DEVELOPMENT OF A PAVEMENT PERFORMANCE INFORMATION SYSTEM (PPIS)

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Abstract

The development of a Pavement Performance Information System (PPIS) forms part of the Revision of the South African Pavement Design Method (SAPDM) initiated and funded by the South African Roads Agency Limited (SANRAL). The study involved the collection of long-term pavement performance data for different South African flexible pavement types and development of a system to make this information available to industry. The PPIS represents both Long Term Pavement Performance (LTPP) and Heavy Vehicle Simulator (HVS) field sections, including the following types of pavements: full-depth granular pavements, granular base with cemented subbase pavements, cemented base pavements, asphalt base pavements, and bitumen stabilised pavements. The objectives of the paper are to describe the framework for data collection and documentation, introduce the web-based PPIS, demonstrate the potential application of the system, and to identify benefits to the industry. Observed performance trends corroborate the validity of the approach and highlight the value of utilizing historical data from available data resources. The data collection and reporting methodology was designed to tap into the project life-cycle and is therefore ideal for long term implementation.

1. INTRODUCTION

The development of a Pavement Performance Information System (PPIS) forms part of the Revision of the South African Pavement Design Method (SAPDM) initiated and funded by the South African Roads Agency Limited (SANRAL). The study involved the collection of long-term pavement performance data for different South African flexible pavement types and development of a system to make this information available to industry. A total of 61 LTPP and HVS pavement sections were selected for performance documentation and inclusion in the PPIS database. LTPP sections represent approximately 80 percent of the total, while the other 20 percent are HVS test sections. The types of pavements represented are: full-depth granular pavements, granular base with cemented subbase pavements, cemented base pavements, asphalt base pavements, and bitumen stabilised pavements. The objectives of developing a PPIS are summarized below.

- To observe key trends in the performance data and validate the basic behaviour models developed as part of the updated SAPDM design method.
- Through internet access to the PPIS, practitioners would be able to test planned designs against the information in the performance database.
- The PPIS also provides road owners with more certainty regarding the suitability and reliability of a proposed design.

The objectives of the paper are to: Describe the data collection and documentation frameworks; introduce the web-based PPIS; demonstrate potential application of the system, and to highlight benefits of using the system. Example outputs are presented and to illustrate the potential use of the PPIS. A more detailed discussion on the development of this system with analysis of performance trends is available in Hefer and Jooste (2008).

2. COLLATION OF PERFORMANCE INFORMATION

2.1 General Approach

The Pavement Performance Information System (PPIS) was mostly compiled from a thorough study of historical documentation related to the construction and maintenance history of specific roads. The majority of roads were in-service pavements subjected to long-term traffic and environmental deterioration. The data related to these pavements are considered to be Long Term Pavement Performance (LTPP) data. In addition to the LTPP data, several pavements in the database were subjected to Heavy Vehicle Simulator (HVS) testing. The data collection methodology was designed to tap into the project life-cycle and utilizes available systems to identify candidate pavements that are likely to have deteriorated to a stage where some form of rehabilitation is required (See Figure 1). These facilities may or may not have reached the end of their serviceable lives. The information extracted from rehabilitation design projects is essentially "repackaged" and fed back into the project life-cycle, effectively creating a performance feedback system that makes "past experience" available to the industry.

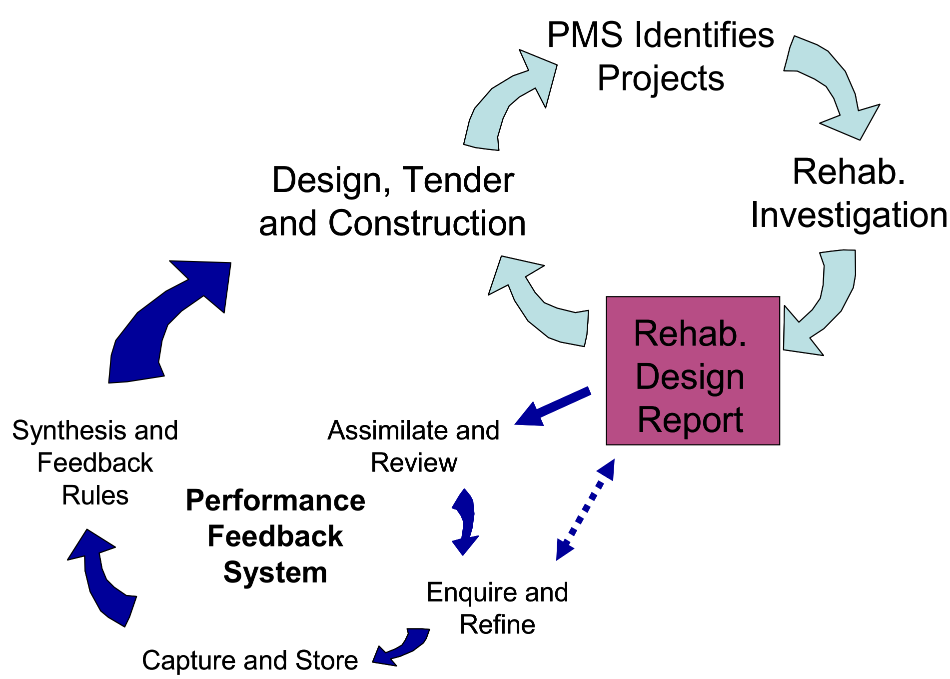

Figure 1: Approach to Performance Data Collection and Link with Existing Processes

The following outline provides a more detailed account of the process. Although this outline represents the typical approach to collate LTPP data, a similar approach was used for sections subjected to HVS testing.

