Confidential Technical Report: TR-2002/22

September 2002

Confidential Report: TR-2002/22

HVS operations: Protocol for instrumentation, data collection and data storage - 2nd Draft

Authors: D Jones and B Morton

PREPARED BY:

CSIR Transportek
PO Box 395
PRETORIA
0001
Tel: +27 12 841-2905
Fax+27 12 841-3232

<table>
<tr><td colspan="4">DOCUMENT RETRIEVAL PAGE</td><td>Report No: TR-2002/22</td></tr>
<tr><td colspan="5">Title: Heavy Vehicle Simulator operations: protocol for instrumentation, data collection and data storage - 2nd Draft</td></tr>
<tr><td colspan="5">Authors: D Jones and B Morton</td></tr>
<tr><td>Client:
Transportek</td><td>Client Reference No:
TR-2002/22</td><td colspan="2">Date:
September 2002</td><td>Distribution:
Confidential</td></tr>
<tr><td>Project No: TIK01</td><td colspan="3">OE2: Infrastructure Engineering</td><td>ISBN:</td></tr>
</table>

Abstract:

Heavy Vehicle Simulator (HVS) operations have been performed by the CSIR for the past 25 years. During this period, experience has been gained with regards to the collection and storage of pavement behaviour data from accelerated pavement testing. Current norms relating to quality management of processes and products necessitate the consolidation of these processes into a protocol for future HVS projects. This document deals with four key aspects of HVS operations:

- Staffing of HVS operations
- Site location and establishment
- Data collection
- Data processing, analysis and storage

The instrumentation used is discussed under the relevant sections.

Keywords:
Accelerated pavement testing (APT), Heavy Vehicle Simulator (HVS)

Proposals for implementation:
Follow protocol in all future HVS testing. Update as required.

Related documents:
Protocol for establishment and operation of LTPP sections (CR-2003/11). HVS Manual.

Signatures:

P Paige-Green	C Fisher	B Verhaeghe		P Hendricks
Language Editor	**Technical Review**	**Prog Manager**	**Info Centre**	**Director**

TABLE OF CONTENTS

1. INTRODUCTION 1
1.1. Background 1
1.2. Accelerated Pavement Testing 1
1.3. Key Activities 2
1.4. Instrumentation 2
2. MANAGEMENT AND RESPONSIBILITIES 4
2.1. Introduction 4
2.2. Staffing 4
2.3. Database Management 8
3. SITE SELECTION AND ESTABLISHMENT 9
3.1. Site Selection 9
3.2. Test Section Selection 9
3.3. Section Numbering 10
3.4. Section Layout and Marking 10
3.5. Site Establishment 11
3.6. Instrument Installation 12
4. DATA COLLECTION AND STORAGE 16
4.1. Introduction 16
4.2. Test Specification 16
4.3. Data Collection 17
4.4. Visual Assessment 17
4.5. Transverse Profile (electronic) and Deflection 18
4.6. Transverse Profile (manual) 19
4.7. Deflection 20
4.8. Permanent Deformation 21
4.9. Density and Moisture Content 21
4.10. HVS Service 22
4.11. HVS Operations 22
4.12. Post Trafficking Assessment 23
4.13. Data Storage and Validation 24
4.14. Reporting 24
5. REFERENCES 27
APPENDIX A: INSTRUMENTATION 29
A.1 HVS Laser Profilometer 29
A.2 Road Surface Deflectometer (RSD) 30
A.3 Multi-Depth Deflectometer (MDD) 31

A.4 Temperature Buttons 34
A.5 Thermocouples 35
A.6 Dual Probe Hydro-density Meter 37
A.7 Crack Activity Meter 37
APPENDIX B: REPORTING FORMS 40

1. INTRODUCTION

1.1. Background

Over the last 25 years of Heavy Vehicle Simulator (HVS) testing, a number of technological advances have been made with respect to pavement behaviour measurements. Specialised instrumentation has been developed specifically to capture pavement behaviour data from HVS trafficking. With the current emphasis on quality management, the need for a protocol for the consolidation of all activities relating to the collection and storage of data from HVS testing was identified. This consolidation and subsequent further development and updating of the protocol is critical to the provision of a high quality service to CSIR clients.

This document forms part of a generic template for HVS operations on future projects conducted by CSIR, Transporteks Infrastructure Engineering Programme. HVS testing of pavements is not a set process since experimental designs vary between projects with respect to pavement type tested, duration of testing, environment, test objectives, instrumentation layout and the trafficking plan. However, in most instances the experiments are carried out following specific programmes developed over the past 25 years, thereby ensuring effective performance, productivity, quality of HVS operations and comparability of results.

This document provides a protocol for the establishment and assessment of HVS test sections and has been developed to provide consistency in all future HVS testing. The protocol discusses staffing, site selection and establishment, and data collection, analysis and storage.

1.2. Accelerated Pavement Testing

Accelerated Pavement Testing (APT) can be described as a controlled application of wheel loading to a pavement structure for the purposes of simulating long-term, in-service loading conditions. Factors critical to this simulation of in-service pavement conditions are that the loading configuration and method of loading be comparable with that encountered by in-service pavements.

In South Africa, most APT is performed using the Heavy Vehicle Simulator (HVS). Pavement response and behaviour of each test section is monitored using a suite of instrumentation, and various non-destructive, partially destructive, and destructive pavement performance monitoring methods.

1.3. Key Activities

The HVS testing operations can be divided into a number of activities that form an integral part of the entire accelerated pavement testing operation. These activities relate to both the physical operation of the HVS and to the activities necessary to obtain value addition from the testing process. HVS operations can be divided into six key activities:

- Site selection and establishment
- Instrumentation and calibration
- HVS operations and maintenance
- Data collection
- Post trafficking investigations
- Data analysis, data storage and documentation

These activities, except machine operation and maintenance, are discussed in more detail in the following chapters. HVS operations and maintenance are discussed in the HVS Mk IV+ Users Manual[1].

1.4. Instrumentation

Instrumentation and behaviour measurement methods provide the capability to record the behaviour of a pavement structure under accelerated pavement testing. Unique instrumentation has been developed in conjunction with the HVS for the measurement of this behaviour. It should be noted that specific test programmes allow for the exclusion of field instrumentation and in certain instances the inclusion of specialised instrumentation, in order to provide behaviour data suitable to achieve the given objectives of the test programme. During HVS testing, the following performance/behaviour measurements are taken:

- In pavement
    - Permanent deformation (multi-depth deflectometer (MDD))
    - Pavement temperature (thermocouples and temperature buttons)
    - Density (dual probe strata guage)

- Surface
    - Deflection (road surface deflectometer (RSD))
    - Transverse profile (Laser Profilometer and straight edge)
    - Visual inspection (Crack Activity Meter may be used to monitor crack movement)

The loads applied to the pavement and the tyre pressures of the wheels are also constantly monitored.

Details on the equipment, installation and calibration are provided in Appendix A.

2. MANAGEMENT AND RESPONSIBILITIES

2.1. Introduction

HVS testing is relatively expensive and closely monitored by many individuals from numerous organisations, both locally and internationally. A team of suitably qualified and experienced personnel is therefore required to manage and operate the programme in close liaison with the client funding the study. Roles and responsibilities need to be clearly defined and monitored by means of appropriate job descriptions, key-result areas and performance evaluation.

2.2. Staffing

The staffing of an HVS testing programme should be made up as follows. Certain functions may be carried out by the same person (eg the HVS Technician may also be the Database Manager):

- Client
- Project Director
- Project manager - analysis
- Project manager - operations
- Database manager
- Project engineer
- HVS operator and crew
- HVS technicians and assistants

An organisation chart is shown in Figure 2.1.

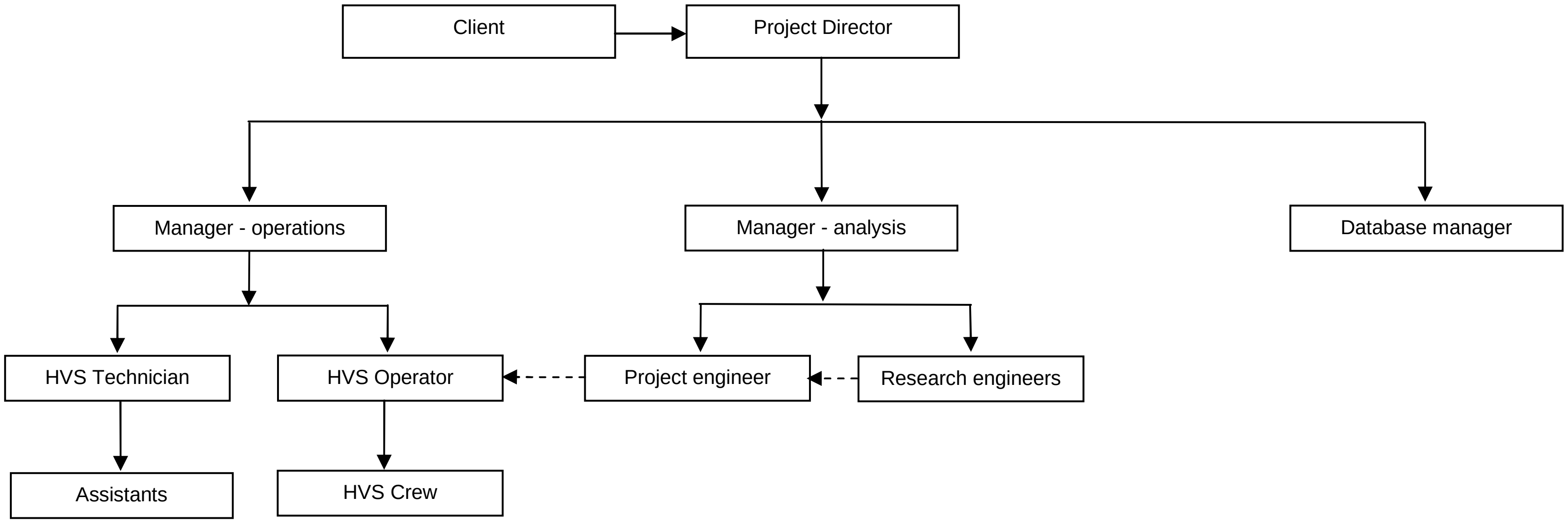

Figure 2.1: HVS staff organisation chart

2.2.1 Client

The client should appoint a project manager to liaise with the CSIR Project Director. This will be the formal link between the CSIR and the client. The client will also liaise with the operations and analysis project managers.

