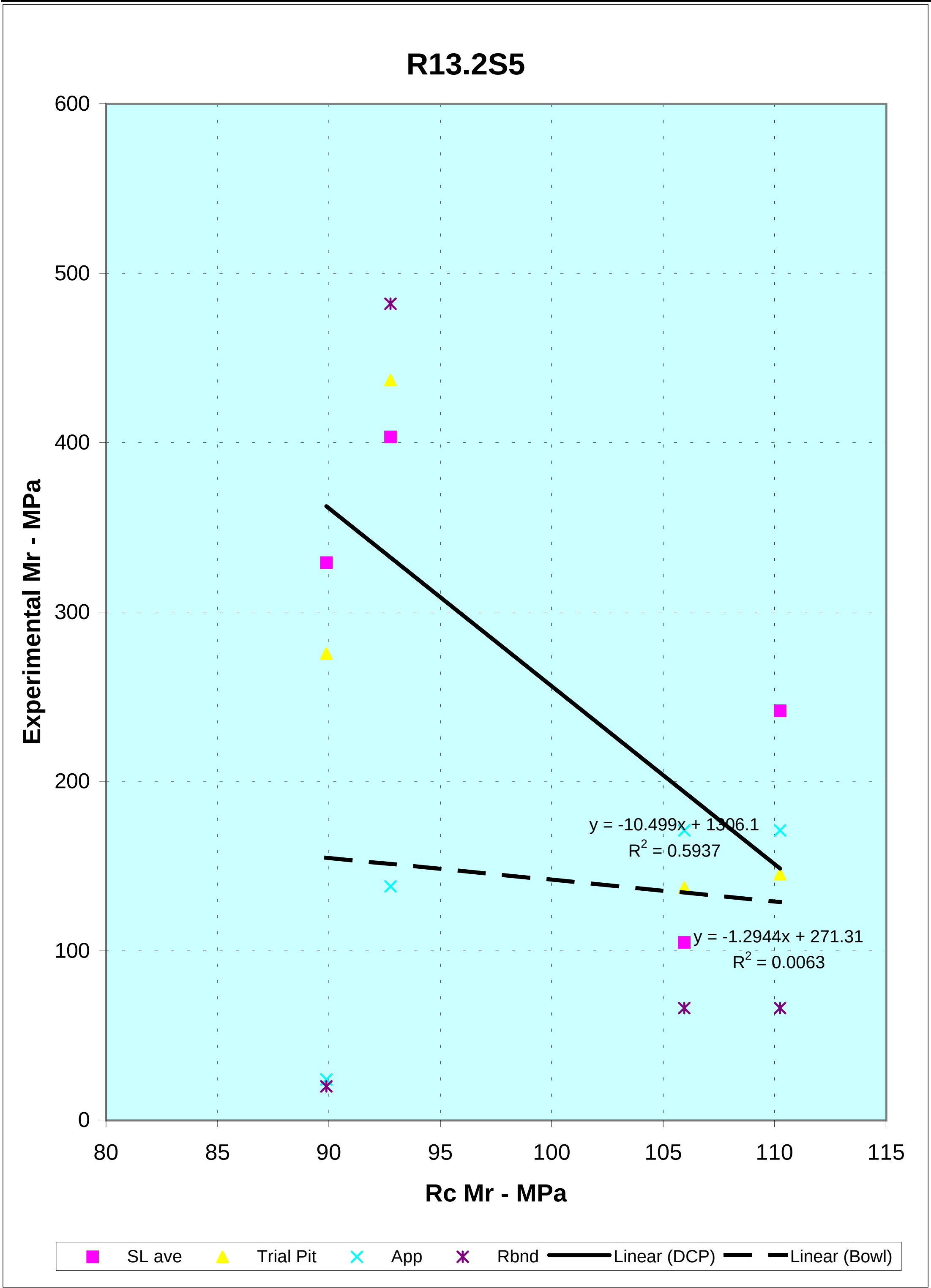
	Road No:	R13.1S3		Chingeni - Liwonde							Soaked CBR %	
	Resilient Modulus (Mpa)					Soil Properties				Dry In Situ Density	%Comp	
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI		98	95
		SL ave	Trial Pit	App	Rbnd							
Base	58	332	339	125	63	Stab Gneiss Gravel	15	N	NP	-	42	37
Subbase	40	733	361	75	946	Sandy Gravel	14	29	22	-	-	-
SSG	122	275	293	132	104	Clayey Sand	32	36	21	-	-	-
SG	116	793	183	132	104							



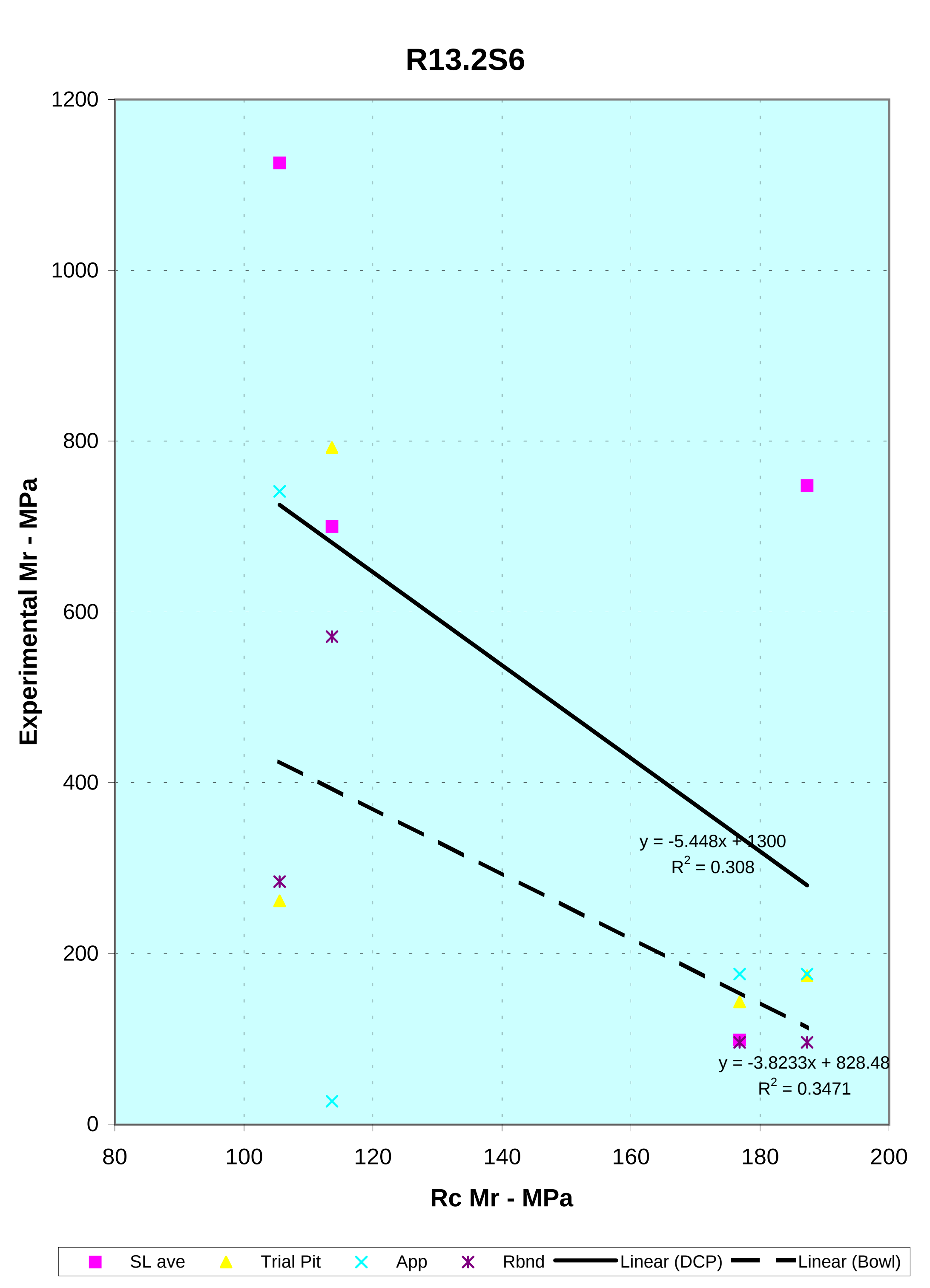
	Road No:	R13.2S4				Liwonde - Zomba					Soaked CBR %	
	Resilient Modulus (Mpa)					Soil Properties				Dry In Situ Density		
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI		%Comp	
		SL ave	Trial Pit	App	Rbnd						98	95
Base	62	258	372	37	92	Stab Gneiss Gravel	21	38	17	-	13	4
Subbase	57	630	296	52	36	Quartz/Lat Gravel	21	30	14	-	-	-
SSG	99	208	211	104	89	Clayey Sand	35	36	19	-	-	-
SG	97	162	176	104	89							



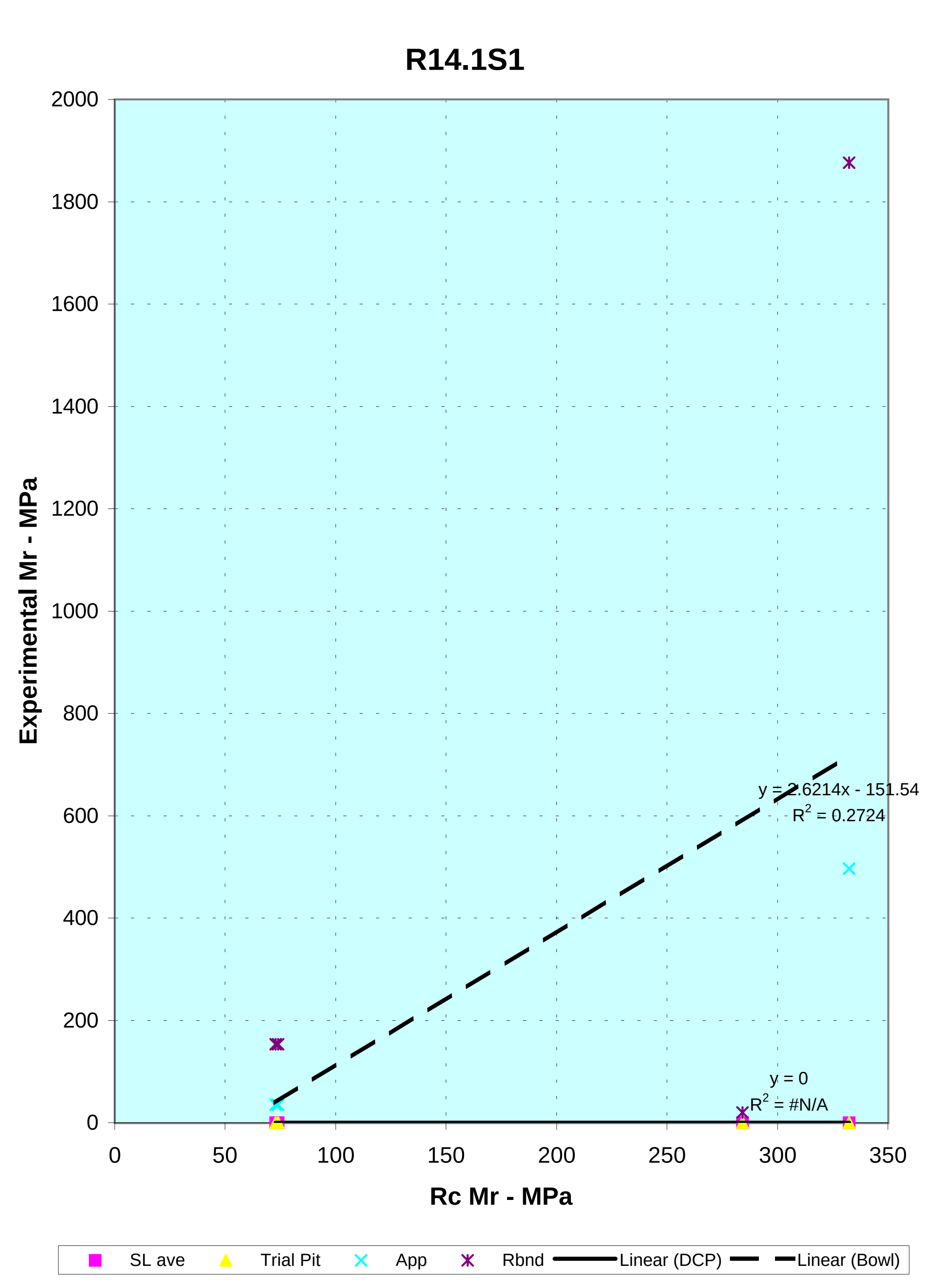
	Road No:	R13.2S5				Liwonde - Zomba					Soaked CBR %	
	Resilient Modulus (Mpa)					Soil Properties				Dry In Situ Density		
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI		%Comp	
		SL ave	Trial Pit	App	Rbnd						98	95
Base	93	403	437	138	482	Stab Laterite Gravel	17	27	15	-	64	53
Subbase	90	329	276	24	20	Clayey Sandy Gravel	21	26	14	-	-	-
SSG	110	242	145	171	66	Clayey Sand	-	0	-	-	-	-
SG	106	105	137	171	66							