(i) Identify candidate projects for first level data collection by liaison with client bodies. Obtain relevant information from consulting engineers, client representatives and contractors.

(ii) Review project information and evaluate the availability and quality of historic data. In some cases it may be feasible to spend time to locate information, if available, from previous maintenance or rehabilitation contracts. Based on this review the project is accepted or rejected for a detailed study and inclusion into the database.

(iii) Obtain outstanding information from client bodies or responsible firms if necessary. In many cases this task would involve a request for information in electronic format, e.g. Pavement Management System records.

(iv) Order and refine available information for inclusion in the database and populate the database. The nature of this task creates an opportunity to conduct quality control checks of the data. Electronic capturing of the data may be necessary if information is only available in hard format.

(v) Study and synthesize information to provide pavement construction, maintenance and performance history.

(vi) Study the latest known road condition and make an assessment of the road condition at the time of study or latest rehabilitation investigation. Depending on the quality and availability of historic data, determine when the road first exhibited the condition under investigation.

(vii) Study historic traffic data, and use typical ranges of loading intensity as well as observed growth rates to estimate a likely range of Equivalent Standard Axles (ESA's) accommodated in the time taken for the condition under consideration to be reached.

(viii) Synthesize information to obtain a summary of (1) the pavement as originally constructed; (2) the likely range of ESA's accommodated by the road; (3) the maintenance history of the road; and (4) the condition of the road at the time under consideration.

(ix) Identify missing data or anomalies and meet or discuss with consultants (or other relevant parties) to obtain missing information, validate data, and test reasonableness of interpretations or assumptions. Update existing information.

(x) Store data in internet-based PPIS.

2.2 Framework for Data Collection and Documentation

The framework for collection and storage of performance data is dictated by available data types. A spreadsheet format was selected to be compatible with typical database formats. **Table 1** shows the data types with typical data fields compiled for each road.

Table 1: Framework for Collection and Documentation of Datasets

Data Tables/ Sheets	Data Fields/ Columns (Illustrative, selected fields shown)
Traffic	Date, Station No., Lanes, AADT, AADTT, E80 factor
Materials	Date, Position, Start Depth, End Depth, Sieve Size, GM, PI, CBR
DCP	Date, Start Depth, End Depth, Thickness, Layer DN
Visuals	Date, Section Start, Section End, Defect_Degree, Defect_Extent
Ride and Rut	Date, Section Start, Section End, Lane, IRI_L, IRI_R, Rut_L, Rut_R
Deflection	Date, Position, Load, D0, D200, D300, D450, D600, D900, D1500

Performance summary reports were produced from synthesised information available for each performance section. The short, 5 to 10 page, summaries contain the following information:

(i) Reference information;
(ii) Description and scope;
(iii) Physiography and geology;
(iv) Pavement Structure and maintenance history;
(v) Past traffic loading;
(vi) Materials investigation;
(vii) Pavement performance indicators;
(viii) Summary and concluding remarks, and
(ix) Information queries and suggestions.

2.3 Selection and Appropriateness of Performance Sections

A total of 50 pavement sections were targeted to produce a database of sufficient size to allow repetition of similar structures, therefore increasing the confidence in the observed performance. A pavement section data matrix was compiled which includes the basic elements of the data collection and documentation frameworks.

The matrix elements listed in **Table 2** provide a basis to define "a section", namely different location, pavement structure, climatic conditions, age, and traffic. It should be noted that "Condition" does not form part of this matrix as it was assumed that the process will produce sections that are distressed. In some instances, it would have been possible to evaluate the same section in terms of different condition stages, i.e. if a "Severe" condition was reached then the standard axles accommodated to reach a "Warning" condition may also be investigated. In this project, different condition stages of the same section have not been listed as separate sections. These data are, however, available and may be included to complement the performance database.

Table 2: Pavement Information System Data Matrix

Data Type	Matrix Elements
General Information	Long Term Pavement Performance (LTPP) section/ Heavy Vehicle Simulator (HVS) test section; Road Name; Location
Pavement Type	Full-depth Granular; Granular Base-Cemented Subbase; Cemented Base; Asphalt Base; Bitumen Stabilized
Climate (TRH4)	Wet; Moderate; Dry
Age (years)	< 10; 10 – 20; 20 – 30; > 30
Traffic (MESA)	< 1; 1 – 3; 3 – 6; 6 – 12; 12 – 30; >30 Million Equivalent Standard Axles

The pavement data matrix was progressively populated to keep track of selected sections and to guide the selection process. In addition the following criteria were used to select appropriate sections:

(i) LTPP sections were mainly selected from information on recently completed rehabilitation investigation projects. These roads would have reached some stage of deterioration that required rehabilitation and, if recent, data would probably be available in electronic format. Some of the BSM sections were not yet up for rehabilitation investigation, therefore the data were collected from as-built and performance records.

(ii) It was attempted to select HVS tests that had been located on sections that were recently investigated or rehabilitated, and vice-versa.