2.2.2 Project Director

The HVS Project Director has overall responsibility for the HVS programme. These responsibilities include:

- Liaison with the client
- Overall programme management and accountability
- Quality management of outputs
- Industry liaison, coordination feedback and implementation

2.2.3 Project Manager - Analysis

The Project Manager - analysis has overall responsibility for research activities associated with HVS testing. He/she reports to the Project Director and should have the following responsibilities for which he/she should be held accountable:

- Liaison with the client on research activities
- Liaison with the Project Manager - operations
- Liaison with HVS Steering Committee
- Development and update of the HVS strategic research plan
- Preparation of project experiment designs project specifications
- Quality management of research outputs
- Site selection and layout

2.2.4 Project Manager - Operations

The Project Manager - Operations has overall responsibility for machine operation. He/she reports to the Project Director and should have the following responsibilities for which he/she should be held accountable:

- Liaison with the client on machine and instrumentation operations
- Liaison with the Project Manager - analysis
- Overall machine management
- Site establishment, instrumentation and demobilisation
- Delegation of authority to the HVS operator
- Training and calibration of HVS Operator and crew and HVS Technician and assistants
- Overall site, environmental, health and safety management for the HVS operation

- Overall responsibility for instrumentation and data acquisition

2.2.5 Database Manager

The Database Manager should report to the Project Director and should have the following responsibilities for which he/she should be held accountable:

- Timeous and accurate capture of data into the database
- Database maintenance
- Facilitating report printing and distribution in suitable formats
- Ensuring long-term availability and accessibility of all records in the database

2.2.6 Project Engineer

The Project Engineer should report to the Project Manager - analysis and should have the following responsibilities for which he/she should be held accountable:

- Test section layout
- Overseeing instrument installation and calibration
- Management of laboratory testing and control sample storage
- Liaison with the Project Manager - Operations and HVS Operator to ensure that the testing plan is being adhered to and that data is being submitted
- Liaison with the Database Manager to ensure that data is useable and in the correct format
- Data validation, first level analysis of results and reporting

2.2.7 HVS Operator

The HVS Operator should report to the Project Manager - operations and should have the following responsibilities for which he/she should be held accountable:

- Daily operation of the HVS, including maintenance and trafficking
- Liaison with the Project Engineer regarding the testing programme
- Measurements and data acquisition
- Weather records
- Training of the HVS crew
- Site, environmental, health and safety management
- Traffic accommodation and safety

2.2.8 HVS Crew

The HVS Crew should report to the HVS Operator and assist with machine operation and maintenance, site management, measurements and data capture duties as required.

2.2.9 HVS Technician

The HVS Technician should report to the Project Manager - operations and should have the following responsibilities for which he/she should be held accountable:

- Instrument installation and calibration
- Assistance with data collection, data processing and first level analysis
- Training of assistants

2.2.10 Technicians Assistants

The Technicians Assistants should report to the HVS Technician and assist with instrument installation and calibration, data collection, data processing and other duties as required.

2.3. Database Management

The quantity of data typically collected on an HVS project, combined with the rapid developments in the Information Technology arena, necessitate conscientious and regular attention to the entire database to ensure that it is always accessible using current hardware and software. Considerable useful information on various road projects collected in the past has been lost or become unusable due to poor or erratic database management. The database must be comprehensively backed up regularly and these backups must always be upgraded when new hardware and software is installed.

The HVS and proposed LTPP databases[2] should be separate but compatible in order that the results from both systems can be directly compared or analysed together.

In order to facilitate the use of the information in the databases by authorised individuals, Internet access should be considered as part of the database development.

3. SITE SELECTION AND ESTABLISHMENT

3.1. Site Selection

Sites are selected according to the HVS testing strategy, derived from the long-term goals of the HVS testing programme, which is reviewed on a periodic basis in line with road authority requirements.

Sites are selected by the following team:

- Client
- Project Manager - analysis
- Project Manager - operations
- Project Engineer.

Site selection should be based on traffic accommodation requirements, structural characteristics of the pavements and overall suitability and safety of the site. The inclusion of associated long-term pavement performance (LTPP) sections should also be considered.

3.2. Test Section Selection

Actual test sections are selected within the proposed site by the Project Engineer, assisted by the HVS technician and HVS Operator, and in consultation with the Project Manager - analysis. The following procedure should be adhered to:

The procedure for site selection will be project specific and is based on pavement deflection measurements (determined with the RSD, and if required by the client, also with a Falling Weight Deflectometer (FWD)), as-built data and the structural characteristics of the specific test sections. Dynamic Cone Penetrometer (DCP) testing (not in the test section) may also be used to assess the shear strength of the pavement materials and to obtain an indication of pavement layer thickness. These thickness measurements are used to validate as-built data or core measurements for the positioning of the MDD modules.

3.3. Section Numbering

Each HVS section should be assigned a unique number for management purposes. No formalised numbering system is in place for HVS sections in South Africa. A centralised list should therefore be initiated, using the following format:

Type of experiment:	HVS
Section number:	Consecutive numbers in order of section adoption
Year:	Year of construction or commencement of monitoring
Province:	Province in which the section is located
Road number:	Provincial road numbering system
Example:	HVS-25a/02-G-P243/8 (Subsection a of the 25th HVS experiment, tested in 2002 in Gauteng on Road number P243/8)

The chainage and direction of survey (positive or negative) should be linked to the section number in the database.

3.4. Section Layout and Marking

Labelling and marking of the test sections should be the responsibility of the Project Engineer and HVS Technician. Once selected the HVS test section should be labelled, marked and instrumented as shown in Figure 3.1. The marking of the test section, with white road marking paint, includes:

- The outer extremity of the 8.0 x 1.0 m test section (width may be variable depending on the test requirements)
- Test section centreline
- Panel numbers at 500 mm intervals (points 0 - 16)
- MDD hole marks
- RSD measurement marks
- Thermocouple marks

Labelling will be in accordance with the naming system used in the HVS database.

3.5. Site Establishment

3.5.1 General

Site establishment and traffic accommodation should be the responsibility of the Project Manager - operations and the HVS Operator. Traffic accommodation should be managed as shown in Figures 3.2 and 3.3, in accordance with the Traffic Act as well as Provincial and local regulations. In order to maintain a safe working environment, a lane closure must be provided either in the form of chevron delineators (low traffic volumes) or preferably concrete barriers along the entire length of the HVS test site. (Figures 3.2 and 3.3):

Site establishment entails positioning trailers and equipment on site in appropriate positions with respect to the test section under investigation (Figure 3.3.). Hardstands may be required if the ground is soft. Direct line of sight of the entire test carriage is required from the HVS site office during trafficking of the test section.

3.5.2 Occupational Health and Safety

The CSIR is required to adhere to all relevant sections of the Occupational Health and Safety Act, Act No 85 of 1993. The HVS site is included. Compliance with the Act is audited both internally and by an independent external assessor, which may include an assessment of the HVS site.

The CSIR is currently implementing the OSHAS 18000 safety standard system, which is an internationally recognised safety standard, compatible with ISO-9000 and ISO-14000 systems.

Guidance on compliance with all relevant requirements of the Act and other systems should be obtained from the Transportek Safety Officer.

3.5.3 Environment

The CSIR and all working sites are subject to an annual environmental audit to assess compliance with the ISO14000 certification. Guidance on compliance with all relevant requirements should be obtained from the Transportek Environmental Officer. Special care will be required for ablution facilities, the storage and handling fuel and oils and the disposal of waste.

3.6. Instrument Installation

Instrument installation should be carried out by the HVS Technician and assistants and is overseen by the Project Engineer. Details on the location, installation and calibration of the instrumentation are standardised and are provided in Appendix A and Figure 3.1.

The following instrumentation should be calibrated and installed prior to HVS trafficking:

- Multi-Depth Deflectometers (MDDs)
- Thermocouples
- Temperature buttons

Other specialized instrumentation for the monitoring of pavement responses such as pressure cells, and strain gauges can be installed if required and agreed upon by the client.