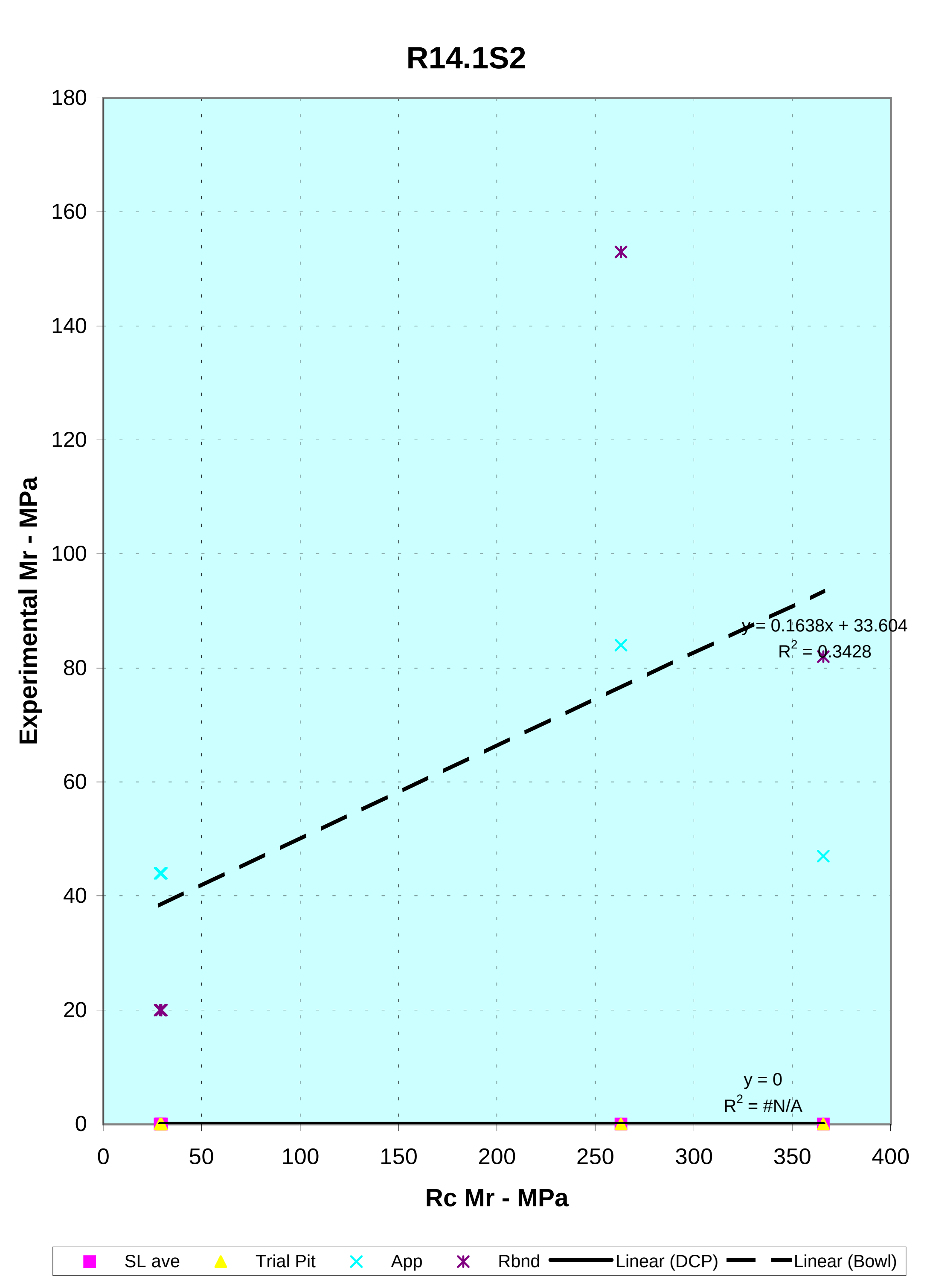
	Road No: R13.2S6			Liwonde - Zomba							Soaked CBR %	
	Resilient Modulus (Mpa)					Soil Properties				Dry In Situ Density		
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI		%Comp	
		SL ave	Trial Pit	App	Rbnd						98	95
Base	114	700	792	27	571	"As Dug" Laterite Gravel	22	37	20	-	16	12
Subbase	106	1126	262	741	284	Clayey Sandy Gravel	-	0	-	-	-	-
SSG	187	748	174	176	96	Clayey Sand	30	39	18	-	-	-
SG	177	99	143	176	96							



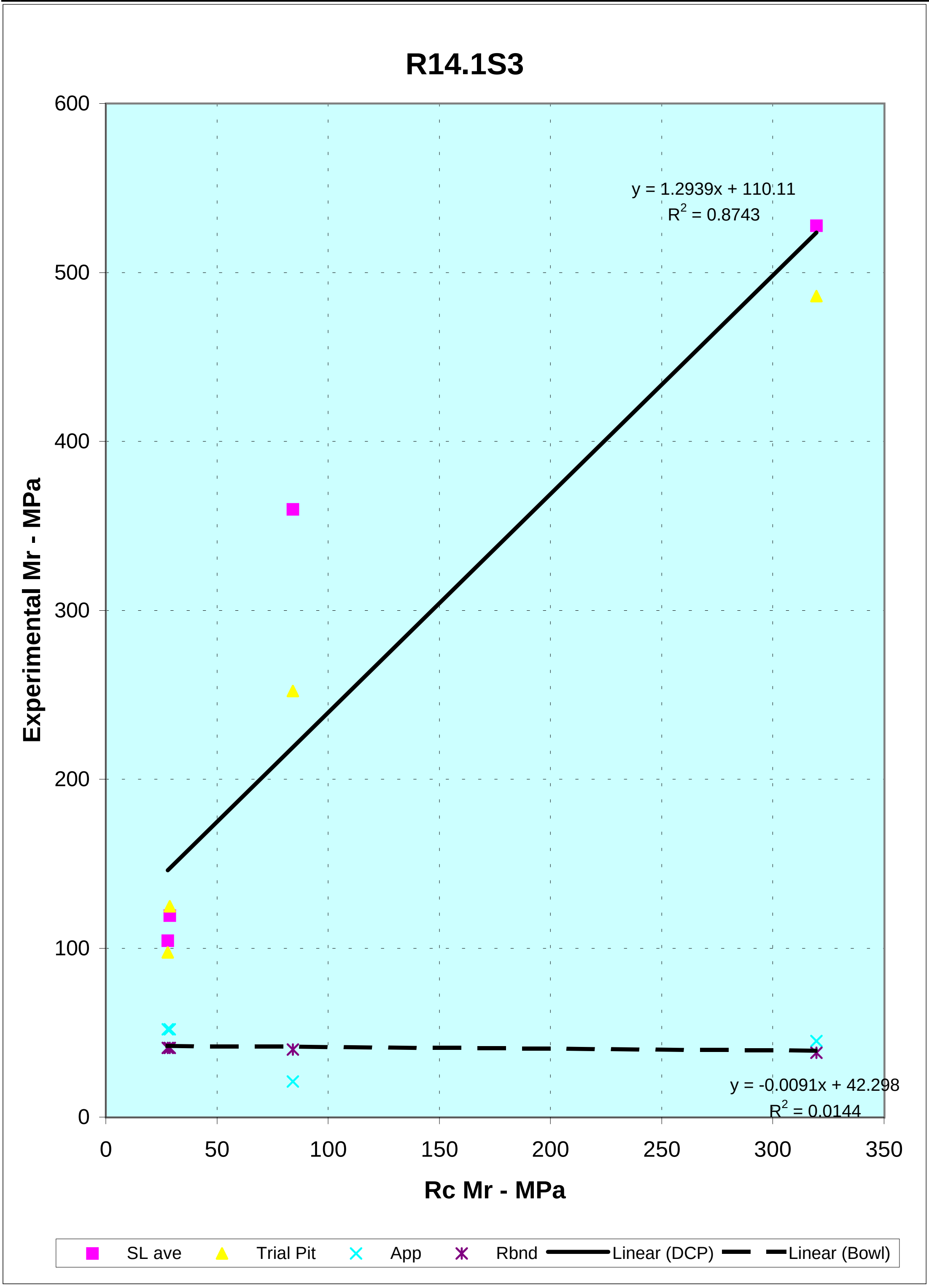
	Road No: R14.1S1					Liwonde - Mangochi					Soaked CBR %	
	Resilient Modulus (Mpa)					Soil Properties				Dry In Situ Density		
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI		%Comp	
		SL ave	Trial Pit	App	Rbnd						98	95
Base	332	0	0	497	1876	Crushed Stone	9	24	9	-	-	-
Subbase	284	0	0	20	20	Clayey Sandy Gravel	-	0	-	-	-	-
SSG	74	0	0	35	153	Gravelly Clay	24	35	18	-	-	-
SG	73	0	0	35	153							