(iii) Sections that exhibit an obvious history of problems, or that previously received heavy rehabilitation and/or geometric upgrades, excluding complete reconstruction, were avoided.

(iv) Availability and quality of information was a key consideration.

Upon completion of the project a total of 61 sections have been included in the PPIS. **Table 3** summarises the representation of the information. The sections representing Bitumen Stabilised Materials (BSM) are relatively high because the documentation of these sections formed part of a different project (Long and Jooste, 2007) dedicated to BSM performance, that were included to complement the PPIS. **Table 3** indicates that the basic data types and ranges are well-represented by the PPIS.

Table 3: Representation of Information

Data Type	**Percentage Representation**				
LTPP vs HVS	LTPP (82%)		HVS (18%)		
Pavement Type	G/G (23%)	G/C (21%)	CB (15%)	AB (13%)	BSM (28%)
Climate (TRH4)	Dry (15%)	Moderate (51%)	Wet (34%)		
Age (years)	< 10 (8%)	10 to 20 (30%)	20 to 30 (34%)	> 30 (28%)	
Traffic (MESA)	< 1 (13%)	1 to 3 (28%)	3 to 6 (21%)	6 to 12 (15%)	12 to 30 (23%)

Legend: LTPP - Long term Pavement Performance; HVS - Heavy Vehicle Simulator; G/G - Full-depth Granular; G/C - Granular Base/ Cemented Subbase; CB - cemented base; AB - Asphalt Base; BSM - Bitumen Stabilised Base; MESA - Million Equivalent Standard Axles

3. WEB-BASED PERFORMANCE INFORMATION SYSTEM

This section introduces the Pavement Performance Information System (PPIS) user interface and provides background on the methods made available to utilize the data. The PPIS website can be visited at www.sapdm.co.za.

3.1 Introduction (Home Page)

Figure 2 shows the PPIS Home Page environment and illustrates the main features accessible from this page. The Home Page introduces the PPIS and makes provision for users to register. Additional information provided includes:

- Project History;
- Data Collection Methodology;
- Pavements from Design Catalogues, and
- How to Use This Site.

Three additional views can be accessed through tabs provided at the top of the page, viz:

- Table View;
- Graphical View, and
- Feedback.

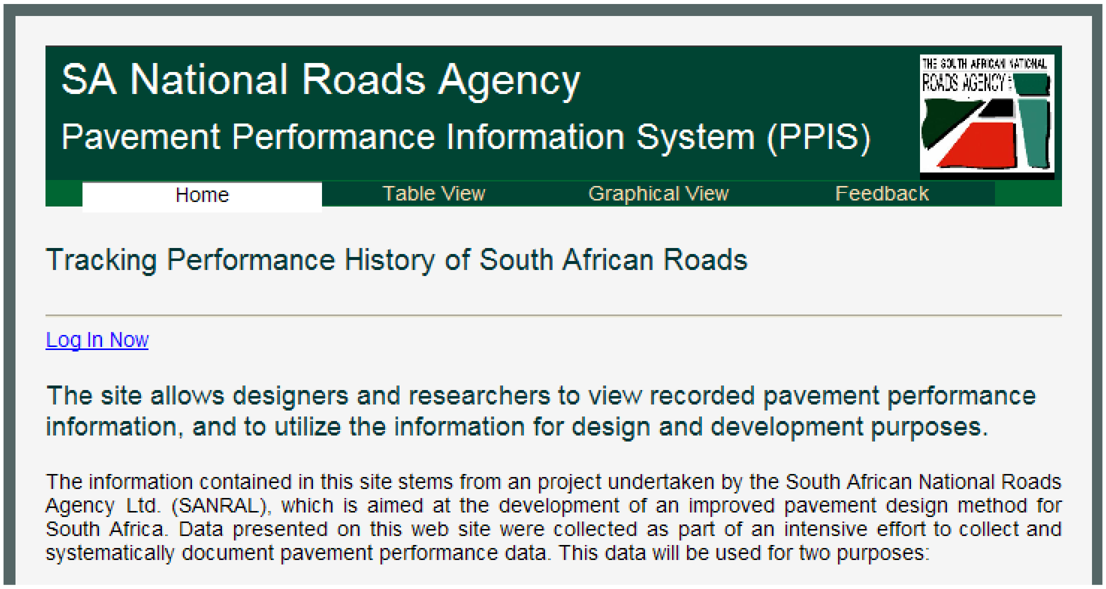

Figure 2: SANRAL PPIS Home Page

3.2 Table View

Figure 3 illustrates the Table View environment (**Figure 3** is only illustrative of the environment and not intended as readable text). This feature allows viewing of the pavement performance data in a table format.