HVS loading should be calibrated prior to commencement of testing. The HVS Operator and crew are responsible for this activity. Static scales are used for calibration and if required, a calibration factor is calculated which will be applied throughout the test programme to ensure uniformity in loading characteristics. An accredited scale supplier should be used to calibrate the static scales as per manufacturers instructions.

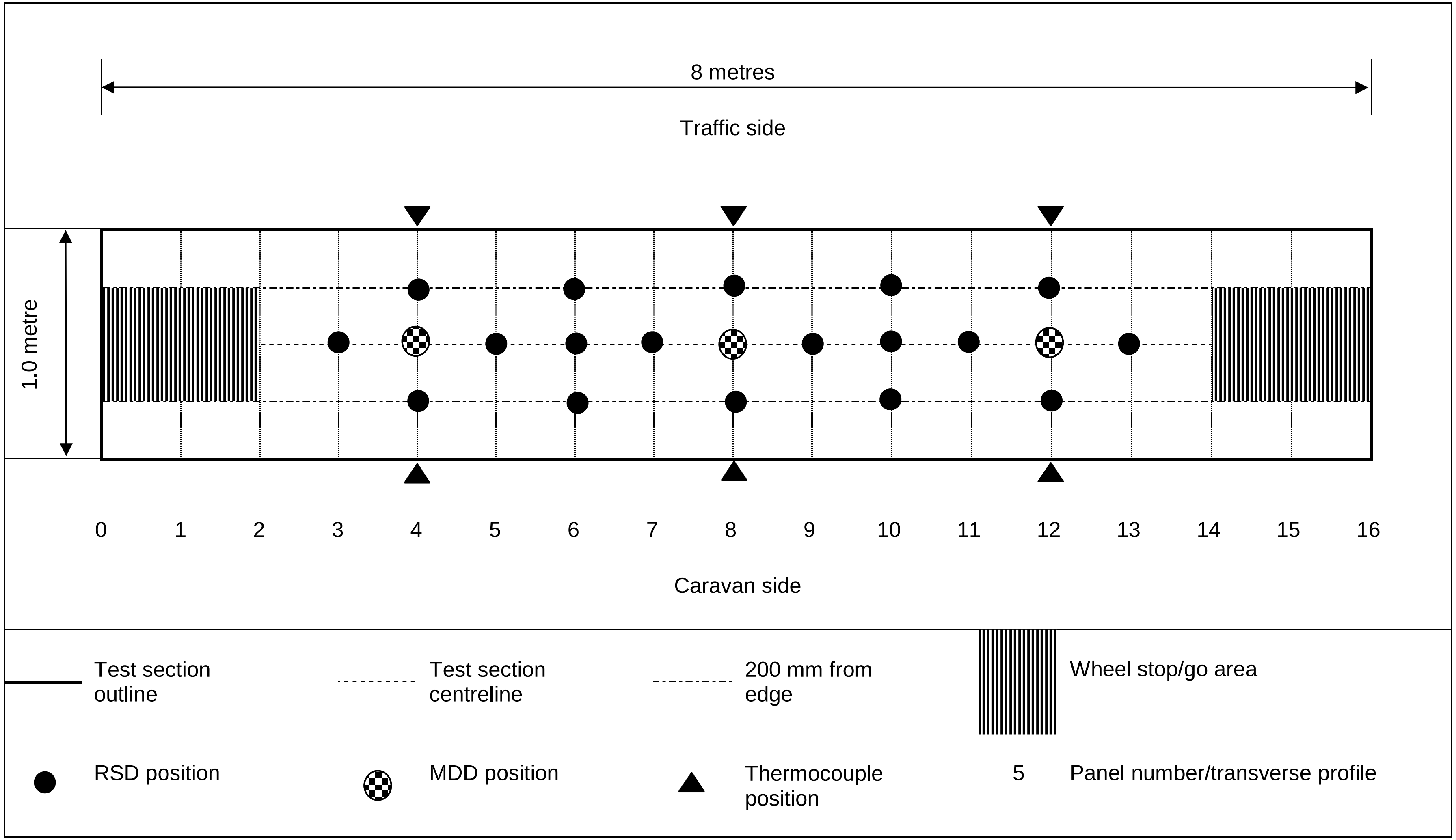

Figure 3.1: Illustration of test section layout for instrumentation and data collection