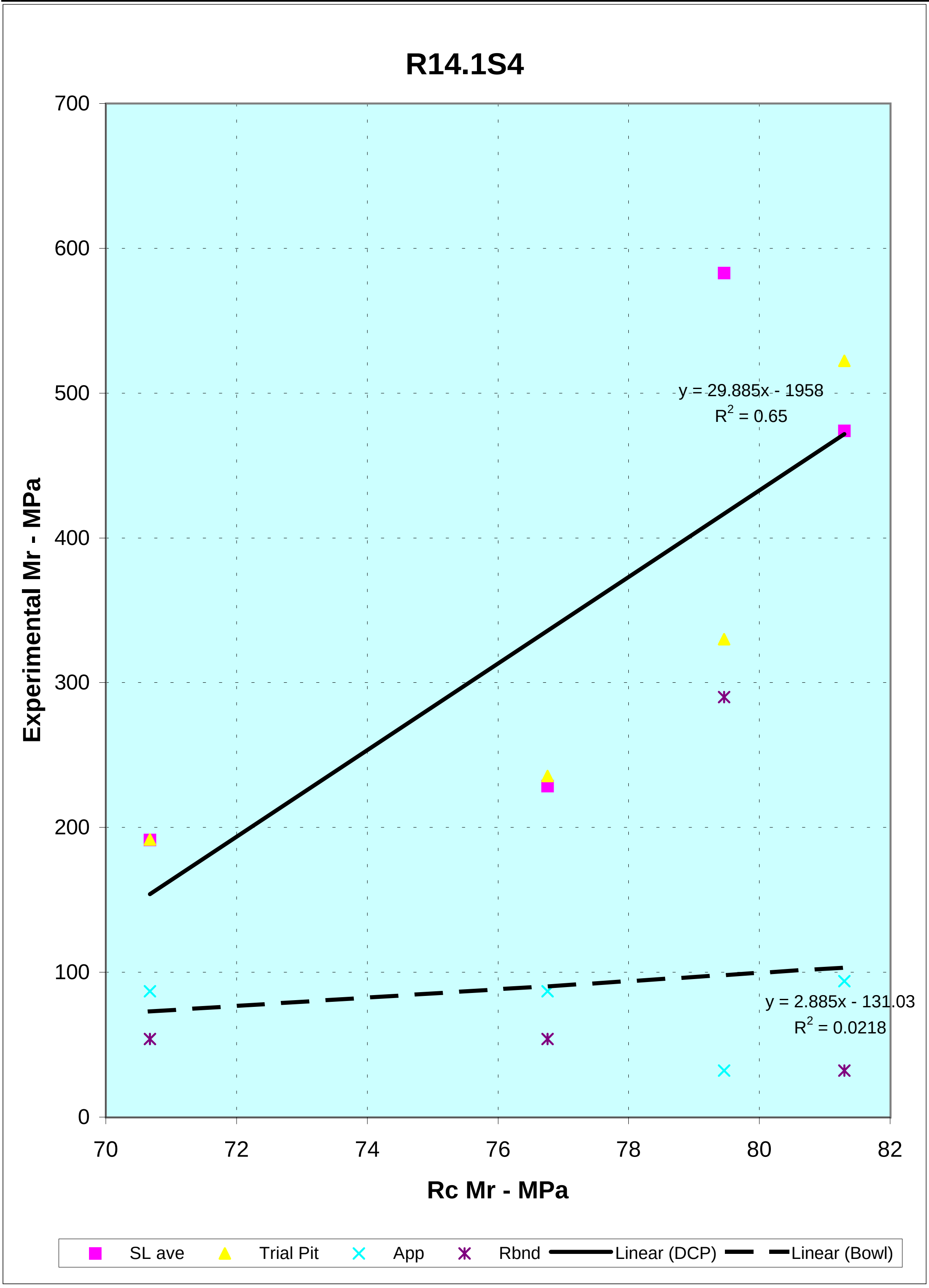
	Road No:	R14.1S2				Liwonde - Mangochi					Soaked CBR %	
	Resilient Modulus (Mpa)					Soil Properties				Dry In Situ Density		
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI		%Comp	
		SL ave	Trial Pit	App	Rbnd						98	95
Base	366	0	0	47	82	Crushed Stone	18	37	20	-	-	-
Subbase	263	0	0	84	153	Clayey Sandy Gravel	27	32	14	-	-	-
SSG	30	0	0	44	20	Clayey Sand	19	N	NP	-	-	-
SG	29	0	0	44	20							



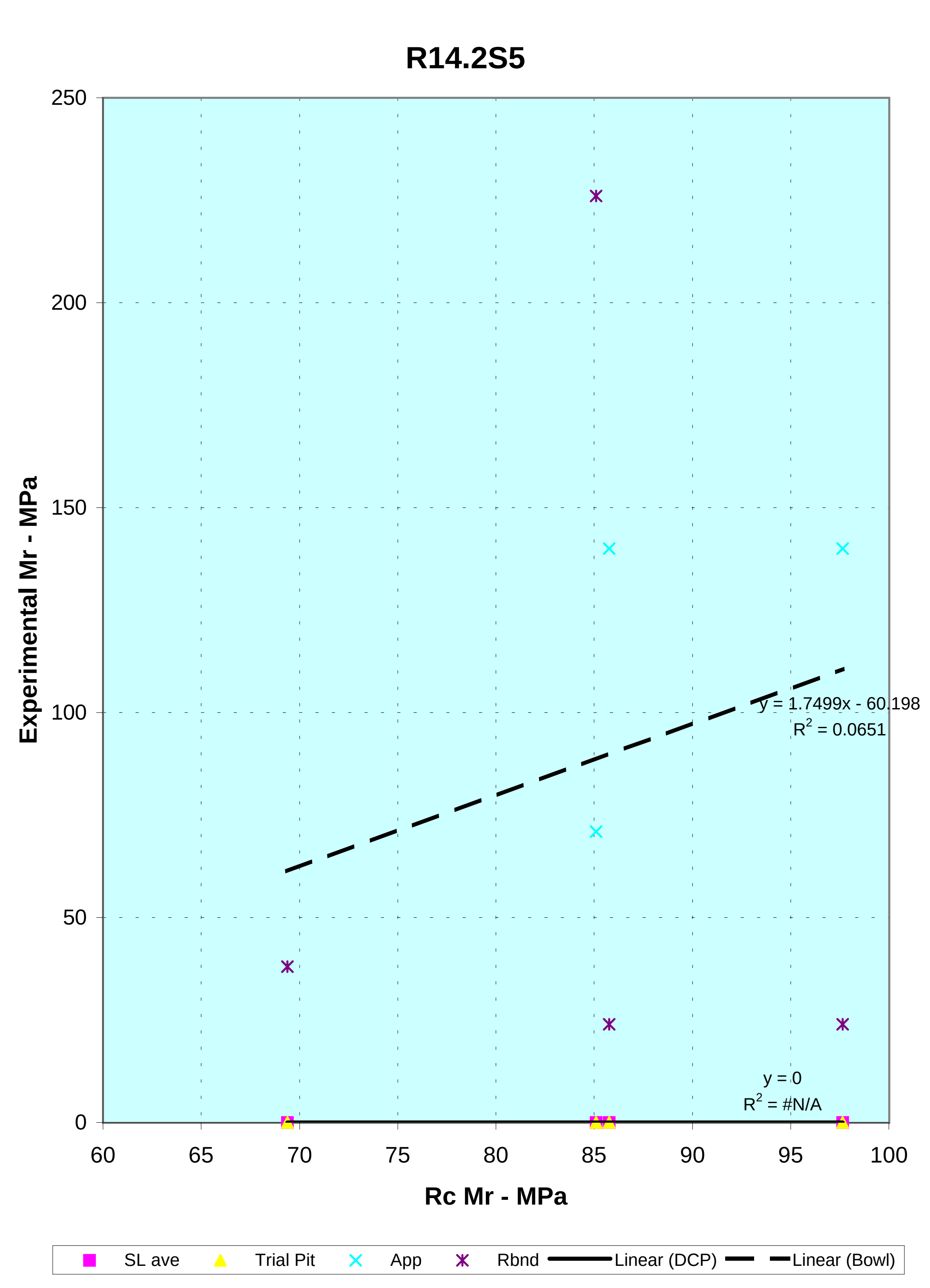
	Road No: R14.1S3					Liwonde - Mangochi					Soaked CBR %	
	Resilient Modulus (Mpa)					Soil Properties				Dry In Situ Density		
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI		%Comp	
		SL ave	Trial Pit	App	Rbnd						98	95
Base	320	528	486	45	38	Crushed Stone	9	36	17	-	7	-
Subbase	84	360	252	21	40	Sandy Gravel	30	35	16	-	-	-
SSG	29	119	125	52	41	Clayey Sand	21	41	20	-	-	-
SG	28	104	97	52	41							



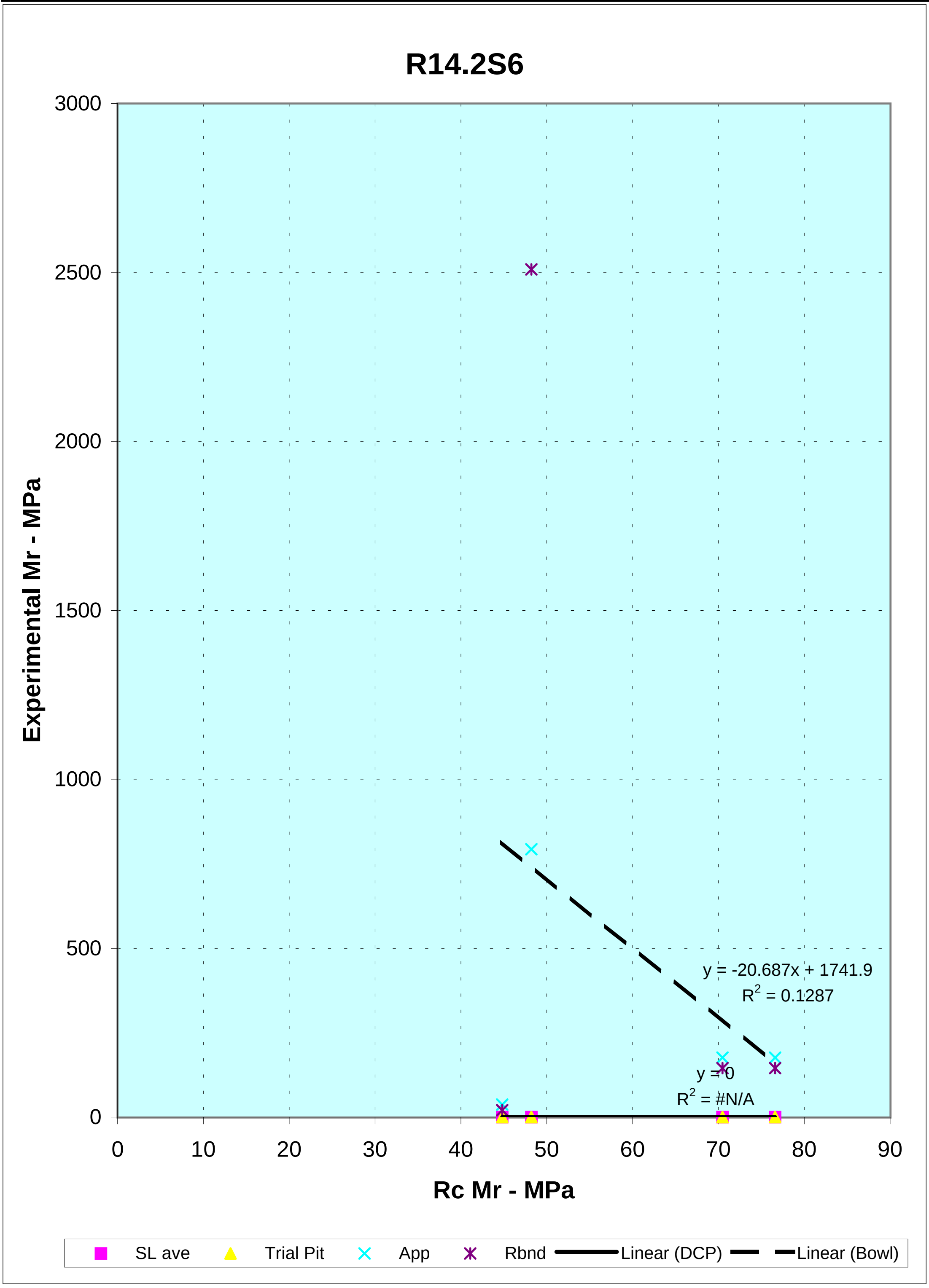
	Road No:	R14.1S4		Liwonde - Mangochi							
	Resilient Modulus (Mpa)				Soil Properties				Dry In Situ Density	Soaked CBR %	
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI		%Comp	
		SL ave	Trial Pit	App	Rbnd						98	95
Base	81	474	522	94	32	-	-	0	-	-	-	-
Subbase	79	583	330	32	290	Sandy Gravel	-	0	-	-	-	-
SSG	77	229	236	87	54	Sandy Clay	49	28	12	-	-	-
SG	71	191	192	87	54							