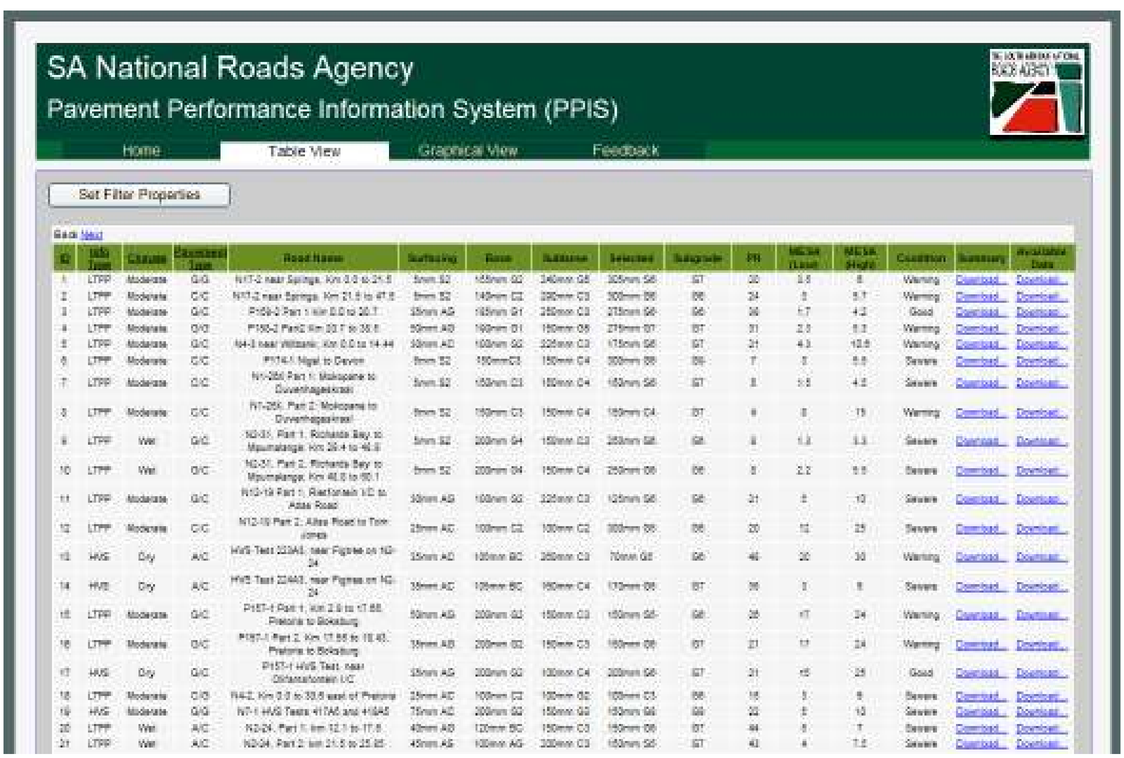

Figure 3: Table View

Each row represents a pavement performance section or structure with columns representing key information such as pavement type, pavement age, traffic accommodated etc. The last two columns contain links to downloadable data, namely, the performance summaries (in .pdf format) and available data (in .xls spreadsheet format). The summaries and data set formats were discussed in Section 2.2.

The “Set Filter Properties” option in the left top corner of the table opens the window shown in **Figure 4**. This database feature enables the user to refine the view by selecting only the data types of interest. The primary options are self-explanatory, while the codes selected for pavement types are as follows:

- G/C Granular Base over Cemented Subbase
- G/G Granular Base over Granular Subbase (i.e. full-depth granular)
- C/G Cemented Base over Granular Subbase
- C/C Cemented Base over Cemented Subbase
- A/C Asphalt Base over Cemented Subbase
- BSM/G Bitumen Stabilised Material Base over Granular Subbase
- BSM/C Bitumen Stabilised Material Base over Cemented Subbase

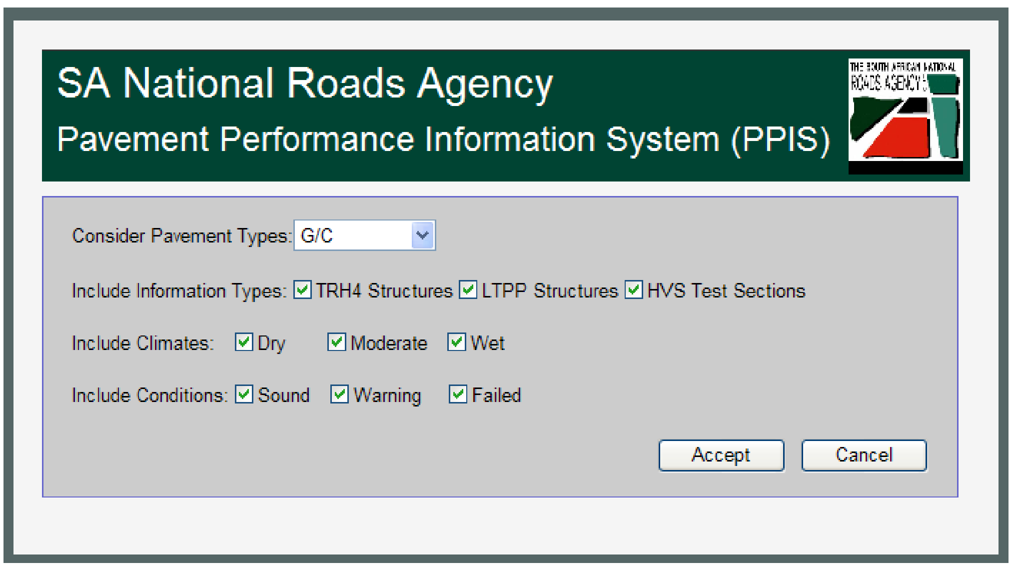

Figure 4: Set Filter Properties

3.3 Graphical View

Figure 5 shows two windows that are used to display performance data. The left hand window presents the performance data graphically in an X-Y plot. In this plot, each point represents a performance section or structure. The graph is interactive and if the curser is moved to one of these points, a short name for the section pops up as shown, i.e. N3-4 HVS in this illustration. If selected, details of the section under consideration are displayed in the window on the right hand side.