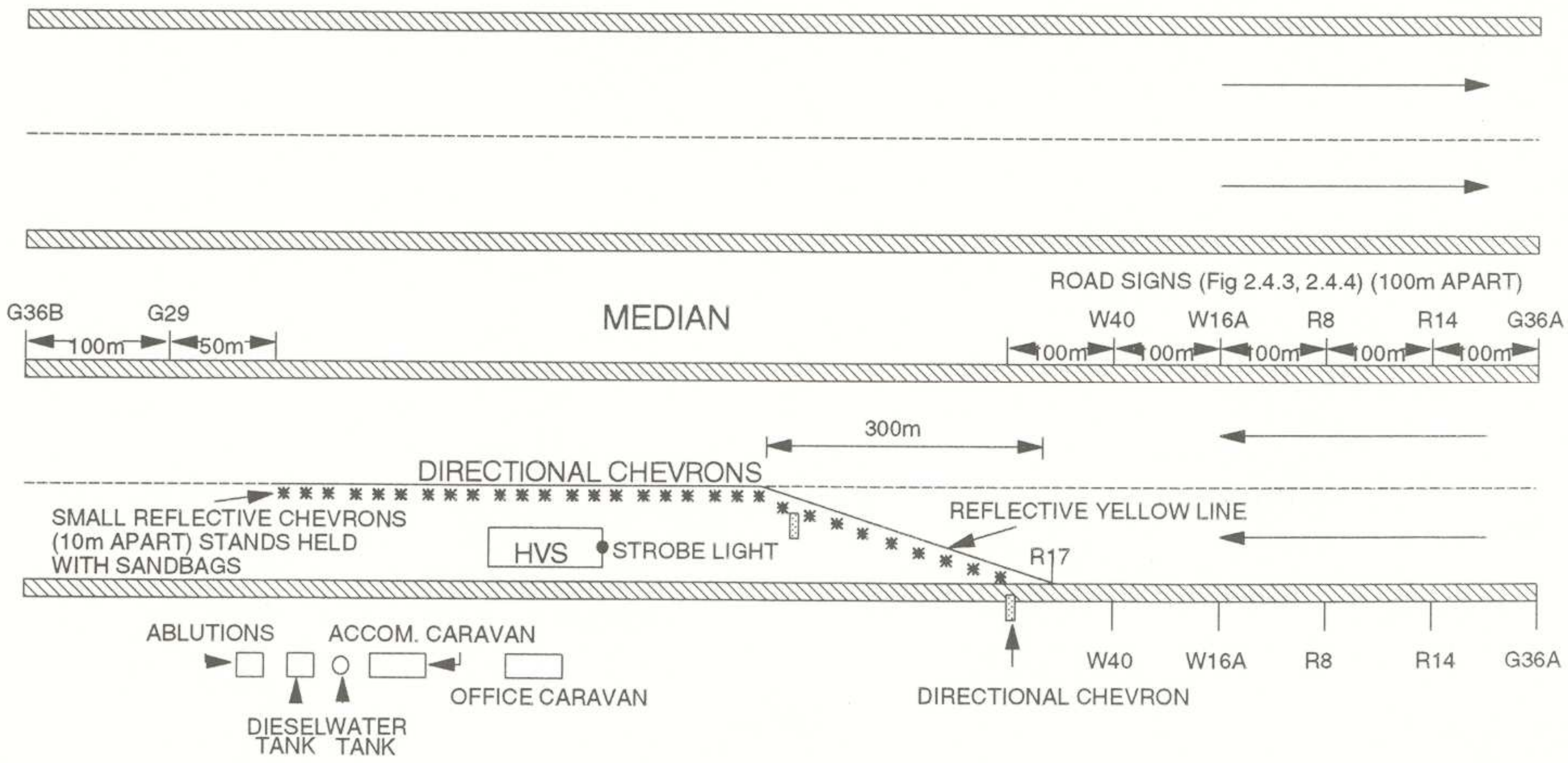

Figure 3.2: Layout of a typical HVS site on a dual carriageway

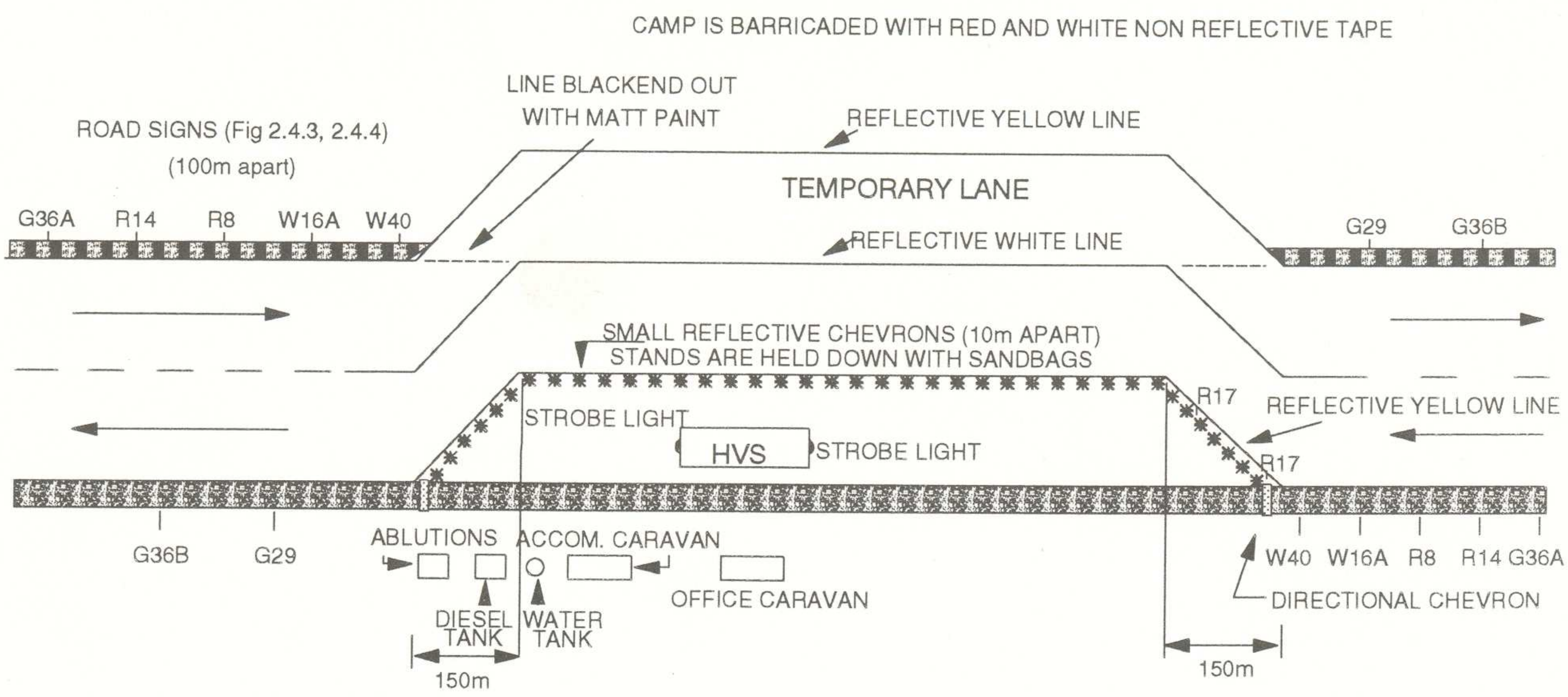

Figure 3.3: Layout of a typical HVS site on a single carriageway

4. DATA COLLECTION AND STORAGE

4.1. Introduction

A comprehensive record of the behaviour of a test section is critical to the success of any accelerated pavement testing programme. This requires a systematic data capture and storage procedure to ensure accuracy, uniformity and continuity in measurements.

A data acquisition management system has been developed over a number of years in conjunction with ongoing HVS testing. This system has been refined to address the needs of CSIR clients.

4.2. Test Specification

The test specification forms the initial plan on which all further testing is based. It is prepared from the original project specification and experimental design by the Project Manager - analysis and the Project Engineer in consultation with the HVS Technician and HVS Operator. It should be approved by the Project Director and Client before being implemented. The HVS Operator will then follow the specification to schedule instrument measurements and the daily tasks of the HVS crew. The following information should be included in the test specification:

- Responsibility matrix (including safety, environment, reporting, data validation)
- Location of test section (including province, region/district, road number)
- Section number
- Start date of testing
- Trafficking speed
- Wheel configuration
- Tyre type and inflation pressure
- The number of repetitions at which measurements need to be taken and at which changes in loading characteristics occur
- Data collection and storage
- Information specific to instruments relating to data collection (including depth of installation of in-pavement instruments, number of points measured, location of measuring points and the load at which measurements will be recorded)
- Special notes (including instructions (including frequency of collection) on the measurement of surface deformation, in situ density and cracking, photographs

of the test section, the recording of weather information and wetting and heating of the section)

- General notes (including the process that should be followed to transfer data from site to the CSIR, the objectives of the testing and general information relevant to the operation of the HVS)
- Contact details of relevant personnel

4.3. Data Collection

The HVS Operator should be responsible for calibrating the equipment and ensuring that data is collected as prescribed in the test plan for each specific section. The Project Engineer oversees the collection of data and validates it once collected. Data is either recorded manually on worksheets or electronically by the data acquisition system (DAQS) on the HVS control computer.

Electronically recorded information includes:

- Number of repetitions
- Load
- Transverse profile
- Road surface deflection
- Permanent deformation

Manually recorded information includes:

- Visual assessment
- Transverse profile (maximum rut)
- In situ density
- Tyre pressure and temperature
- Pavement temperature
- Weather details
- HVS operational details

4.4. Visual Assessment

The test section should be monitored continuously by the HVS Operator and crew. Formal assessments should be carried out in the morning and evening by the HVS Operator. Data should be recorded on the Visual Assessment and Permanent

Deformation recording Form (Form 1 in Appendix B). If any change has occurred since the previous assessment, the change should be recorded on digital photographs, with date and time embedded in the image. The following detail should be assessed:

- Appearance of cracks, crack type and crack progression (cracks should be marked with chalk prior to assessment)
- Pumping
- Rutting
- Deformation
- Bleeding/flushing
- Other damage
- Other measurements as required to suit the needs of the experiment

The following additional information should also be recorded on the form:

- Rainfall
- Maximum and minimum temperature
- Water addition
- Heating

Digital photographs should be taken as soon as the section is in the shade. The HVS operator should stand on the caravan side, on the yellow shoulder line, or road edge if there is no shoulder, and take overlapping photographs (pointing the camera straight at the section and ensuring that the entire width is captured), starting at point zero. Three points are typically captured with each photograph. Additional photographs can be taken to illustrate specific detail. The Project Engineer may also request additional photographs taken from different angles.

The Project Manager - operations should calibrate the HVS operator on visual assessment at least twice a year to ensure repeatability and consistency.

Output: Completed Visual Assessment and Permanent Deformation Form with digital photographs of the section, sent to the HVS Technician on a weekly basis.

4.5. Transverse Profile (electronic) and Deflection

Transverse profile is measured with a Laser Profilometer every 500 mm along the length of the section at the points shown in Figure 3.1.

The profilometer should be checked and calibrated by the HVS Operator. Measurements are taken by the HVS operator and at least two members of the HVS crew. All data is recorded electronically by the DAQS at the times specified in the test programme. The system records the specific points at which data was collected and assigns a specific filename, unique to that particular set of measurements. If required, a longitudinal profile can be obtained from the set of transverse profiles

Data collected includes:

- Section Number
- Date
- Number of repetitions, trafficking load and tyre pressure
- Transverse profile
- Number of repetitions of each measurement recorded
- Filename of cross reference to other relevant data

A copy of the DAQS form (Form 2) is provided in Appendix B.

The HVS operator also records the data manually on a form at the same time as the data is captured electronically. This serves as a back-up hard copy. Two repetitions are recorded. The HVS operator should also undertake a first validation of the instrumentation data by comparing previous measurements with the latest ones taken. He should inform the Project Engineer if any discrepancies are noted. Data is captured on the Backup Data Collection Form (Form 3 in Appendix B).

Output: Relevant electronic files stored on DAQS and a completed Backup Data Collection Form copied to disc and forwarded to HVS Technician on a weekly basis for data verification and capture.

4.6. Transverse Profile (manual)

In addition to the transverse profile measured with the laser profilometer, the profile is also measured manually with a 2.0 m straightedge and steel rule. Measurements are taken at the same time as the profilometer and at the same points on the section at the intervals specified in the test programme. The following measurements should be taken:

- Section Number
- Date
- Number of repetitions, trafficking load and tyre pressure

- A profile of measurements from traffic side to caravan side at 0, 200, 400, 500 (centreline) 600, 800 and 1 000 mm
- Maximum rut depth
- Rut width (measured with a tape measure).

A longitudinal profile can be obtained from joining the points on each transverse profile. This should be compiled by the Project Engineer if required.

Measurements should be recorded on the Visual Assessment and Permanent Deformation Form (Form 1 in Appendix B).

Output: Completed Visual Assessment and Permanent Deformation Form forwarded to HVS Technician on a weekly basis for data verification and capture.

4.7. Deflection

Surface deflections are measured with the RSD every 500 mm along the centre of the section at the points shown in Figure 3.1. Three repetitions are recorded. Elastic deflection in the pavement layers is measured using the MDDs.

Calibration is checked and measurements are taken by the HVS Operator and at least two members of the HVS crew. All data is recorded electronically by the DAQS at the times specified in the test programme. The system records the specific points at which data was collected and differentiates between varying test loads, if applicable. Data collected from each instrument is designated a specific filename, unique to that particular set of measurements.

Data collected includes:

- Section Number
- Date
- Number of repetitions, trafficking load and tyre pressure
- Road surface deflection (RSD)
- Deflection at depth (MDD)
- Number of repetitions of each measurement recorded
- Filename of cross reference to other relevant data

A copy of the DAQS form (Form 2) is provided in Appendix B.

The HVS operator also records the data manually on a form at the same time as the data is captured electronically. This serves as a back-up hard copy. Two repetitions are recorded. The HVS operator should also undertake a first validation of the instrumentation data by comparing previous measurements with the latest ones taken. Data is captured on the Backup Data Collection Form (Form 3 in Appendix B).