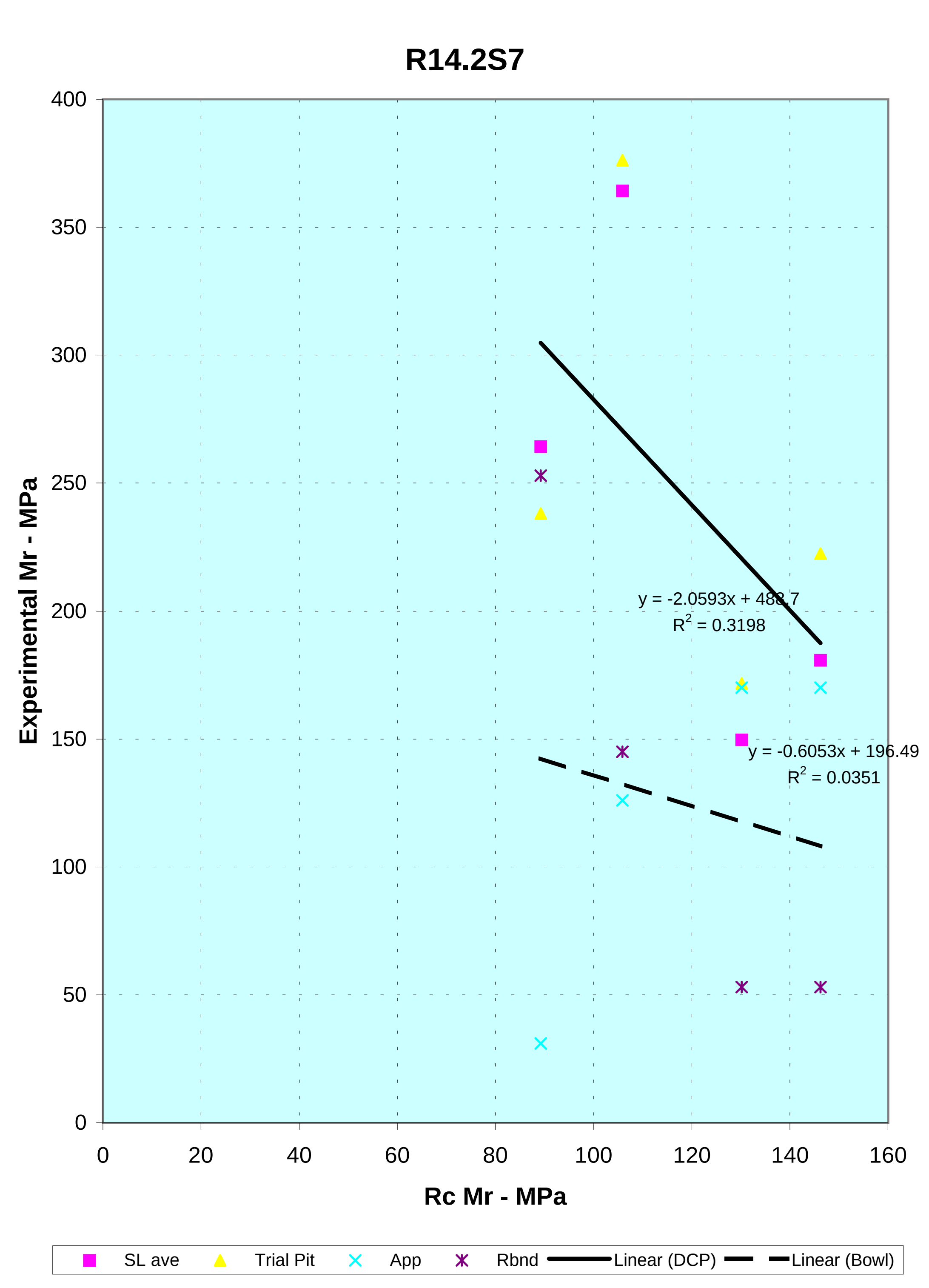
	Road No: R14.2S5					Mangochi - Monkey Bay						Soaked CBR %	
	Resilient Modulus (Mpa)					Soil Properties					Dry In Situ Density		
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI			%Comp	
		SL ave	Trial Pit	App	Rbnd							98	95
Base	85	0	0	71	226	Stab Sandy Gravel	14	N	NP		-	36	23
Subbase	69	0	0	38	38	Sandy Gravel	26	43	26		-	-	-
SSG	98	0	0	140	24	-	-	-	-		-	-	-
SG	86	0	0	140	24								



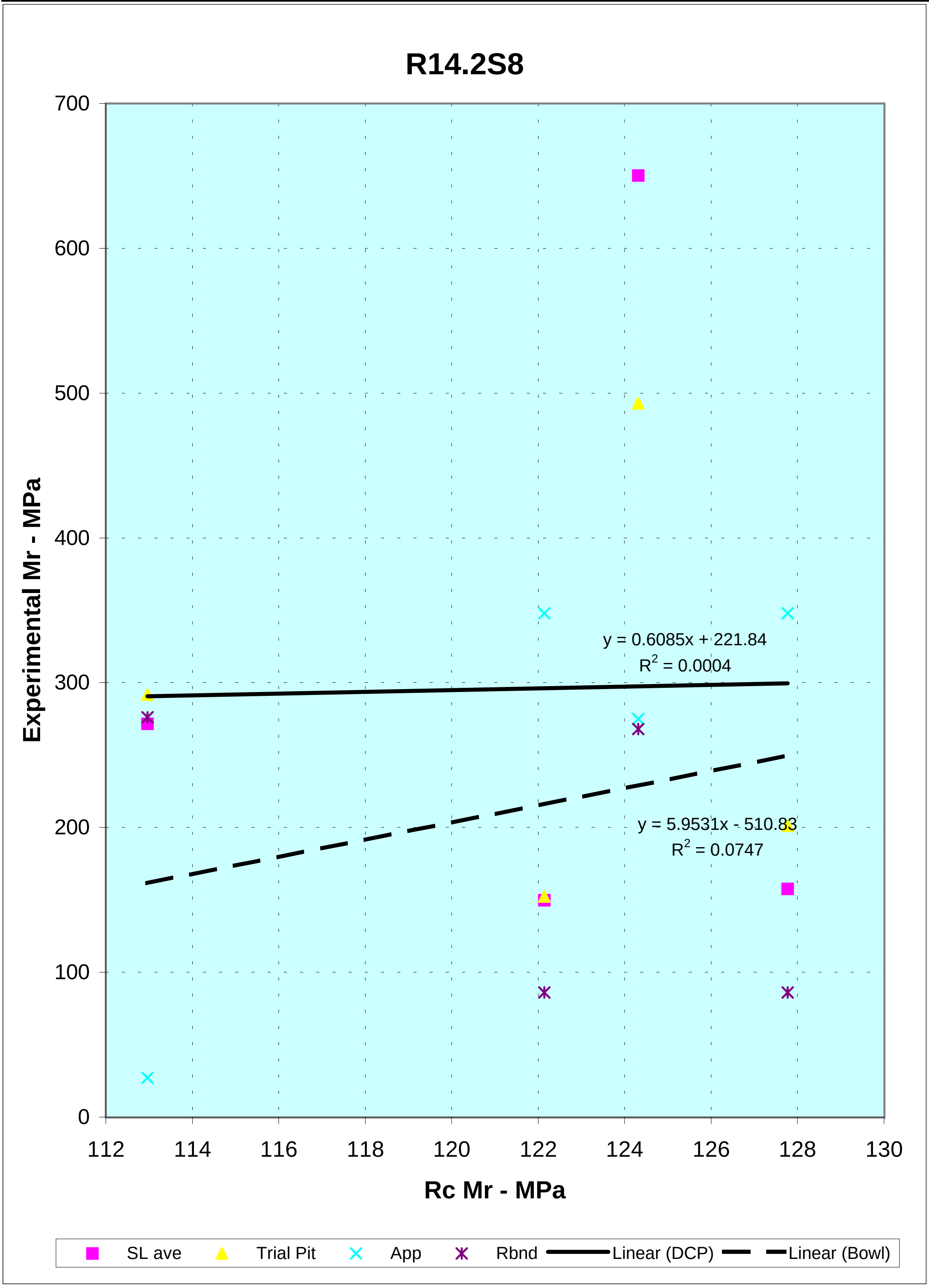
	Road No:	R14.2S6				Mangochi - Monkey Bay					Soaked CBR %	
	Resilient Modulus (Mpa)					Soil Properties				Dry In Situ Density		
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI		%Comp	
		SL ave	Trial Pit	App	Rbnd						98	95
Base	48	0	0	793	2509	Stab Sandy Gravel	23	33	17	-	-	-
Subbase	45	0	0	37	20	Sandy Gravel	23	47	30	-	-	-
SSG	77	0	0	176	145	-	-	-	-	-	-	-
SG	70	0	0	176	145							



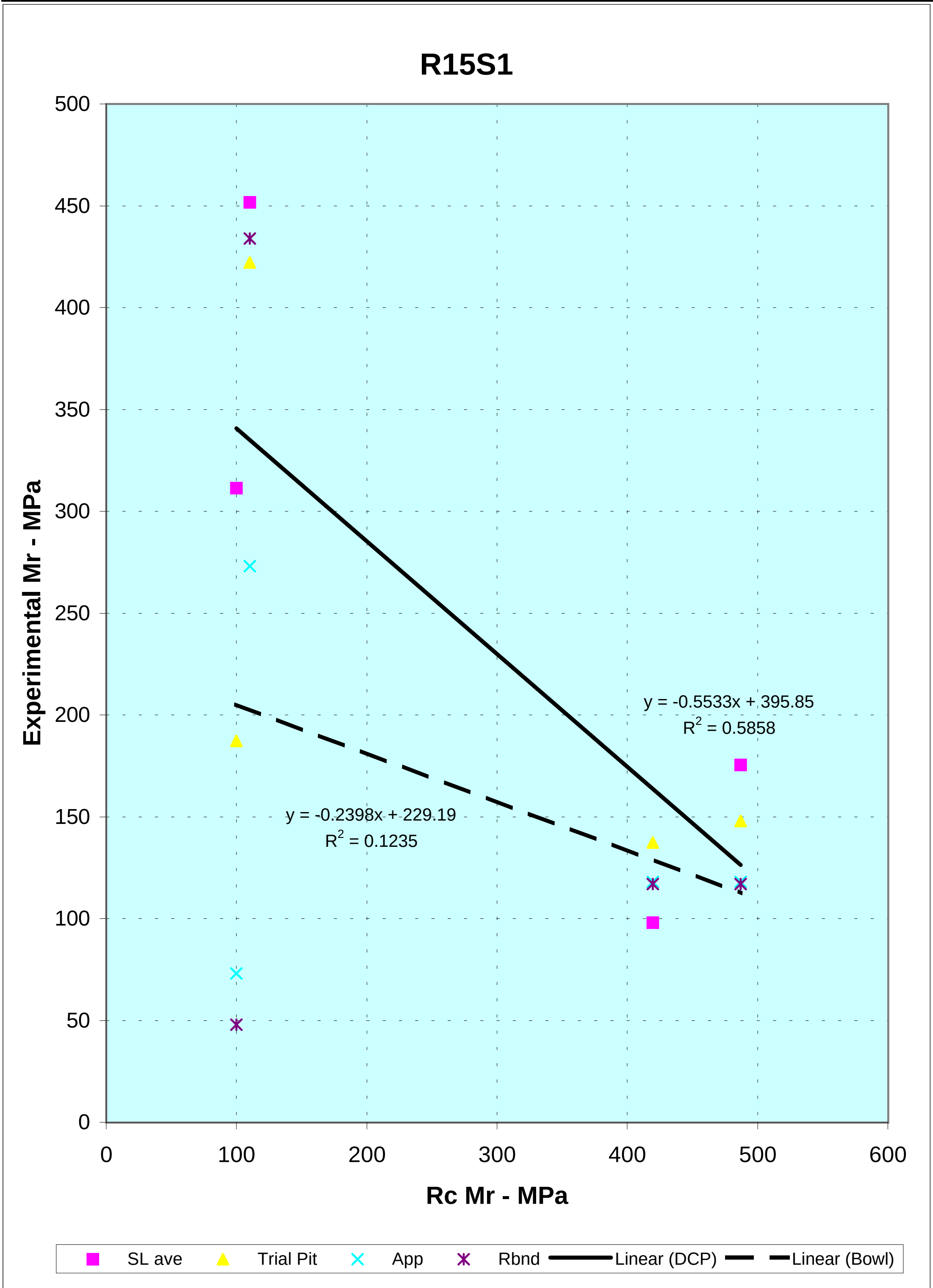
	Road No:	R14.2S7				Mangochi - Monkey Bay					Soaked CBR %	
	Resilient Modulus (Mpa)					Soil Properties				Dry In Situ Density		
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI		%Comp	
		SL ave	Trial Pit	App	Rbnd						98	95
Base	106	364	376	126	145	-	-	-	-	-	-	-
Subbase	89	264	238	31	253	Sandy Gravel	-	-	-	-	-	-
SSG	146	181	222	170	53	-	-	-	-	-	-	-
SG	130	150	172	170	53							