Several buttons are provided at the top of the page which includes the “Set Filter Properties” button. This option takes the user to the window previously shown in **Figure 4** and allows data filtering. The user can also select the way in which the traffic loading is presented, viz.,

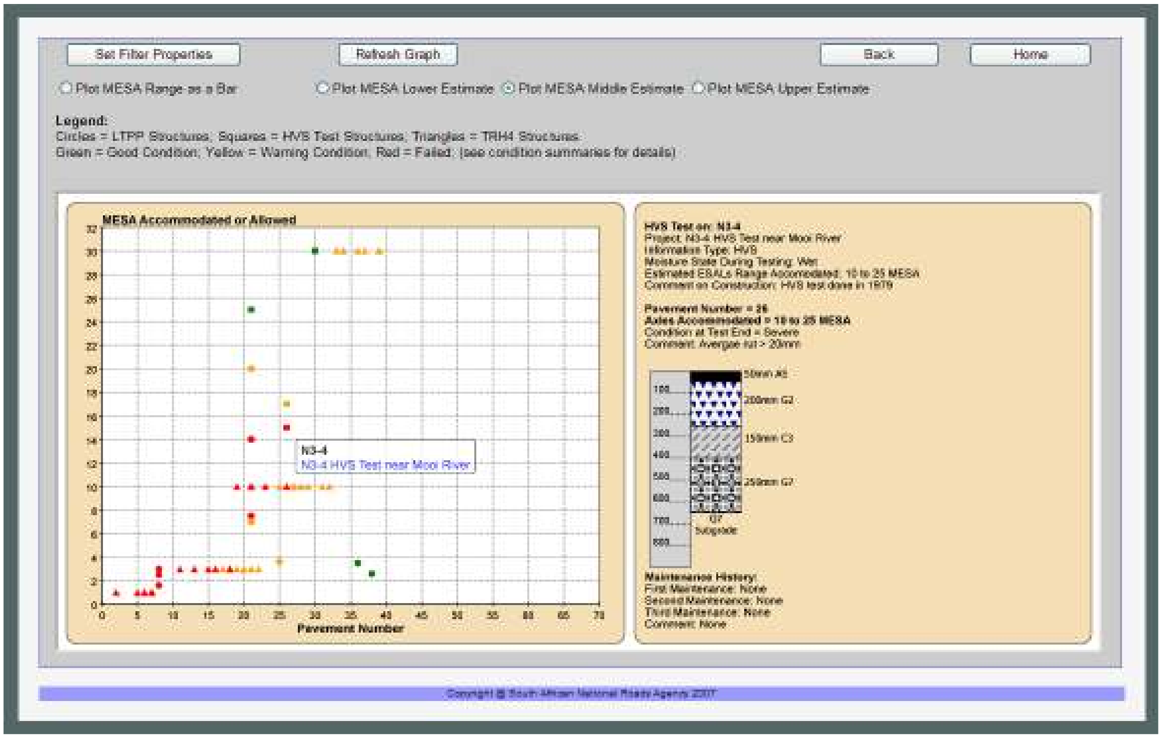

Figure 5: The Graphical View

as a range, the highest, middle, or lowest estimates. The "Refresh Graph" button applies the selection. In the illustrated X-Y plot, the Pavement Number (PN) appears on the X-axis and represents the geometric and materials make-up of the structures contained in the PPIS database. The Y-axis represents the estimated traffic accommodated by each section. The PN-concept allows the overall structural capacity of a pavement to be represented by a single number, where higher pavement numbers corresponding to stronger pavements. The method for calculating a pavement's PN is such that the number takes account of layer types, layer thicknesses and layer placement. Specifically, the method ensures that lower PN values are assigned where unbound layers are supported by weaker materials. The development and details of the PN-concept are discussed by Jooste and Long (2007) and Asphalt Academy (2009).

It is important to note that in the PPIS context, the PN value and estimated traffic loading are determined independently, i.e. traffic loading (or structural capacity) is not calculated as a function of the pavement structure, which is traditionally the case in a design situation. *The application of the PN value in the current context is therefore not as a design tool but as a convenient means to view the data.*

Apart from LTPP and HVS data, other sources of performance data may also be included. At present, a number of structures from the South African TRH4 Design Catalogue have been included. These structures are deemed to be well-proven in terms of their long term performance.

Different symbols are used to represent data from different generic sources as explained below.

- Squares (□) HVS data
- Dots (○) LTPP data
- Triangles (Δ) Catalogue structures

The colour of the symbols reveals the condition of the section under consideration:

- Green Sound
- Orange Warning
- Red Failed

To illustrate data interpretation using this feature, two aspects of the Graphical View are discussed, termed horizontal and vertical data trends. Consider the X-Y plot of TRH4 structures presented in **Figure 6**. The horizontal trends suggest that different structures essentially produce the same structural capacity (traffic allowed). These trends should be viewed from a design perspective and represent the structures required for different operational conditions, such as climate, subgrade support, and the desired design reliability. Pavements operating under dryer moisture regimes, or with stronger subgrades, or generally of lower risk, require a lower order structure and tend to "move" to the left. In turn, pavements operating under moderate or wet conditions, or with weaker support, or with higher risk applications require a higher order structure, and tends to "move" to the right.