Output: Relevant electronic files stored on DAQS and a completed Backup Data Collection Form copied to disc and forwarded to HVS Technician on a weekly basis for data verification and capture.

4.8. Permanent Deformation

Permanent deformation is downloaded from each MDD at each installation depth at the same time as the deflection measurements, at the intervals specified in the test programme. The data is recorded on the Visual Assessment and Permanent Deformation Form (Form 1 in Appendix B).

4.9. Density and Moisture Content

Density and moisture content should be measured with a dual-probe hydro-density meter by a delegated member of the HVS crew who is trained and authorised to do so. The operator should wear a radioactivity dosimeter at all times. Measurements should be taken in permanent holes drilled and lined with a thin aluminium tube (1.0 mm wall thickness) for this purpose at the end of the test section. The holes must be sealed with an appropriate bung immediately after testing. Moisture contents measured with the hydro-density meter should be calibrated against a gravimetric moisture content sampled with a hand or power auger from an adjacent section before and after HVS trafficking. Material representative of each layer should be sampled to the same depth as measurements taken with the hydro-density meter and the gravimetric moisture content compared with the recorded readings. The machine wet and dry densities and moisture content should be recorded for every 50 mm depth. These readings should be recorded on the Density and Moisture Form (Form 4 in Appendix B).

Detailed instructions on the measurement of density and moisture are provided in Appendix A.

Output: Completed form Density and Moisture Content Form forward to the HVS Technician on a weekly basis for verification and capture.

4.10. HVS Service

The HVS Service Report (Form 5 in Appendix B) is a record of the machine serviceability and crew activities. It should be completed every hour, on the hour, by the HVS Operator or a delegated member of the HVS crew. The following data should be recorded:

- Machine productivity (daily log)
  - Operational
  - Inoperative
    - Breakdown (electrical, hydraulic/mechanical, instruments)
    - Service
    - Measurements (routine, special, data processing)
  - Number of repetitions
- Machine service details
- Instrument serviceability
- Visitors to the site
- Accidents, incidents and injuries on the site
- Other issues pertaining to the site

Output: Completed HVS Service Report forwarded to the Project Manager - operations on a weekly basis.

4.11. HVS Operations

The HVS Operations Report (Form 6 in Appendix B) is a record of key parameters associated with the testing programme. Readings are taken every two hours by the HVS Operator or a delegated member of the HVS crew. The following information should be recorded:

- Number of repetitions
- Average load
- Tyre pressure and temperature
- Oil Pressure and temperature of Deutz 10-Cyl engine
- Road temperature from the thermocouples

Output: Completed HVS Operations Report forwarded to the HVS Technician on a weekly basis.

4.12. Post Trafficking Assessment

4.12.1 Test Pit

After completion of HVS trafficking, the section should be trenched in the transverse, and if specifically required, the longitudinal direction to trafficking. The pit should be excavated into the subgrade. Material from each layer should be separated and placed into sealed and labelled bags. Material from the trafficked section and adjacent sections should be sampled separately. Moisture content samples should be removed from each layer as soon as the material is loosened, and placed in sealed tins. Profiling should start has soon as all the material has been removed from the hole.

The test pit should be profiled by the Project Engineer. The profiles should be fully described according to the Jennings, Brink and Williams standard[3]. However, additional information on the nature of the interlayer boundaries (deviations and conditions, eg ruts and cracks) should also be included. For cemented layers, it will be important to assess the in-situ condition of the stabilized layer. This is best done using a phenolphthalein spray. Observations should be recorded on an HVS Test Pit Form (Form 7 in Appendix B).

On completion of profiling, the pit should either be covered with a steel plate (if further investigations or site visits are planned), or reinstated using material and layer thicknesses conforming as closely as possible to those in the respective layers and then sealed.

Output

Completed HVS Test Pit From

4.12.2 Dynamic Cone Penetrometer (DCP)

DCP measurements (number specified in the test programme) should be taken by the HVS Technician in the test and adjacent untrafficked sections. Measurements should be recorded at 5-blow intervals to a depth of 800 mm. Cemented layers should be drilled if unacceptably slow penetration with the DCP is obtained.

Results should be recorded on the HVS DCP Form (Form 8 in Appendix B).

Output

Completed HVS DCP form.

4.13. Data Storage and Validation

The data collected from the various instruments is stored in the DAQS under specified filenames that are recorded on the specified forms (Appendix B). These files are copied onto disks and forwarded to the HVS Technician at the CSIR on a weekly basis. The HVS Technician should carry out a first-level validation (comparison with previous measurements) before processing the raw data files into MS Excel file format. The processed data is then stored on the CSIR network where it can be accessed by the Project Engineer who carries out a second level validation (comparison with previous results). When the data has been validated, it is stored in the HVS Database at the CSIR, where it can be accessed by research engineers and other authorised interested parties. A backup of the data for each test section is copied to a CD.

The HVS Technician or the Database Manager is responsible for data storage. Access to the data should be arranged through them.

Data should be validated at a series of levels as follows:

- HVS Operator - checks the newly recorded data against the last recorded data.
- HVS Technician - checks the data submitted by the HVS Operator on a weekly basis against the previous weeks summary data. If any abnormal trends are noted, the Project Engineer should be notified immediately. Signatures on the Client Weekly Report imply that the data has been checked and validated.
- Project Engineer - checks the Client Weekly Report against the previous weeks report and signs it off, if satisfied. If problems are noted, the Project Engineer should implement appropriate remedial measures.

4.14. Reporting

4.14.1 Client Weekly Report

The client weekly report (Form 9 in Appendix B) provides a summary of key issues for the client. It should be compiled by the HVS Technician from data provided by the HVS Operator. The completed form should be approved and forwarded to the client by the Project Director or Project Manager - operations. The form contains the following information:

- Date
- Week number
- Section number

- Wheel load
- Tyre pressure
- Repetitions for the week and total repetitions for the section
- Heat or water applications
- Weather detail
- Machine productivity with summary of operational times
- Measurements taken and scheduled
- Progress according to plan

4.14.2 Client Monthly Report

The client monthly report should be presented at the monthly technical meeting. This meeting is attended by the Client, Project Manager - analysis, Project Engineer and members of the HVS Steering Committee. Other interested parties may also be invited. The following issues are presented and discussed:

- Testing progress
- Deviation from the test programme
- Data collected and interim results
- Laboratory testing and interim results

Minutes of the meeting are recorded and distributed. Copies of the minutes and presentations are stored on the HVS website and database.

4.14.3 First Level Analysis Report

A first-level analysis report should be compiled when all testing has been completed and all data has been captured. It should provide a summary of the measurements taken, test interventions and behaviour. The report should be prepared by the Project Engineer in CSIR Contract Report format[4], reviewed by a Technical Specialist and approved by the Project Director before being submitted to the client. The report should include the following chapters:

- Introduction
- General aspects and test conditions
- HVS test results
- Section assessment
- Conclusions and recommendations
- References
- Appendices

4.14.4 Second Level Analysis

A second level analysis report should be compiled on completion of the research investigation. It should provide a summary of the experimental design, relationship between laboratory test results and HVS test results, data analysis and the findings. Recommendations towards implementing the findings should also be made. The actual content of the report will depend on the objectives of the experiment. The report should be prepared by the Project Engineer, Research Engineers and Project Manager - analysis. Standard CSIR Contract Report formats and approval procedures should be followed[4]. The report should be reviewed by a Technical Specialist and approved by the Project Director before submission to the client.

5. REFERENCES

1. **MkIV Heavy Vehicle Simulator Manual**. 1998. Pretoria: CSIR, Transportek.

2. JONES, D. and Paige-Green, P. 2003. **A protocol for the establishment and operation of LTPP sections**. Pretoria: CSIR, Transportek. (Contract Report CR-2003/11).

3. JENNINGS, J.E., Brink, A.B.A. and Williams, A.A.B. 1973. Revised guide to soil profiling for civil engineering purposes in South Africa. **The Civil Engineer.** January 1973, pp 3- 12.

4. **Standards and procedures for project documentation**. 1996. Pretoria: CSIR, Transportek. (Technical Report TR-96/056).

APPENDIX A

INSTRUMENTATION

APPENDIX A: INSTRUMENTATION

A.1 HVS Laser Profilometer

A.1.1 Description

The laser profilometer measures the transverse surface profile over the test section, monitoring changes in profile caused by continuous traffic. The profilometer consists of a 3.0 m long frame, which is positioned over the width of the test section at specific locations. A laser device is attached to the frame inside a mobile control box. On commencement of the measurement, the control box moves over the width of the test section, measuring the profile every 9.0 mm.

A.1.2 Calibration

The laser profilometer is calibrated by the HVS Operator before daily measurements are taken. Calibration is carried out using a steel calibration as follows:

- Position the calibration plate on a level surface
- Place the profilometer on the calibration plate
- Initiate the measurement in the data acquisition system (DAQS)
- Check recorded profile against the actual profile
- Adjust the profilometer if required

A.1.3 Measurement Method

Profiles of the test section are taken as follows:

- Position the profilometer on the markings on the section at Position 0
- Check cable connections
- Activate the measurement on the DAQS
- Take a measurement
- Record the measurements manually on the backup data form
- Move the profilometer to Position 1 and repeat the process

A.1.4 Reporting

Transverse profiles are captured electronically on the DAQS and manually on the backup data record form

A.2 Road Surface Deflectometer (RSD)

A.2.1 Description

The RSD is a modification of the Benkelman Beam and measures the elastic surface deflection of a pavement under the action of a wheel load. The RSD consists of a 3.0 m long beam, which is supported on two reference feet at one end and the measuring point on the other. A Linear Variable Displacement Transducer (LVDT) is located between these two points. The RSD is positioned in such a way that the reference feet stand outside the deflection bowl area and the measuring point lies between the wheels of the test carriage. The deflection under the measuring point is then measured by logging the movement of the LVDT at various distances. At the measuring point a setscrew is located with which the RSD is zeroed before measurement starts.