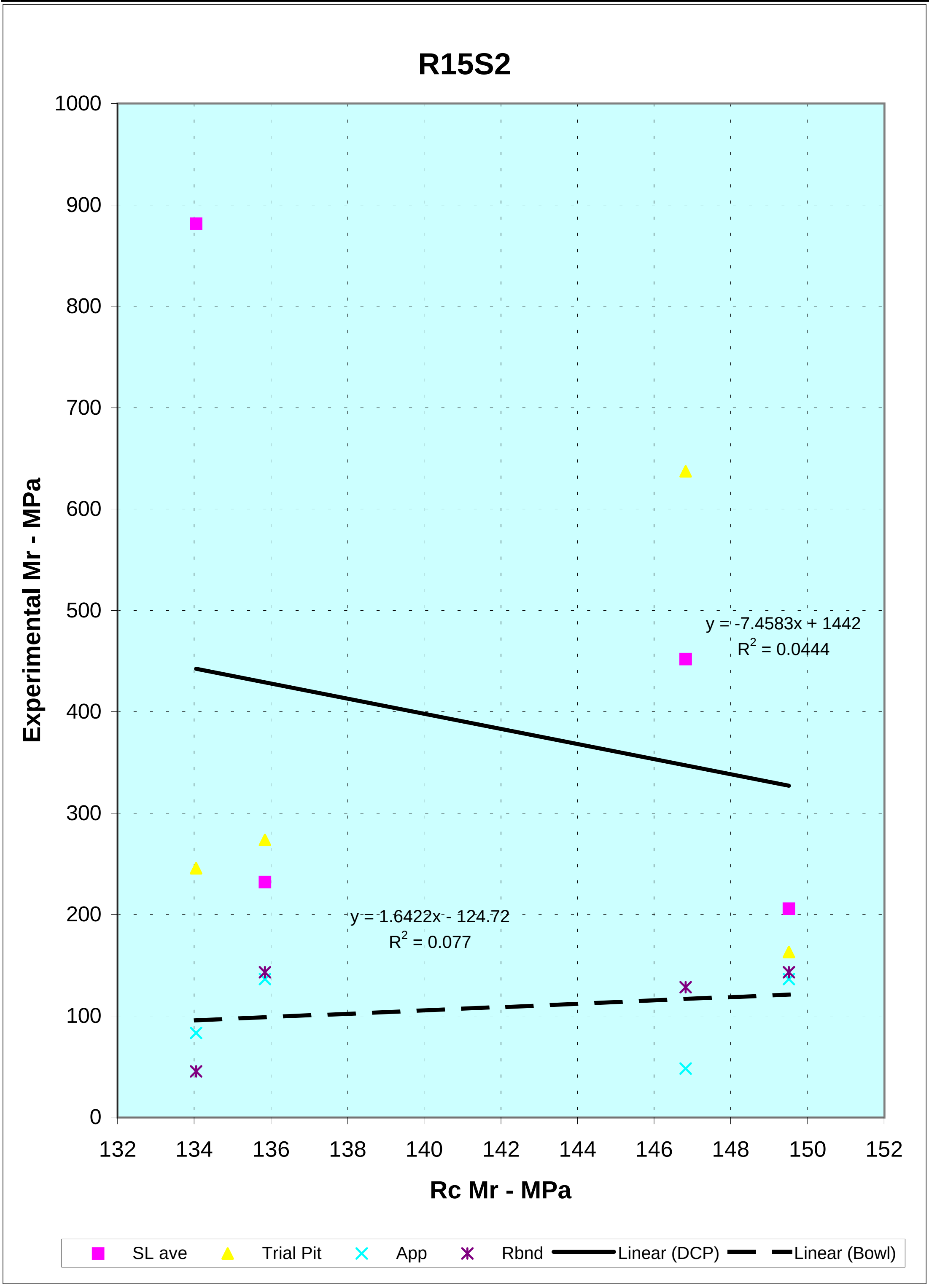
	Road No:	R14.2S8				Mangochi - Monkey Bay					Soaked CBR %	
	Resilient Modulus (Mpa)					Soil Properties				Dry In Situ Density		
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI		%Comp	
		SL ave	Trial Pit	App	Rbnd						98	95
Base	124	650	493	275	268	Stab Sandy Gravel	18	N	NP	-	40	25
Subbase	113	272	292	27	276	Clayey Sandy Gravel	29	26	13	-	-	-
SSG	128	158	201	348	86	Sandy Clay	35	30	14	-	-	-
SG	122	150	152	348	86							



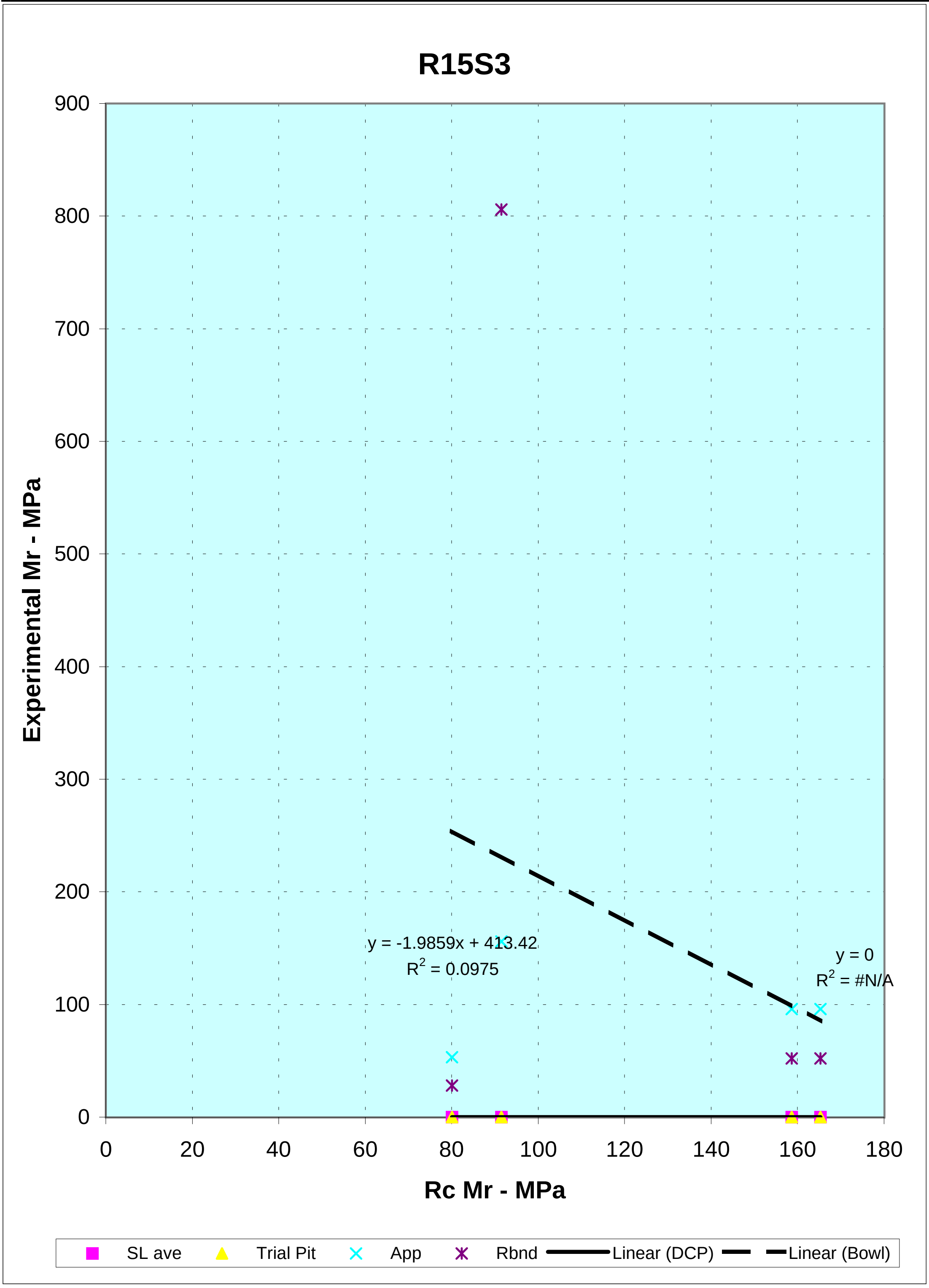
	Road No: R15S1					Zomba - Blantyre						Soaked CBR %	
	Resilient Modulus (Mpa)					Soil Properties				Dry In Situ Density			
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI			%Comp	
		SL ave	Trial Pit	App	Rbnd							98	95
Base	110	452	422	273	434	Crushed Stone Macadam	16	28	16	-		-	-
Subbase	100	311	187	73	48	-	-	-	-	-		-	-
SSG	487	175	148	118	117	Sandy Clay	32	27	14	-		-	-
SG	420	98	137	118	117								



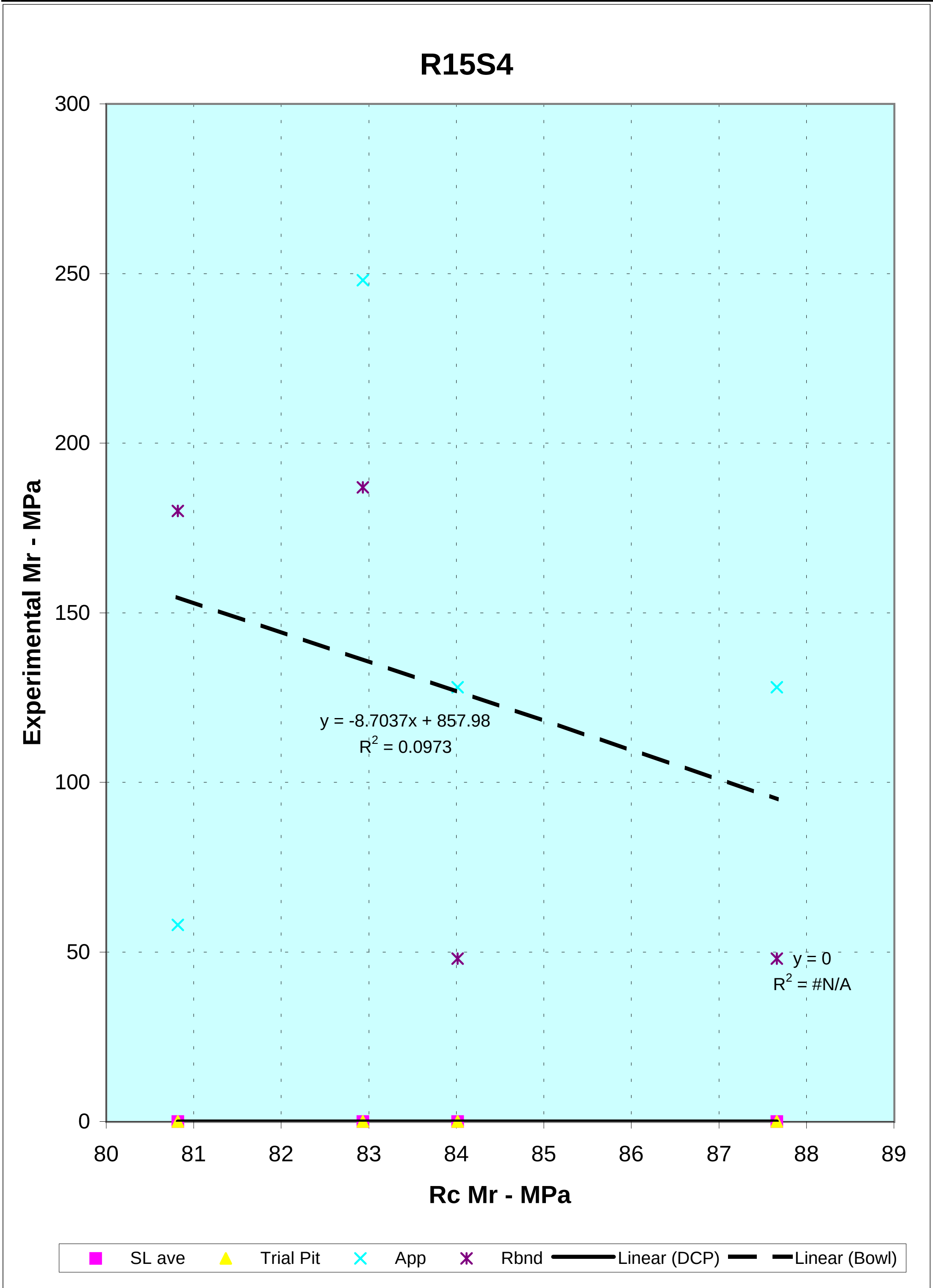
	Road No:	R15S2			Zomba - Blantyre					Soaked CBR %	
	Resilient Modulus (Mpa)				Soil Properties				Dry In Situ Density		
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI		%Comp	
		SL ave	Trial Pit	App	Rbnd						98	95
Base	147	452	637	48	128	-	-	-	-	-	-	-
Subbase	134	882	246	83	45	-	-	-	-	-	-	-
SSG	150	206	163	136	143	-	-	-	-	-	-	-
SG	136	232	273	136	143							