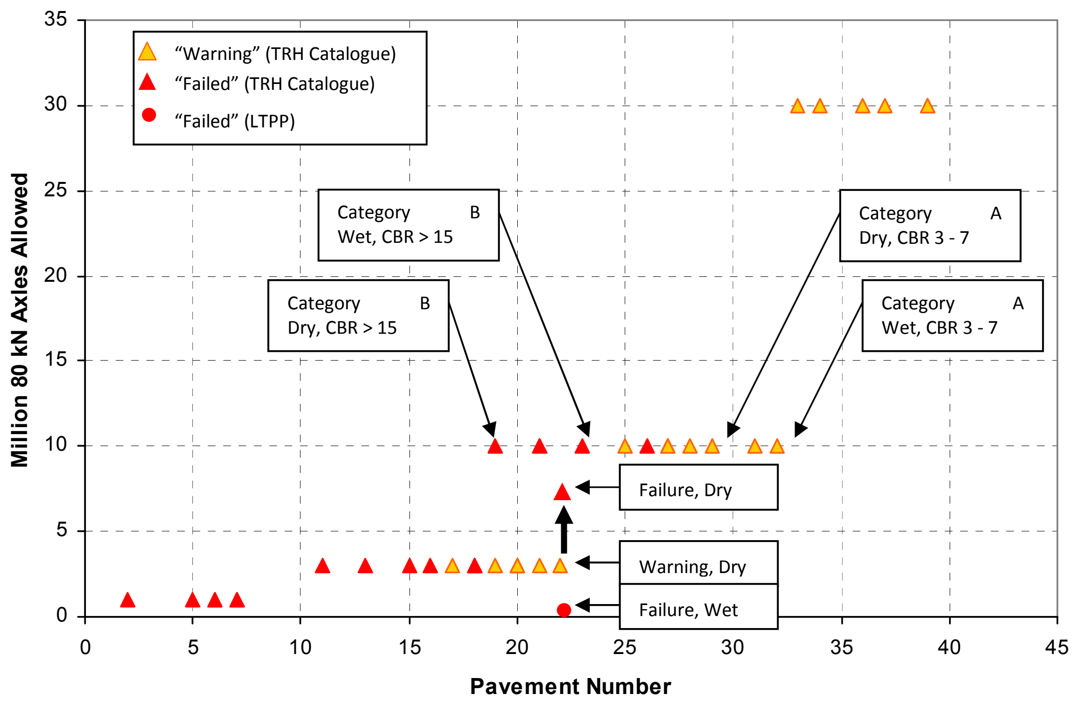

Figure 6: Interpretation of General Trends

Note that for TRH structures, a "warning" (yellow) condition is assigned where 5 percent failure is allowed at the end of the structural design period (TRH4 Category A), while "failure" (red) is assigned where 10 percent failure is allowed at the end of the structural design period (TRH4 Category B). For LTPP and HVS sections, a "warning" state means that the traffic loading may still increase towards a terminal condition as shown in the figure. The data are valuable even if a pavement is in a "sound" condition as it represents a level of minimum expected performance. Trends exhibited by these points should therefore be viewed as *performance frontiers* and it is not always appropriate to analyse the data by means of regression analysis. Furthermore, structures with the same apparent capacity may have performed differently due to the impact of environmental effects. For example in **Figure 6**, the fictitious pavement represented by the red dot failed earlier than expected based on the proposed performance of other structures with the same PN. In this illustration, the structure may have been subjected to wet environmental conditions.

4. PPIS DATA TREND EXAMPLES

One of the primary objectives of the development of a PPIS is to provide a solid empirical base from which new models of material behaviour and performance can be validated and calibrated. This section illustrates the potential application of the PPIS by analysing data for two selected pavement types, namely, Full-Depth Granular Pavements and Granular Base – Cemented Subbase Pavements.

4.1 Full-Depth Granular Pavements

Table 4 shows 13 PPIS sections that comprise Full-Depth Granular Pavements. **Figure 7** displays the data in graphical form. General observations and trends are outlined below:

- The data indicates a good general correlation between traffic loading accommodated and calculated PN values.
- Three HVS test sections are included, one from Road N7-1 and two from Road TR77-1. Although the corresponding LTPP sections were investigated in all cases, the N7-1 HVS test occurred after the structure received an overlay in 2000.