A.2.2 Calibration

The RSD should be calibrated by the HVS Technician during site establishment for each test section. The instrument should be calibrated on the calibration jig, supplied with the instrument, according to the following procedure:

i) Select a smooth level surface.
ii) Place the measuring point of the RSD on the jig plate
iii) Set the RSD (software) and jig dial gauge to zero
iv) Wind jig to 0.1 mm on the dial gauge and check the reading is the same on the RSD software
v) Repeat the test at 0.1 mm intervals to 1.0 mm

If inconsistent results (compared to the previous days readings) are recorded when taking daily measurements, the HVS Operator should notify the HVS Technician and Project Engineer, and if necessary, the RSD should be re-calibrated.

The calibration form is shown Appendix B

A.2.3 Measurement Method

RSD measurements are taken as follows:

i) Position the RSD on the painted marks (point at which the elastic surface deflection is to be measured) on the test section
ii) Position the carriage at the end of the beam such that the beam lines up with the centre of the wheels
iii) Start the test on the computer and move the carriage at creep speed ± 1.0 m past the measuring point, towards the reference feet of the RSD. Stop the data log.

iv) Move the wheel back to the starting point (± 3 metres away)
v) Check that the reading has been taken
vi) Repeat the test two more times
vii) Move the RSD to the next point and repeat the procedure

A.2.4 Reporting

Peak deflection and deflection bowl are captured electronically on the DAQS and manually on the backup data form.

A.3 Multi-Depth Deflectometer (MDD)

A.3.1 Description

The MDD consists of several modules with LVDTs, which are installed at various depths in the pavement. The MDD measures the elastic deflection and permanent deformation of the various layers in the pavement. The modules are installed at distances of not less than 150 mm apart inside a vertical hole in the pavement. Installation depths depend on the depths of the layers whose elastic deflection and permanent deformation are to be quantified and should be determined by the Project Engineer and Project Manager - analysis from DCP surveys, as-built data and/or test pits and cores as part of the HVS section design.

A.3.2 Installation

Installation of MDDs should be done as follows:

i) Three MDD position marks should be painted on the test section (centre and 2.66 m on either side). A percussion drill and a specially designed drilling rig are used for drilling the holes, which are normally approximately 3.3 m deep and 36 mm in diameter. After each hole is drilled it is cleaned out with compressed air. A core drill should be used for the top 100 mm of the hole, especially if the pavement consists of asphaltic layers. Ream the top of the hole to a diameter of 90 mm and depth of 25 mm, or until the MDD top cap is level with the pavement surface after installation. Cut a 50 x 50 mm slot from the top of the hole to the road edge to accommodate the wiring.
ii) Prepare the neoprene lining (0.08 mm thick neoprene rubber, formed round a stainless steel tube 33 mm diameter x 1 200 mm long) by covering the stainless steel tube with silicon grease placing then placing the rubber lining. Attach the aluminium bush with oil seal to the bottom end of the rubber lining.
iii) Secure the anchor assembly in the hole with 200 mℓ of a mixture of cement and coarse river-sand in a ratio of 3 to 1.
iv) Form the top cap with epoxy glue ensuring that it is positioned such that the screw holes in the top cap are in line with those in the cross section of the test

section. The top cap must be left overnight for the epoxy to cure before the mould is removed.

v) Mix the lining compound (2.0 ℓ of Prostruct 30/42 and up to 300 mℓ xylene (depending on material) to liquidize the compound to a workable consistency, using a mixer connected to a hand drill) to secure the MDD anchor pin and the lining in the drilled hole. Pour the mixed liquid into the drilled hole, filling 50 per cent of the hole, to prevent air traps. Push the lining tube down into the hole while filling the hole with the remaining liquid. Use a neoprene cover around the hole to prevent spillage on the road surface. The lining compound will take between 12 and 48 hours to set, depending on the weather conditions (setting time increases with decreasing temperature). When set, remove the lining tube and cut the lining flush with the bottom of the top cap. Clean the lining with a cloth.

vi) Fit the MDD snap connector onto the anchor pin using the supplied tool designed for this purpose.

vii) Mark the MDD modules 1, 2, 3, etc. Ensure that each MDD slug has the same marks as its matching module. Do a final inspection on the modules to be used and check that all six securing ball bearings are fitted. Check that the cables are intact and properly soldered to each module.

viii) Install the pilot rod (M5 brass rod, which is long enough to protrude ± 100 mm above surface) with the snap pin attached into the hole and ensure that the snap pin locks securely and positively in position. Write the depths at which the modules are located and the number of each module on the MDD information form. Clip the deepest installed module onto the MDD installation tool and mark on the tube of the MDD installation tool the desired depths of each module to be installed, using a marking pen. Measure from the centre of the securing ball bearings of the clipped on module to the prescribed depth. Guide the module to the deepest installed module position and with the MDD installation tool and pilot rod on the marked depth, secure the module with the MDD installation tool. Follow the same procedure with all the modules as required in this MDD hole. The sequence of modules is from the deepest, (with the highest number) to the shallowest, (No 1).

ix) Feed the ribbon cables through the channels provided. The wires coming from levels 1, 2 and 3 modules on the module bodies are connected to the plug situated on the left-hand side of the top cap. The wires from levels 4, 5 and 6 are connected to the plug situated on the right-hand side of the top cap.

x) Connect an installation unit to the MDD connections and check that every module is operating. This can be done with a dummy rod (M5 brass rod with length equal to the depth of the MDD hole and which has an MDD slug screwed onto its tip). While the rod is being pushed through the MDD modules fitted in the hole, the reading on the installation unit should be -13.00, 00.00, +13.00, as the slug on the dummy rod goes through each module.

xi) Push another M5 rod with snap connector fitted into position in the hole until it clips into the snap connector. Mark the point at which the rod is flush with the surface of the test section with a marking pen or a strip of masking tape. Use the dummy rod to establish the position of the deepest MDD module by inserting it through the module until a zero reading is reached on the conditioner. Mark this depth with a marking pen or a strip of masking tape at the point on the road flush with the surface of the pavement. Repeat this operation with each module installed and mark each depth on the rod. Remove the marked rod from the MDD hole.

xii) When assembling the MDD slug rod, attach a strip of masking tape on a flat working area. Place the rods on the working place alongside the masking tape. Mark the total depth from the dummy rod onto the tape. Mark the locations of the MDD slugs for each module as marked on the rod.

xiii) With the markings on the strip of masking tape, assemble the MDD slug rod starting from the snap connector pin. Place the numbered slug of each MDD on its mark on the masking tape. Place the snap connector pin on the snap connector pin mark from the reference point and cut lengths of M3 brass threaded rod to connect the snap connector pin and each slug forming the MDD slug rod. Use M3 brass threaded taper ferrules to lock the lengths of rods into the slugs.

xiv) Screw a ±300 mm long rod onto the top slug. Do not lock with a ferrule, as the rod is used for handling the MDD slug rod and will be removed after completion of installation. Push the MDD slug rod into the MDD hole through the modules until it snaps on the snap connector on the anchor pin.

xv) The final adjustments to the slug positions can be made, based on the readings on the different channels on the installation unit, in order to have the slug located in the correct position. Shortening of the rod results in positive readings and lengthening of the rod in negative readings.

xvi) Once the correct readings are obtained, thread the wires into a conduit and embed it in the prepared slot with cold mix patching material. Bury the conduit in the road reserve and connect to the DAQS in the HVS office.

Detailed tool and equipment lists are provided in the HVS Manual.

A.3.3 Calibration

After the installation of the MDD modules at the desired depths, the MDD must be calibrated. This will ensure that the measurements agree with the actual movement in the pavement. The HVS technician is responsible for the calibration of the MDD.

The following tools are required to calibrate the MDD modules fitted into an MDD hole:

- A calibration unit (part of the data acquisition software)
- A calibration jig fitted with a dial indicator mounted into a screw adjusting mechanism

The calibration process is as follows:

i) Remove the snap connector pin from the MDD slug rod in order to facilitate free movement of the slug assembly. Move the MDD slug rod up and down to determine the mid (zero) position of the module (ie -13.00, 00.00, +13.00).

ii) Place the calibrator unit above the MDD hole and connect the MDD slug rod with the calibrator unit. Turn the screw mechanism until the deepest module reads 0.00 on the conditioner unit.

iii) Set the dial gauge on the screw mechanism to a zero reading and turn the screw mechanism until the reading is 7.5 mm on the dial gauge (using an E300 LVDT).

iv) The same procedure is repeated for the calibration of the other modules. When the calibration procedures are complete replace the snap connector pin on the MDD slug rod and enter the final pot setting readings on the MDD information form.

v) Do a final general inspection of the installation and connections and close the top cap.