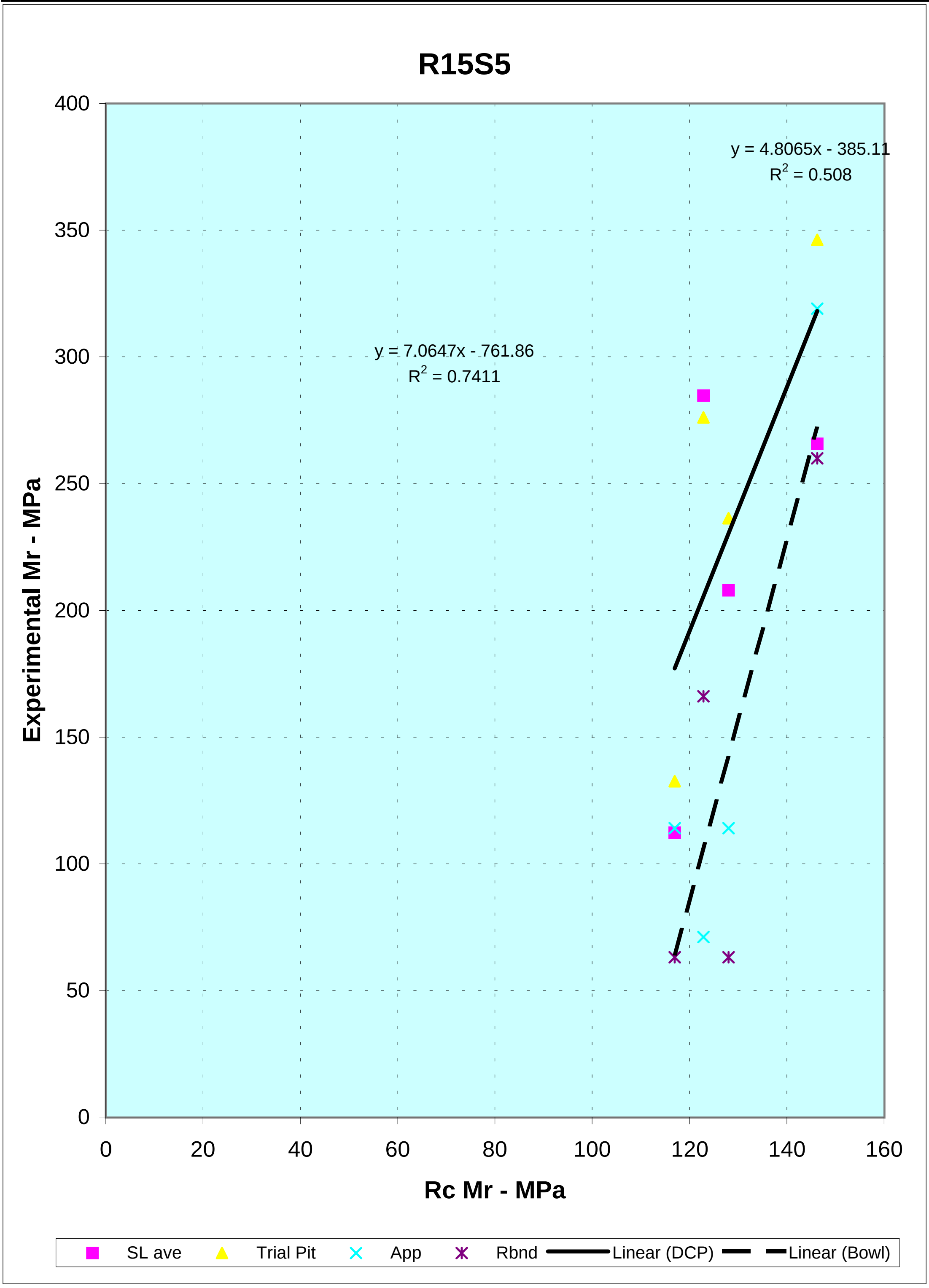
	Road No:	R15S3		Zomba - Blantyre								Soaked CBR %	
	Resilient Modulus (Mpa)					Soil Properties				Dry In Situ Density			
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI			%Comp	
		SL ave	Trial Pit	App	Rbnd							98	95
Base	92	0	0	156	806	-	-	-	-	-		-	-
Subbase	80	0	0	53	28	-	-	-	-	-		-	-
SSG	165	0	0	96	52	-	-	-	-	-		-	-
SG	159	0	0	96	52								



	Road No: R15S4					Zomba - Blantyre					Soaked CBR %	
	Resilient Modulus (Mpa)					Soil Properties				Dry In Situ Density	%Comp	
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI		98	95
		SL ave	Trial Pit	App	Rbnd							
Base	83	0	0	248	187	Crushed Stone Macadam	6	N	NP	-	-	-
Subbase	81	0	0	58	180	Clayey Sandy Gravel	22	24	11	-	-	-
SSG	88	0	0	128	48	Clayey Sand	11	N	NP	-	-	-
SG	84	0	0	128	48							



	Road No: R15S5					Zomba - Blantyre						
	Resilient Modulus (Mpa)					Soil Properties				Dry In Situ Density	Soaked CBR %	
	Rc	DCP		Deflection Bowl		Description	% 75um	LL	PI		%Comp	
		SL ave	Trial Pit	App	Rbnd						98	95
Base	146	266	346	319	260	Crushed Stone Macadam	6	N	NP	-	-	-
Subbase	123	285	276	71	166	Clayey Sandy Gravel	14	24	11	-	-	-
SSG	128	208	236	114	63	Clayey Sand	11	N	NP	-	-	-
SG	117	112	132	114	63							



Sample Length Code	DCP Layers CBR				Trial Pit DCP CBR				Convert CBR to mm/blow by using TRL Equation								Converts mm/blow (DCP) to Stiffness, based on TFT							
									DCP Layers CBR				Trial Pit DCP CBR				DCP Layers CBR				Trial Pit DCP CBR			
	Base	Subbase	SSG	SG	Base	Subbase	SSG	SG	Base	SB	SSG	SG	Base	SB	SSG	SG	Base	SB	SSG	SG	Base	SB	SSG	SG
R1S1	125	73	46	16	128	68	20	22	2.3	3.8	5.9	16.0	2.3	4.1	12.8	12.0	231.0	140.6	91.2	34.2	236.3	130.5	42.7	45.4
R1S2	143	76	29	9	138	69	21	12	2.0	3.7	9.0	28.1	2.1	4.0	12.7	20.5	262.7	146.2	60.1	19.6	254.0	133.3	43.1	26.8
R1S3	107	135	107	23	132	26	28	35	2.7	2.1	2.7	11.6	2.2	10.0	9.6	7.8	200.9	249.2	200.7	47.1	243.6	54.4	56.7	69.8
R2.1S1	210	83	30	17	198	38	40	21	1.4	3.4	8.8	14.9	1.5	7.2	6.8	12.6	375.3	158.5	62.0	36.8	355.4	75.3	79.4	43.1
R2.1S2	129	39	23	24	158	18	17	14	2.2	6.9	11.6	10.8	1.8	14.5	14.9	18.5	238.5	78.4	47.0	50.2	289.2	37.7	36.7	29.6
R2.1S3	208	39	17	12	207	36	20	15	1.4	7.0	14.9	20.7	1.4	7.4	12.9	16.6	373.0	77.1	36.8	26.5	371.4	73.2	42.2	32.9
R2.1S4	125	43	31	25	126	29	25	28	2.3	6.3	8.6	10.5	2.3	9.1	10.7	9.5	232.4	85.6	62.9	51.9	233.8	59.8	51.0	57.0
R2.2S1	205	71	45	36	166	51	41	35	1.4	3.9	6.0	7.4	1.8	5.4	6.6	7.6	368.5	137.2	90.1	72.7	301.9	100.2	81.6	71.3
R2.2S2	214	63	28	18	149	29	17	21	1.4	4.4	9.4	14.5	1.9	9.2	15.4	12.5	382.5	121.4	57.6	37.6	273.3	58.9	35.5	43.5
R2.2S3	192	86	27	21	209	75	49	23	1.5	3.3	9.7	12.7	1.4	3.7	5.6	11.2	345.2	164.0	56.3	43.1	374.9	143.5	96.8	48.6
R3S1	137	39	34	24	166	87	28	29	2.1	6.9	7.9	11.2	1.8	3.3	9.4	9.3	253.0	78.7	68.2	48.8	301.7	164.7	58.0	58.6
R3S2	258	28	20	15	169	47	27	21	1.2	9.4	13.3	17.4	1.7	5.8	9.9	12.2	456.0	57.7	41.0	31.5	307.8	93.6	55.0	44.6
R3S3	182	86	30	26	166	46	41	24	1.6	3.3	8.8	10.2	1.8	6.0	6.6	10.8	328.8	164.0	61.9	53.2	301.7	90.4	81.5	50.5
R3S4	186	65	27	29	170	46	31	28	1.6	4.3	9.9	9.2	1.7	6.0	8.6	9.6	336.6	126.1	54.7	58.8	309.1	90.4	63.1	56.7
R4S1	154	47	19	13	95	69	26	15	1.9	5.8	13.5	19.6	3.0	4.1	10.3	16.9	281.5	93.6	40.5	28.0	179.8	132.2	52.9	32.4
R4S2	287	56	22	13	246	103	67	18	1.0	4.9	11.8	20.0	1.2	2.8	4.2	14.2	503.9	109.4	46.2	27.4	436.7	193.1	129.5	38.6
R4S3	147	43	20	19	190	30	24	16	2.0	6.3	13.1	13.6	1.6	9.0	10.9	16.2	269.5	85.6	41.8	40.3	342.0	60.2	49.9	33.9
R5S1	160	57	22	36	171	63	27	34	1.8	4.8	11.8	7.5	1.7	4.4	10.0	7.9	291.0	111.7	46.2	72.2	310.2	122.3	54.6	68.8
R6S1	89	25	12	17	87	36	16	12	3.2	10.6	20.7	15.4	3.3	7.4	15.7	20.4	168.5	51.3	26.5	35.5	164.4	73.4	34.9	26.9
R6S2	109	72	63	331	114	70	60	45	2.6	3.9	4.4	0.9	2.5	4.0	4.6	6.1	203.2	139.1	123.1	574.6	212.9	134.9	116.9	89.2
R7S1	113	111	29	16	126	67	37	25	2.5	2.6	9.3	16.6	2.3	4.1	7.3	10.4	210.7	206.5	58.4	33.0	232.8	130.1	73.9	52.2
R7S2	97	41	44	24	105	65	33	31	2.9	6.6	6.2	10.8	2.7	4.3	8.2	8.6	183.3	81.9	87.2	50.3	197.4	125.6	65.9	63.1
R7S3	90	35	26	32	104	40	29	21	3.1	7.6	10.1	8.5	2.7	6.8	9.3	12.3	170.5	71.5	53.7	64.2	195.1	79.2	58.3	44.4
R8S1	127	29	22	29	89	42	26	26	2.3	9.2	12.0	9.2	3.2	6.4	10.1	10.1	235.4	58.9	45.3	58.8	168.2	83.9	53.9	53.6
R8S2	66	32	52	26	75	48	28	23	4.2	8.3	5.3	10.1	3.7	5.7	9.6	11.4	128.2	65.7	101.8	53.8	144.5	94.7	56.7	47.7
R9S1	203	325	45	11	268	73	22	13	1.5	0.9	6.1	23.8	1.1	3.8	11.7	19.4	363.8	565.2	89.0	23.1	472.1	141.1	46.4	28.3
R9S2	249	356	195	159	315	57	38	24	1.2	0.9	1.5	1.8	1.0	4.9	7.1	10.9	441.3	616.0	351.0	290.7	549.5	110.7	76.6	49.9
R9S3	265	399	475	64	474	125	28	33	1.1	0.8	0.7	4.3	0.7	2.3	9.4	8.0	467.9	684.1	805.5	124.3	803.6	232.3	58.0	67.7
R10S1	183	99	56	20	195	62	60	27	1.6	2.9	5.0	12.7	1.5	4.5	4.6	9.7	330.4	186.2	108.7	42.8	350.5	120.7	116.3	56.0
R10S2	406	405	111	13	287	201	43	23	0.8	0.8	2.6	19.8	1.0	1.5	6.4	11.5	695.8	694.0	207.8	27.7	503.9	361.8	84.7	47.5
R10S3	258	366	663	22	329	198	79	39	1.2	0.8	0.5	11.7	0.9	1.5	3.6	6.9	455.8	631.1	1099.9	46.4	571.2	355.5	150.7	78.7
R11S1	142	98	28	15	147	104	46	19	2.0	2.9	9.4	17.4	2.0	2.8	5.9	13.8	260.5	184.2	58.0	31.4	269.0	194.3	90.8	39.7
R11S2	124	427	168	22	119	93	84	53	2.3	0.7	1.7	11.8	2.4	3.1	3.3	5.2	230.0	730.3	305.2	46.3	220.4	175.1	160.3	104.0
R12.1S1	209	377	43	87	283	129	65	43	1.4	0.8	6.3	3.2	1.1	2.2	4.3	6.3	373.8	649.7	86.2	165.1	497.7	238.2	125.8	85.5
R12.1S2	232	173	38	55	216	69	50	41	1.3	1.7	7.1	5.0	1.4	4.1	5.5	6.6	412.3	313.5	76.6	107.2	385.8	132.2	98.8	82.5
R12.2S3	308	131	81	16	292	58	44	25	1.0	2.2	3.5	16.3	1.0	4.8	6.2	10.7	537.9	241.5	154.0	33.6	512.3	112.4	87.6	50.9