Table 4: Full-Depth Granular Sections

PPIS ID	Info Type	Road	Climate	Prob. MESA	PN	Structure				
1	LTPP	N17-2	Moderate	4.8	20	S2	155G2	240G5	305G6	G7
7	LTPP	N1-26X	Moderate	3.0	9	S2	150G4	150G5	150G6	G7
24	LTPP	TR16-3	Dry	0.9	10	S4	100G3	100G5	150G6	G6
25	LTPP	TR16-3	Dry	0.4	8	S4	100G4	100G5	150G6	G7
26	LTPP	N1-16	Dry	5.0	16	S2	200G3	150G5	150G5	G5
32	HVS	N7-1	Mod*	7.0	22	75AC	200G2	150G3	150G8	G8
33	LTPP	N7-1	Moderate	5.5	16	25AC	200G3	150G5	150G7	G7
34	LTPP	N7-1	Moderate	2.7	14	S4	200G3	150G5	250G7	G8
35	HVS	TR77-1	Dry*	6.0	18	S4	200G2	150G5	250G6	G7
36	HVS	TR77-1	Wet*	2	14	S4	200G2	150G5	250G6	G7
37	LTPP	TR77-1	Wet	1.4	16	25AC	200G3	150G4	150G7	G7
43	LTPP	Nata - 1	Dry/Mod	0.8	0	S2	150G6	150G6	150G6	G8
46	LTPP	Jwaneng - 2	Dry	0.4	3	S2	150G6	150G7	450G7	G7
Note: *Climatic indicators for HVS sections reflect the condition of the layer during testing. Where testing is conducted under natural in-situ moisture conditions, testing was considered “Dry”										

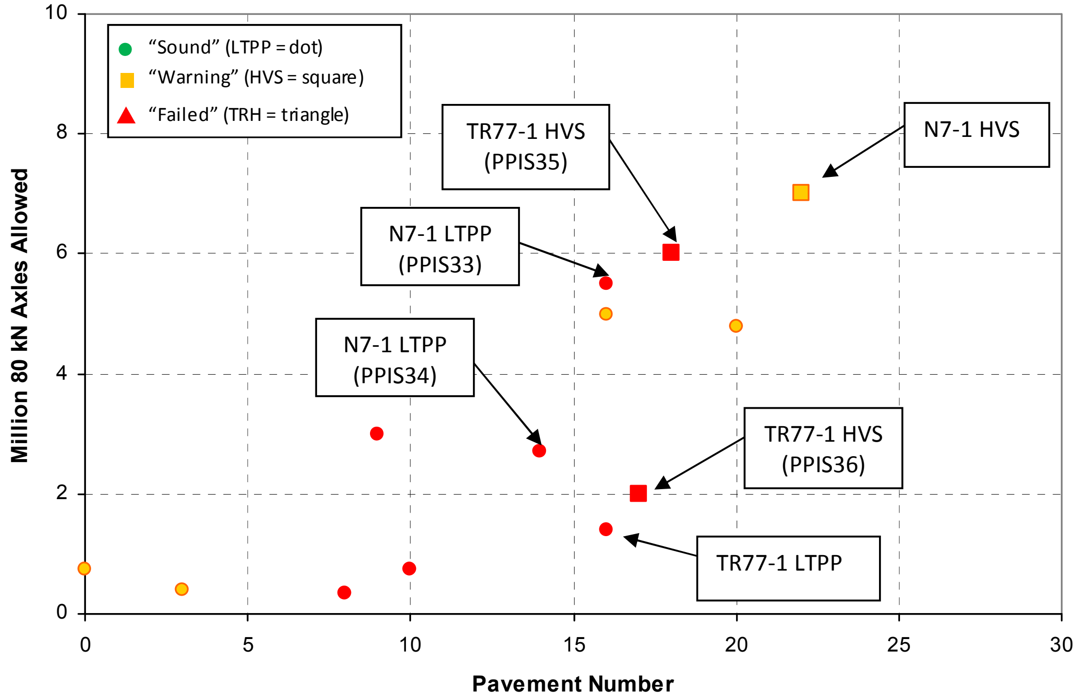

Figure 7: Full-Depth Granular Pavements

- The two N7-1 LTPP data points show that the relative performance of these structures is as expected. The performance exhibited by PPIS33, constructed in 1963, includes the effect of a 40 mm asphalt overlay constructed 18 years later. PPIS34 was constructed in 1982 and only received seals. The N7 HVS test section was conducted on a section that appears to comprise higher quality materials and after receiving 50 mm asphalt with a 19 mm Cape seal. The performance relative to the two LTPP sections therefore seems appropriate.
- The TR77-1 HVS sections are identical except for the fact that PPIS35 was tested dry and PPIS36 was tested wet. Apart from the slightly weaker LTPP structure, this section of TR77-1 only received one reseal late in its service life. Cracking and surface failures were recorded almost 10 years before the last reseal and for this reason it was assumed that the pavement, situated in a moderate climatic region, operated under wet conditions and accumulated excessive damage during rainy seasons. The data therefore suggest a good comparison between performance based on LTPP and HVS data.

Figure 8 shows the comparison between LTPP, HVS, and TRH4 Catalogue structures for full-depth granular pavements.

- For clarity, the TRH structures associated with 95 percent reliability are presented as "warning" and those with 90 percent reliability as "failed". A good general relationship exists between the different data sets.
- The LTPP data generally represent moderate climatic conditions, with the exception of N1-16 and the TR16-3 sections. Whilst the performance for the N1-16 section appears to be in order, the traffic loading accommodated by the TR16-3 structures seem somewhat low. It should be noted that for low volume roads, traffic data are usually sparse and it is possible that these estimates are somewhat low.