The calibration form is shown in Appendix B

A.3.4 Measurement Method

MDD measurements are downloaded into the data acquisition system.

A.3.5 Reporting

Permanent deformation and elastic deflection are recorded electronically and manually on the backup data form.

A.4 Temperature Buttons

A.4.1 Description

The temperature button is a computer chip enclosed in a 16 mm stainless steel casing that stores temperature data in a range between -10 and 85°C. It is designed to withstand harsh conditions.

A.4.2 Installation

Temperature buttons are installed as follows:

i) Drill a 25 mm diameter hole to the required depth (typically bottom of the surfacing) in the required position (centre of the lane in Panels A, B and C)
ii) Place thin levelling layer of sand on the bottom of the hole
iii) Set temperature button to the required recording interval (120 minutes)
iv) Place temperature button in the bottom of the hole
v) Seal the hole with cold mix filler, ensuring that there is no protruding aggregate

A.4.3 Calibration

Temperature buttons can be calibrated in hot water, by checking the temperature of the water and then immersing the button and checking the temperature recorded.

A.4.4 Measurement Method

Temperature buttons must be extracted from the pavement to download the data. This should be done carefully to prevent damage. Once removed, the data should be downloaded. The button can then be cleaned, calibrated and used on another test section.

A.4.5 Reporting

Data is captured electronically and presented in spreadsheet compatible format.

A.5 Thermocouples

A.5.1 Description

The K-type thermocouples used for HVS tests are a copper constant thermocouple wire. Readings are taken on K-type hand-held readout unit

A.5.2 Installation

Thermocouple installation depths are determined by the Project Engineer and the Project Manager - analysis when preparing the test program and will depend on the pavement structure. Thermocouples are not normally installed in the test section itself, but next to the test section so as to prevent the HVS wheel damaging the wires. Thermocouples are installed as follows:

i) Drill a 10 mm hole to the desired depth.
ii) For multi-depth measurements at the same location, cut a wooden dowel to the same length as the depth of hole

iii) Mark the different depths at which the thermocouples are to be installed on the dowel
iv) Attach the thermocouple wire to the dowel on the corresponding marking with masking tape
v) Push the dowel into the hole
vi) Fill the cavity around the dowel with fine-grained sand to prevent air pockets and to ensure that the wire ends are in direct contact with the surrounding material
vii) Cut the wires to the desired lengths, so that they can reach a suitable point where the reading instrument can be connected. If a number of thermocouples are installed on the same section, it is recommended that all the reading points be located at the same point to facilitate the taking of readings

A.5.3 Calibration

Calibration of the thermocouples is taken prior to installation by the HVS Technician. Calibration is as follows:

i) Fill three beakers with water at three different temperatures in a range expected in the pavement structure
ii) Measure the temperatures of the water with a thermometer
iii) Place the thermocouple in the beaker and check the temperature on the hand-held reader
iv) Compare the two readings
v) Calculate a calibration factor if required

A.5.4 Measurement Method

Measurements are taken by the HVS Operator or delegated member of the crew as follows:

i) Connect the hand-held reader to the thermocouple connector plug and take a reading checking that the position of the thermocouple is recorded correctly, and that the units of the readout unit are set correctly.

A.5.5 Reporting

Temperatures are recorded on the HVS Operations Form.

A.6 Dual Probe Hydro-density Meter

A.6.1 Description

The dual probe hydro-density meter (Strata gauge) is used to measure density and in-situ moisture content of the pavement structure. Measurements are recorded in 50 mm increments to a depth of 600 mm. The source material in the hydro-density meter is radioactive and although this does not pose a hazard to the operator under normal operating conditions, strict operating, maintenance and transport procedures, supplied with the equipment, must be followed at all times. Certain legal requirements in this regard must also be followed.

A.6.2 Calibration

The hydro-density meter should be calibrated on standard blocks according to the manual supplied with the instrument. Calibration blocks are available at the CSIR.

A.6.3 Measurement Method

The following procedure should be followed:

i) Remove the cap of the predrilled holes.
ii) Drop a 1.0 m x 10 mm wooden dowel into the hole to check for standing water/mud. If the holes have standing water/mud, new holes will have to be drilled 30 cm along the wheel track from the previous hole.
iii) Measure the density and moisture at 50 mm intervals, starting at 600 mm, strictly following the specific operating and safety instructions provided with the gauge.
iv) Record the information on the HVS Density and Moisture Form.
v) Reseal the holes.

A.6.4 Reporting

Density and moisture content are recorded on an HVS density and moisture content form.

A.7 Crack Activity Meter

A.7.1 Description

The CAM measures movement of a crack under a wheel load. It consists the CAM body and two LVDTs attached to the body by setscrews.

A.7.2 Installation

If crack activity measurements are required, the CAM should be installed by the HVS Technician as follows:

i) Identify the crack to be measured, clean the surface around the crack and mark out the extremities of the CAM on the road. The CAM is installed at right angles across a crack in the surface of the test section
ii) Glue the two brass plates to the road surface, one on each side of the crack, with epoxy. Attach the body of the CAM to one of the brass plates
iii) Attach the LVDTs so that one measures the vertical movement of one side of the crack relative to that on which the body of the CAM is attached, while the other LVDT measures the horizontal movement of one side of the crack relative to that on which the body of the CAM is attached

A.7.3 Measurement Method

Measurements are recorded by the HVS Operator as follows:

Move the wheels of the HVS carriage across the CAM at the desired axle load

i) Record the horizontal and vertical movements of the crack on the appropriate form
ii) Take three repeat measurements

A.7.4 Reporting

Crack activity (horizontal and vertical movement) is recorded on the Crack Activity Measurement form (Form ? in Apendix B).

APPENDIX B

REPORTING FORMS

APPENDIX B: REPORTING FORMS

The following forms for the monitoring of HVS sections are provided:

- Visual assessment, profile and deformation
- Data acquisition (electronic)
- Back-up data collection
- Density and moisture content
- Daily service
- HVS operations
- Test pit
- DCP
- Client weekly report

The following calibration forms are also provided:

- Road surface deflectometer
- Multi-depth deflectometer

HVS VISUAL ASSESSMENT, PROFILE AND DEFORMATION FORM					Form 1
HVS Section		**Date**		**Evaluator**	
Repetitions		**Wheel load**		**Tyre pressure**	

Visual assessment

	Degree						Extent					Narrow	Wide	Position	Panels
	Slight					Severe	Slight				Severe	(% area)	(% area)		
Cracks - surfacing	0	1	2	3	4	5	1	2	3	4	5				
Cracks - block	0	1	2	3	4	5	1	2	3	4	5				
Cracks - longitudinal	0	1	2	3	4	5	1	2	3	4	5				
Cracks transverse	0	1	2	3	4	5	1	2	3	4	5				
Cracks - crocodile	0	1	2	3	4	5	1	2	3	4	5				
Cracks - parabolic	0	1	2	3	4	5	1	2	3	4	5				
Bleeding/flushing	0	1	2	3	4	5	1	2	3	4	5				
Pumping	0	1	2	3	4	5	1	2	3	4	5				
Rutting	0	1	2	3	4	5	1	2	3	4	5				

Transverse profile (manual rut)

Point		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Distance		0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5
Caravan side	0															
	200															
	400															
Centre line	500															
	600															
	800															
Traffic side	1000															

Permanent deformation

	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
MDD No 4						
MDD No 8						
MDD No 12						

Environment

Weather conditions					
Rainfall		Description			
Temperature		Max		Min	
Water applied					
Heat applied					

Notes

Validated by		Signature	

HVS DATA ACQUISITION FORM	Form 2

INSTRUMENTATION MEASUREMENT REPORT

SITE:-	SECTION	DATE	DISK
TRAFFICING LOAD		REPS	CODE

PROFILOMETER
POINTS NO. 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15

FILENAME .PRF

TEST LOAD kN

TEMPERATURE

4CS	12CS	12TS	4TS	Depth
				0
				35

RSD (CENTRELINE)
POINTS NO. 3,R,R 4,R,R 5,R,R 6,R,R 7,R,R 8,R,R 9,R,R 10,R,R 11,R,R 12,R,R 13,R,R
FILENAME .RSD

MDD 12	MDD 8	MDD 4
POINTS NO. 12,R,R	POINTS NO. 8,R,R	POINTS NO. 4,R,R
FILENAME .MDD	FILENAME .MDD	FILENAME .MDD

NEXT LOAD

TEST LOAD kN

MDD 4	MDD 8	MDD 12
POINTS NO. 4,R,R	POINTS 8,R,R	POINTS NO. 12,R,R
FILENAME .MDD	FILENAME .MDD	FILENAME .MDD

RSD (CENTRELINE)
POINTS NO. 13,R,R 12,R,R 11,R,R 10,R,R 9,R,R 8,R,R 7,R,R 6,R,R 5,R,R 4,R,R 3,R,R
FILENAME .RSD

PD's READINGS	MDD 12	MDD 8	MDD 4

HISTORY DETAILS
FILENAME .HIS

HVS BACKUP DATA COLLECTION FORM					Form 3
HVS Section		**Date**		**Evaluator**	
Repetitions		**Wheel load**		**Tyre pressure**	