Sample Length Code	DCP Layers CBR				Trial Pit DCP CBR				Convert CBR to mm/blow by using TRL Equation								Converts mm/blow (DCP) to Stiffness, based on TFT							
									DCP Layers CBR				Trial Pit DCP CBR				DCP Layers CBR				Trial Pit DCP CBR			
	Base	Subbase	SSG	SG	Base	Subbase	SSG	SG	Base	SB	SSG	SG	Base	SB	SSG	SG	Base	SB	SSG	SG	Base	SB	SSG	SG
R12.2S4	383	293	253	11	264	101	32	23	0.8	1.0	1.2	23.6	1.1	2.8	8.3	11.3	659.0	512.7	447.3	23.3	465.4	189.0	65.6	48.1
R13S1	142	47	23	12	240	45	34	21	2.0	5.9	11.4	21.8	1.2	6.0	7.9	12.4	260.6	92.3	47.7	25.2	425.9	89.6	68.9	44.0
R13.1S2	174	315	29	28	164	72	46	22	1.7	1.0	9.3	9.6	1.8	3.9	5.9	11.7	314.9	550.0	58.3	56.7	298.9	137.9	91.6	46.5
R13.1S3	104	358	78	405	107	118	86	41	2.7	0.9	3.6	0.8	2.7	2.4	3.3	6.6	195.4	619.6	148.3	695.1	200.6	220.4	162.6	81.7
R13.2S4	70	283	50	34	124	87	51	39	4.0	1.1	5.5	7.9	2.3	3.3	5.3	7.0	135.3	497.0	98.7	68.6	229.8	164.5	100.9	77.3
R13.2S5	141	102	63	17	160	78	29	26	2.1	2.8	4.4	15.1	1.8	3.6	9.3	10.1	259.0	192.5	122.7	36.3	291.0	148.6	58.3	53.7
R13.2S6	1348	700	370	16	404	72	38	28	0.2	0.5	0.8	16.5	0.8	3.9	7.1	9.5	2135.1	1158.1	637.7	33.2	693.7	137.7	76.0	57.2
R14.1S3	214	118	21	17	188	68	23	15	1.4	2.4	12.4	15.2	1.6	4.1	11.6	16.8	383.3	219.3	43.8	36.1	339.9	130.6	46.8	32.6
R14.1S4	181	250	58	44	211	103	61	44	1.6	1.2	4.8	6.2	1.4	2.8	4.6	6.2	327.6	443.2	113.1	87.3	377.7	193.3	118.1	87.5
R14.2S7	120	73	40	30	126	62	56	37	2.4	3.8	6.7	8.9	2.3	4.5	5.0	7.3	223.2	139.7	80.3	61.0	233.9	120.1	108.7	74.5
R14.2S8	297	76	32	30	193	85	48	31	1.0	3.7	8.3	8.9	1.5	3.3	5.8	8.7	520.1	145.5	65.7	61.1	347.2	161.4	93.9	62.5
R15S1	168	94	38	15	151	42	29	26	1.7	3.0	7.0	16.7	1.9	6.4	9.1	10.1	305.6	177.5	76.9	32.9	276.8	84.5	59.9	53.7
R15S2	168	478	49	59	288	65	34	77	1.7	0.6	5.6	4.7	1.0	4.3	7.9	3.7	305.6	810.6	96.9	115.6	504.7	125.6	68.9	146.8
R15S5	73	82	50	19	111	78	61	25	3.8	3.4	5.5	13.6	2.6	3.6	4.5	10.7	140.8	155.9	98.5	40.1	207.3	149.0	118.7	51.0
R34S1	288	38	73	16	181	41	26	18	1.0	7.0	3.9	16.4	1.6	6.6	10.2	14.1	504.5	77.1	139.5	33.4	326.8	82.0	53.4	38.8
R36S1	229	18	14	15	220	23	16	15	1.3	14.4	18.0	17.6	1.3	11.4	16.3	16.9	407.5	38.0	30.5	31.2	392.8	47.9	33.6	32.4
R38S1	170	41	15	16	153	27	14	21	1.7	6.6	17.3	16.6	1.9	9.8	17.8	12.6	308.6	82.1	31.7	33.0	279.5	55.2	30.7	43.2
R44S1	51	63	54	25	62	56	63	31	5.4	4.4	5.1	10.7	4.4	5.0	4.4	8.6	100.5	122.8	105.1	50.9	121.2	108.7	122.0	63.3
R45S1	251	143	33	32	226	44	41	33	1.2	2.0	8.0	8.3	1.3	6.2	6.5	8.2	443.6	263.5	67.7	65.6	403.3	87.2	82.6	66.3
Average	200	149	74	40	185	68	39	27	1.5	1.9	3.8	6.8	1.6	4.1	7.0	9.7	359.7	273.3	142.1	79.0	334.3	130.9	77.3	56.3

Sample Length Code	Converts a mm/blow (STD TIP) to a small flat tip reading								Converts a mm/blow (flat tip) to a Stiffness Reading bsed on Imads								Converts a CBR to a Stiffness Reading bsed on TRL 17x^0.64							
	DCP Layers CBR				Trial Pit DCP CBR				DCP Layers CBR				Trial Pit DCP CBR				DCP Layers CBR				Trial Pit DCP CBR			
	Base	SB	SSG	SG	Base	SB	SSG	SG	Base	SB	SSG	SG	Base	SB	SSG	SG	Base	SB	SSG	SG	Base	SB	SSG	SG
R1S1	7.5	8.5	10.0	16.9	7.4	8.7	14.7	14.1	25.8	23.9	21.8	16.0	25.9	23.6	17.4	17.8	372.9	265.4	197.2	100.6	752.1	605.0	500.3	325.2
R1S2	7.3	8.4	12.1	25.2	7.3	8.7	14.6	20.0	26.2	24.1	19.5	12.7	26.1	23.7	17.5	14.5	407.3	272.6	148.2	68.9	795.8	615.4	416.7	255.1
R1S3	7.7	7.4	7.7	13.9	7.4	12.8	12.5	11.2	25.3	26.0	25.3	18.0	26.0	18.9	19.1	20.3	338.9	392.8	338.6	125.4	707.5	777.5	707.1	374.3
R2.1S1	6.9	8.2	11.9	16.1	6.9	10.8	10.6	14.6	27.1	24.4	19.6	16.5	27.0	20.8	21.1	17.5	520.1	288.1	151.3	105.9	930.5	637.6	422.3	336.0
R2.1S2	7.4	10.6	13.9	13.3	7.1	15.9	16.2	18.6	25.9	21.0	18.0	18.4	26.5	16.6	16.5	15.2	381.1	177.8	125.2	131.1	762.7	468.1	374.0	385.2
R2.1S3	6.9	10.7	16.1	20.2	6.9	11.0	14.8	17.3	27.1	20.9	16.5	14.5	27.1	20.6	17.3	15.8	517.9	175.9	105.8	84.5	928.0	464.9	335.9	290.8
R2.1S4	7.5	10.2	11.8	13.1	7.5	12.1	13.2	12.5	25.8	21.5	19.7	18.6	25.8	19.4	18.5	19.1	374.5	188.9	152.9	134.0	754.1	486.6	425.1	390.7
R2.2S1	6.9	8.6	10.0	11.0	7.1	9.6	10.4	11.1	27.1	23.8	21.7	20.6	26.6	22.3	21.2	20.5	513.6	260.9	195.6	168.9	923.1	598.4	497.7	453.1
R2.2S2	6.8	8.9	12.4	15.9	7.2	12.2	16.5	14.5	27.2	23.2	19.2	16.6	26.3	19.4	16.3	17.5	526.9	239.9	144.0	107.5	938.3	567.2	409.1	339.3
R2.2S3	6.9	8.1	12.5	14.6	6.9	8.5	9.7	13.6	26.9	24.5	19.1	17.5	27.1	24.0	22.1	18.2	491.1	294.9	141.7	118.1	897.0	647.1	404.9	360.2
R3S1	7.3	10.6	11.4	13.6	7.1	8.1	12.3	12.3	26.1	21.0	20.2	18.2	26.6	24.6	19.3	19.3	396.9	178.3	161.7	128.4	782.7	468.9	440.6	380.2
R3S2	6.7	12.4	15.1	17.9	7.1	9.9	12.7	14.3	27.5	19.2	17.1	15.5	26.6	21.9	18.9	17.7	594.3	144.2	114.0	95.1	1013.5	409.4	352.3	313.7
R3S3	7.0	8.1	11.9	12.9	7.1	10.0	10.5	13.3	26.8	24.5	19.6	18.7	26.6	21.8	21.2	18.4	475.0	294.8	151.2	136.3	878.1	647.1	422.0	395.0
R3S4	7.0	8.8	12.7	12.2	7.1	10.0	11.8	12.5	26.9	23.4	18.9	19.3	26.6	21.8	19.8	19.1	482.7	246.3	138.9	146.0	887.1	576.7	399.7	412.7
R4S1	7.2	9.9	15.2	19.4	7.9	8.7	13.0	17.5	26.4	21.9	17.1	14.8	24.9	23.6	18.7	15.7	427.0	200.7	113.2	87.9	820.2	506.0	350.6	298.2
R4S2	6.6	9.3	14.0	19.7	6.7	7.8	8.7	15.6	27.7	22.7	17.9	14.7	27.4	25.2	23.5	16.8	636.5	223.4	123.8	86.5	1058.9	541.9	371.3	295.2
R4S3	7.2	10.2	14.9	15.2	7.0	12.1	13.4	17.0	26.3	21.5	17.3	17.0	26.9	19.5	18.4	16.0	414.4	188.8	115.5	112.7	804.7	486.6	355.2	349.6
R5S1	7.1	9.2	14.0	11.1	7.1	8.9	12.7	11.3	26.5	22.8	17.9	20.5	26.6	23.3	18.9	20.3	436.9	226.6	123.8	168.0	832.3	546.8	371.3	451.5
R6S1	8.1	13.2	20.2	16.5	8.1	11.0	16.7	20.0	24.7	18.5	14.5	16.3	24.6	20.6	16.2	14.6	300.4	133.0	84.6	103.4	654.9	388.9	291.0	330.8
R6S2	7.7	8.5	8.9	6.5	7.6	8.6	9.1	10.1	25.3	23.9	23.3	27.9	25.5	23.7	23.1	21.7	341.5	263.3	242.2	696.3	710.9	602.0	570.6	1121.6
R7S1	7.6	7.7	12.3	17.3	7.5	8.7	10.9	13.1	25.5	25.4	19.3	15.8	25.8	23.6	20.7	18.6	350.1	345.4	145.3	98.2	722.3	716.1	411.4	320.3
R7S2	7.9	10.4	10.2	13.3	7.7	8.8	11.6	11.8	25.0	21.2	21.6	18.4	25.2	23.4	20.0	19.8	318.2	183.2	191.2	131.2	679.5	477.2	490.5	385.5
R7S3	8.0	11.1	12.9	11.7	7.8	10.6	12.3	14.3	24.7	20.5	18.8	19.9	25.2	21.0	19.3	17.6	302.9	166.9	137.3	155.0	658.4	449.6	396.7	428.9
R8S1	7.4	12.2	14.2	12.2	8.1	10.3	12.8	12.9	25.8	19.3	17.8	19.3	24.6	21.4	18.8	18.8	377.8	146.1	122.2	146.1	758.4	412.9	368.2	412.8
R8S2	8.8	11.6	9.5	12.9	8.4	9.8	12.5	13.7	23.5	20.0	22.4	18.8	24.0	22.0	19.1	18.1	249.0	157.5	212.7	137.3	580.8	433.3	525.1	396.8
R9S1	6.9	6.5	10.1	22.3	6.7	8.5	14.0	19.2	27.0	27.9	21.7	13.6	27.6	23.9	17.9	14.9	509.1	688.5	194.0	76.9	917.9	1113.6	495.0	273.8
R9S2	6.7	6.5	6.9	7.1	6.5	9.2	10.8	13.4	27.5	28.0	27.0	26.5	27.9	22.8	20.9	18.3	581.1	730.3	496.7	436.6	999.1	1156.4	903.6	831.9
R9S3	6.7	6.4	6.3	8.9	6.3	7.5	12.3	11.4	27.6	28.2	28.4	23.3	28.4	25.8	19.3	20.2	604.9	784.8	877.7	243.9	1025.0	1210.8	1300.8	573.1
R10S1	7.0	7.9	9.3	14.7	6.9	9.0	9.1	12.6	26.8	25.0	22.7	17.4	27.0	23.2	23.0	19.1	476.5	321.7	222.4	117.5	879.9	684.2	540.4	359.1
R10S2	6.4	6.4	7.7	19.5	6.6	6.9	10.3	13.8	28.2	28.2	25.4	14.7	27.7	27.0	21.4	18.1	794.0	792.5	346.9	87.1	1219.9	1218.4	718.1	296.6
R10S3	6.7	6.5	6.2	14.0	6.5	6.9	8.3	10.6	27.5	28.1	28.7	17.9	27.9	27.0	24.2	21.0	594.1	742.5	1086.6	124.1	1013.3	1168.7	1491.2	372.0
R11S1	7.3	7.9	12.3	17.9	7.2	7.8	10.0	15.4	26.2	25.0	19.3	15.5	26.3	25.2	21.8	16.9	404.9	319.4	144.6	95.1	792.8	681.1	410.1	313.6
R11S2	7.5	6.4	7.1	14.0	7.6	8.0	8.2	9.5	25.8	28.3	26.6	17.9	25.6	24.8	24.5	22.5	371.8	820.7	451.4	124.0	750.6	1246.0	849.9	371.7
R12.1S1	6.9	6.4	10.2	8.1	6.6	7.4	8.8	10.2	27.1	28.1	21.5	24.6	27.7	25.9	23.4	21.5	518.6	757.5	189.7	296.2	928.9	1183.8	488.0	649.1
R12.1S2	6.8	7.1	10.8	9.3	6.8	8.7	9.6	10.4	27.3	26.7	20.9	22.6	27.2	23.6	22.2	21.3	554.6	459.7	175.0	220.4	969.6	859.9	463.5	537.2
R12.2S3	6.6	7.4	8.3	17.1	6.6	9.2	10.1	13.3	27.8	25.9	24.3	15.9	27.7	22.9	21.6	18.5	665.5	384.4	282.4	99.4	1089.6	766.9	629.5	322.8

Sample Length Code	Converts a mm/blow (STD TIP) to a small flat tip reading								Converts a mm/blow (flat tip) to a Stiffness Reading bsed on Imads								Converts a CBR to a Stiffness Reading bsed on TRL 17x^0.64							
	DCP Layers CBR				Trial Pit DCP CBR				DCP Layers CBR				Trial Pit DCP CBR				DCP Layers CBR				Trial Pit DCP CBR			
	Base	SB	SSG	SG	Base	SB	SSG	SG	Base	SB	SSG	SG	Base	SB	SSG	SG	Base	SB	SSG	SG	Base	SB	SSG	SG
R12.2S4	6.4	6.6	6.7	22.2	6.7	7.8	11.6	13.7	28.1	27.7	27.5	13.7	27.6	25.1	20.0	18.1	764.9	644.1	586.5	77.3	1191.1	1067.0	1004.9	274.8
R13S1	7.3	9.9	13.8	20.9	6.7	10.0	11.3	14.4	26.2	21.9	18.1	14.2	27.4	21.7	20.3	17.6	405.0	198.8	126.5	81.6	792.9	502.9	376.5	284.4
R13.1S2	7.0	6.5	12.3	12.5	7.1	8.6	9.9	14.0	26.7	27.9	19.3	19.1	26.5	23.8	21.8	17.9	461.1	675.8	145.2	142.4	861.6	1100.3	411.2	406.1
R13.1S3	7.8	6.5	8.4	6.4	7.7	7.6	8.2	10.4	25.2	28.0	24.1	28.2	25.3	25.6	24.5	21.2	332.5	733.3	275.2	793.3	698.8	1159.3	619.2	1219.3
R13.2S4	8.6	6.6	9.7	11.3	7.5	8.1	9.6	10.7	23.7	27.7	22.2	20.2	25.8	24.6	22.3	20.9	258.4	630.4	208.2	162.2	594.8	1052.5	517.9	441.5
R13.2S5	7.3	7.8	8.9	16.3	7.1	8.4	12.3	12.9	26.1	25.2	23.3	16.4	26.5	24.1	19.3	18.8	403.3	329.1	241.7	104.8	790.8	694.2	569.9	333.9
R13.2S6	6.0	6.2	6.5	17.3	6.4	8.6	10.8	12.4	29.2	28.8	28.1	15.8	28.2	23.8	20.8	19.2	1711.9	1125.7	747.9	98.6	1125.4	1525.3	1174.1	321.0
R14.1S3	6.8	7.6	14.5	16.3	7.0	8.7	13.9	17.5	27.2	25.6	17.6	16.4	26.9	23.6	18.0	15.7	527.7	359.9	119.4	104.4	939.2	735.2	362.8	333.1
R14.1S4	7.0	6.7	9.2	10.1	6.8	7.8	9.0	10.1	26.8	27.5	22.9	21.6	27.1	25.2	23.1	21.6	473.8	582.8	228.6	191.4	876.7	1000.9	549.9	490.8
R14.2S7	7.5	8.5	10.5	12.0	7.5	9.0	9.3	10.9	25.7	23.9	21.1	19.6	25.8	23.2	22.7	20.7	364.2	264.2	180.8	149.7	740.8	603.2	473.2	419.3
R14.2S8	6.6	8.4	11.6	12.0	6.9	8.2	9.8	11.9	27.8	24.0	20.0	19.6	26.9	24.5	22.0	19.7	650.4	271.6	157.6	149.9	1073.7	614.0	433.4	419.7
R15S1	7.1	8.0	10.7	17.4	7.2	10.3	12.1	12.9	26.6	24.9	20.9	15.8	26.3	21.4	19.5	18.8	451.8	311.4	175.5	98.0	850.4	670.1	464.2	319.7
R15S2	7.1	6.3	9.7	9.1	6.6	8.8	11.3	8.4	26.6	28.4	22.1	23.0	27.7	23.4	20.3	24.1	451.7	881.5	205.6	232.1	850.3	1304.4	513.8	555.2
R15S5	8.5	8.3	9.7	15.3	7.7	8.4	9.0	13.2	23.9	24.3	22.2	17.0	25.4	24.1	23.1	18.5	265.7	284.8	208.0	112.3	605.4	632.9	517.6	348.8
R34S1	6.6	10.7	8.5	17.2	7.0	10.4	12.9	15.6	27.7	20.9	23.9	15.9	26.8	21.2	18.8	16.8	636.9	175.8	264.0	99.1	1059.4	464.9	602.9	322.0
R36S1	6.8	15.8	18.3	18.0	6.8	13.7	17.1	17.5	27.3	16.7	15.3	15.5	27.2	18.1	15.9	15.7	550.2	108.2	93.1	94.6	964.7	340.7	309.5	312.6
R38S1	7.1	10.4	17.8	17.3	7.2	12.7	18.2	14.6	26.6	21.2	15.6	15.8	26.4	19.0	15.4	17.5	454.8	183.6	95.6	98.3	854.0	477.9	314.8	320.4
R44S1	9.6	8.9	9.4	13.3	8.9	9.3	8.9	11.8	22.3	23.3	22.5	18.5	23.2	22.7	23.3	19.8	210.8	241.8	217.4	132.2	522.1	570.0	532.5	387.3
R45S1	6.7	7.3	11.4	11.6	6.8	10.2	10.4	11.5	27.5	26.2	20.2	20.0	27.3	21.6	21.3	20.0	583.2	408.1	160.8	157.4	1001.3	796.8	438.9	433.0
Average	6.9	7.2	8.5	10.6	7.0	8.7	10.7	12.5	27.0	26.3	23.9	21.0	26.8	23.6	20.9	19.1	505.1	418.5	267.3	178.8	810.6	711.7	520.1	402.8