Transverse profile						**Calibrated?**		**Y**	**N**	**Sign**	
Repetition 1						Repetition 2					
Points	Max	Min	Points	Max	Min	Points	Max	Min	Points	Max	Min
0			8			0			8		
1			9			1			9		
2			10			2			10		
3			11			3			11		
4			12			4			12		
5			13			5			13		
6			14			6			14		
7			15			7			15		

Road surface deflection				**Calibrated?**	**Y**	**N**	**Sign**
Traffic side - Repetition 1				Caravan side - Repetition 1			
4				12			
6				10			
8				8			
10				6			
12				4			
Centreline - Repetition 1							
3				9			
4				10			
5				11			
6				12			
7				13			
8							
Traffic side - Repetition 2				Caravan side - Repetition 2			
4				12			
6				10			
8				8			
10				6			
12				4			
Centreline - Repetition 2							
3				9			
4				10			
5				11			
6				12			
7				13			
8							

In-pavement deflection						
						Comments
MDD 12		**MDD 8**		**MDD 4**		
Level 1		Level 1		Level 1		
Level 2		Level 2		Level 2		
Level 3		Level 3		Level 3		
Level 4		Level 4		Level 4		
Level 5		Level 5		Level 5		
Level 6		Level 6		Level 6		
MDD 4		**MDD 8**		**MDD 12**		
Level 1		Level 1		Level 1		
Level 2		Level 2		Level 2		
Level 3		Level 3		Level 3		
Level 4		Level 4		Level 4		
Level 5		Level 5		Level 5		
Level 6		Level 6		Level 6		
Validated by				**Signature**		

HVS DENSITY AND MOISTURE CONTENT ASSESSMENT							Form 4
HVS Section		**Date**		**Evaluator**			
Calibration	Prv	Std	Std	Std		**Calibrated by**	
Std MC						**Calibration date**	
Std wet density							

	Probe	Input	Actual	Wet	Dry	MC	Notes
Test A	24	200	600				
	22	200	550				
	20	200	500				
	18	200	450				
	16	200	400				
	14	200	350				
	12	200	300				
	10	200	250				
	8	200	200				
	6	150	150				
	4	100	100				
	2	50	50				
Test B	24	200	600				
	22	200	550				
	20	200	500				
	18	200	450				
	16	200	400				
	14	200	350				
	12	200	300				
	10	200	250				
	8	200	200				
	6	150	150				
	4	100	100				
	2	50	50				
Test C	24	200	600				
	22	200	550				
	20	200	500				
	18	200	450				
	16	200	400				
	14	200	350				
	12	200	300				
	10	200	250				
	8	200	200				
	6	150	150				
	4	100	100				
	2	50	50				

Gravimetric moisture content

	Sample depth	Tin No	Moisture content	Actual dry density	Notes
Test A					
Test B					
Test C					

Validated by		**Signature**	

HVS DAILY SERVICE					Form 5
HVS Section		**Date**			
Daily log					
00:00 - 01:00	01:00 - 02:00	02:00 - 03:00	03:00 - 04:00	04:00 - 05:00	05:00 - 06:00
06:00 - 07:00	07:00 - 08:00	08:00 - 09:00	09:00 - 10:00	10:00 - 11:00	11:00 - 12:00
12:00 - 13:00	13:00 - 14:00	14:00 - 15:00	15:00 - 16:00	16:00 - 17:00	17:00 - 18:00
18:00 - 19:00	19:00 - 20:00	20:00 - 21:00	21:00 - 22:00	22:00 - 23:00	23:00 - 24:00
Codes	1: Inoperative	2: Breakdown 2.1: Electrical 2.2: Hydraulic 2.3: Mechanical 2.4: Instruments	3: Service	4: Trafficking	

Service Details	**Hour Meter**	**Condition**
F10L413		
F6L912		
Hydraulic		
Mechanical		
Repairs		

Service	Daily		Fortnightly		Monthly		
Condition of	Hydraulic						
	Electrics						
	Tyres						
	Lights						
	Road signs						
	Caravans		Conditioner				
	Computer		Clock cable				
	Profilometer		Cable				
	RSD		Cable				
	MDDS		Cable				
	Thermocouples		Cable				

HVS Operational condition		
Accidents up to time		
Detail		
Injuries up to time		
Detail		
Site visits		
Comments		

Assistant operator		Operator	
Checked by		Signature	

HVS OPERATIONS						Form 6
HVS Section		**Date**				
	00:00	02:00	04:00	06:00	08:00	10:00
Repetitions						
Average load						
Tyre pressure 1 (T)						
Tyre temperature						
Tyre pressure 2 (C)						
Tyre temperature						
10 cyl temperature						
10 cyl oil pressure						
Road temperature						
Thermocouple 1						
Thermocouple 2						
Thermocouple 3						
Thermocouple 4						
Thermocouple 5						
Thermocouple 6						
	00:00	02:00	04:00	06:00	08:00	10:00
Repetitions						
Average load						
Tyre pressure 1 (T)						
Tyre temperature						
Tyre pressure 2 (C)						
Tyre temperature						
10 cyl temperature						
10 cyl oil pressure						
Road temperature						
Thermocouple 1						
Thermocouple 2						
Thermocouple 3						
Thermocouple 4						
Thermocouple 5						
Thermocouple 6						
Assistant operator			Operator			
Checked by			Signature			

HVS TEST PIT FORM									Form 7
LTPP Section:		**Panel:**		**Position**		**Date:**		**Profiled by:**	
Surface/layer bond									

Depth (mm)	**Moisture**	**Colour**	**Consistency**	**Structure**	**Soil type**	**Origin**	**Disturbed sample**	**Undisturbed Sample**	**Comments**
to									
to									
to									
to									
to									
to									

Checklist	Cracks		Description								
	Rutting		Heaving		Interface bond		Moisture at interface		Layer definition		
	Carbonation										

HVS DCP RECORDING SHEET								Form 8
HVS Section			Panel		Date		Operator	
Position A			Position B			Position C		
0			0			0		
5	205	405	5	205	405	5	205	405
10	210	410	10	210	410	10	210	410
15	215	415	15	215	415	15	215	415
20	220	420	20	220	420	20	220	420
25	225	425	25	225	425	25	225	425
30	230	430	30	230	430	30	230	430
35	235	435	35	235	435	35	235	435
40	240	440	40	240	440	40	240	440
45	245	445	45	245	445	45	245	445
50	250	450	50	250	450	50	250	450
55	255	455	55	255	455	55	255	455
60	260	460	60	260	460	60	260	460
65	265	465	65	265	465	65	265	465
70	270	470	70	270	470	70	270	470
75	275	475	75	275	475	75	275	475
80	280	480	80	280	480	80	280	480
85	285	485	85	285	485	85	285	485
90	290	490	90	290	490	90	290	490
95	295	495	95	295	495	95	295	495
100	300	500	100	300	500	100	300	500
105	305	505	105	305	505	105	305	505
110	310	510	110	310	510	110	310	510
115	315	515	115	315	515	115	315	515
120	320	520	120	320	520	120	320	520
125	325	525	125	325	525	125	325	525
130	330	530	130	330	530	130	330	530
135	335	535	135	335	535	135	335	535
140	340	540	140	340	540	140	340	540
145	345	545	145	345	545	145	345	545
150	350	550	150	350	550	150	350	550
155	355	555	155	355	555	155	355	555
160	360	560	160	360	560	160	360	560
165	365	565	165	365	565	165	365	565
170	370	570	170	370	570	170	370	570
175	375	575	175	375	575	175	375	575
180	380	580	180	380	580	180	380	580
185	385	585	185	385	585	185	385	585
190	390	590	190	390	590	190	390	590
195	395	595	195	395	595	195	395	595
200	400	600	200	400	600	200	400	600
Validated by				Signature				

HVS CLIENT WEEKLY REPORT					Form 9
HVS Section		**Week from**		to	
Dual wheel load					
Tyre pressure (kPa)					
Repetitions for the week					
Total repetitions to date					
Heat applications					
Water applications					
Rainfall					
Major breakdowns					
Measurements taken					
Measurements scheduled					
Progress according to plan					
Total hours					
Trafficking					
Measurements					
Service					
Breakdown					
Inoperative					
Comments					

Assistant operator		Operator	
Checked by		Signature	

HVS RSD CALIBRATION SHEET			
LTPP Section No:		**Panel:**	
Date:		**Calibrated by:**	
RSD ID No:		**Level No:**	
Dial gauge	**Computer Up**	**Computer Down**	**Difference**
0.0			
0.1			
0.2			
0.3			
0.4			
0.5			
0.6			
0.7			
0.8			
0.9			
1.0			
		Average	
		Therefore mm/v = 1/average	
Checked by		**Signature**	

HVS MULTI DEPTH DEFLECTOMETR CALIBRATION SHEET			
LTPP Section No:		**Panel:**	
Date:		**Calibrated by:**	
MDD No:		**Level No:**	
Dial gauge	**Computer Up**	**Computer Down**	**Difference**
0			
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
		Average	
		Therefore mm/v = 1/average	
MDD No:		**Level No:**	
Dial gauge	**Computer Up**	**Computer Down**	**Difference**
0			
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
		Average	
		Therefore mm/v = 1/average	
MDD No:		**Level No:**	
Dial gauge	**Computer Up**	**Computer Down**	**Difference**
0			
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
		Average	
		Therefore mm/v = 1/average	
Checked by		**Signature**	