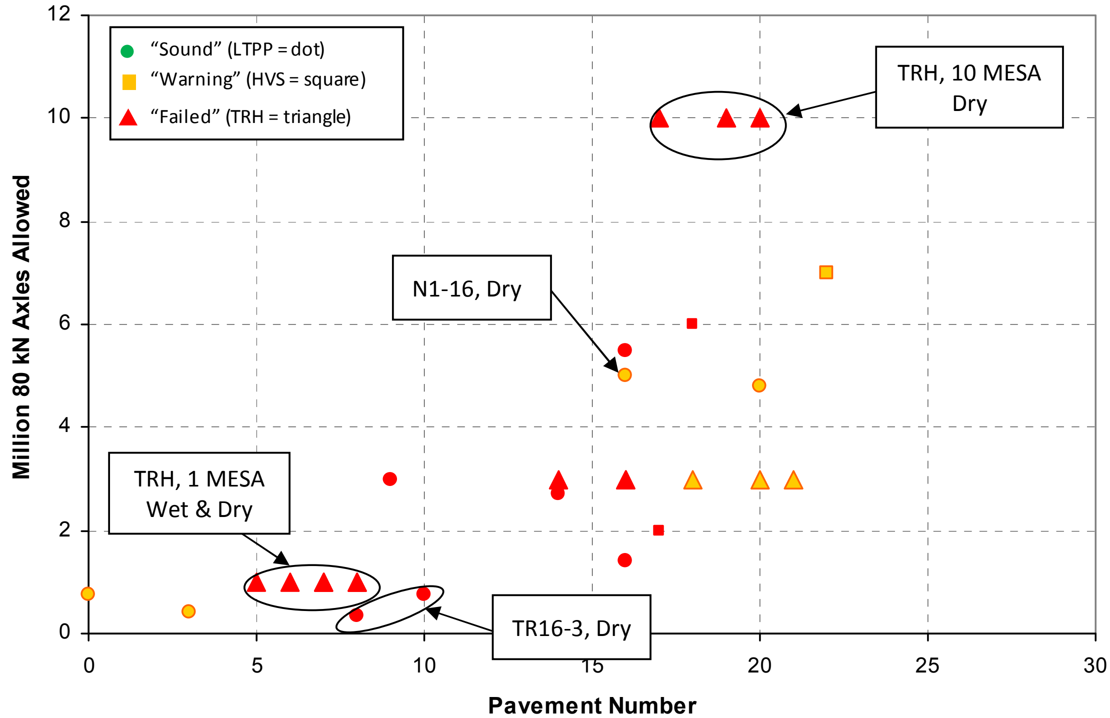

Figure 8: Full-Depth Granular Pavements including TRH Catalogue Structures

- The PN value of zero assigned to the Nata-1 section is due to the unconventional use of G6 (calcrete in this case) as a base material with relatively poor subgrade support. Despite the apparently weak structure, the pavement performed well which may be ascribed to the relatively dry climate. Again, traffic information for these low volume roads is limited.

Table 5 provides a summary of different statistics related to the PPIS sections with full-depth granular structures. A few aspects are highlighted.

- This type of pavement can accommodate up to a maximum of 10 MESA which is generally in line with the TRH4 guidelines.
- Bituminous double seals and Cape seals appear to be the most typical type of surfacing.
- As expected, the average layer structural qualities increase with an increase in traffic loading class.
- Most of the sections received two reseal treatments, on average every 10 years over a service period of 26 years. In a few instances 3rd and 4th reseal treatments were noted.

Table 5: Statistics for PPIS Full-Depth Granular Pavements

General

Section Type	All	LTPP	HVS
Total	100% (13)[1]	77% (10)	23% (3)
Dry (D)	31% (4)	31% (4)	0
Moderate (M)	54% (7)	46%(6)	8% (1)
Wet (W)	15% (2)	0	15% (2)
Sound (S)	0	0	0
Warning (W)	31% (4)	31% (4)	0
Failed (F)	69% (9)	46% (6)	23% (3)
< 1 MESA	31% (4)	31% (4)	0
1 – 3 MESA	31% (4)	23% (3)	8% (1)
3 – 10 MESA	38% (5)	23% (3)	15% (2)

Original Surfacing Type

Traffic (MESA)	Climate (%)			Condition (%)			Single Seal	Double Seal	Cape Seal	Asphalt 25-50 mm	Asphalt 50-75 mm
	D	M	W	S	W	F					
< 1	75	25	0	0	50	50	0	50% (2)	50% (2)	0	0
1 – 3	0	50	50	0	0	100	0	25% (1)	50% (2)	25% (1)	0
3 – 10	20	80	0	0	40	60	0	40% (2)	20% (1)	20% (1)	20% (1)
All	31	54	15	0	31	69	0	38% (5)	38% (5)	15% (2)	8% (1)

Compositional and Structural

Traffic (MESA)	Climate (%)			Condition (%)			Base Thickness (mm)[2]	Base Material[2]	Subgrade Cover (mm)[2]	Subgrade Material[2]
	D	M	W	S	W	F				
< 1	75	25	0	0	50	50	125	G5	485	G7
1 – 3	0	50	50	0	0	100	190	G3	555	G7
3 – 10	20	80	0	0	40	60	190	G2	585	G7
All	31	54	15	0	31	69	170	G3	545	G7

Maintenance Frequency

Traffic (MESA)	Climate (%)			Condition (%)			Age (years)[2,3]	1st Action (years)[2]	2nd Action (years)[2]	3rd Action (years)[2]	4th Action (years)[2]
	D	M	W	S	W	F					
< 1	75	25	0	0	50	50	27	11	10	6	-
1 – 3	0	50	50	0	0	100	25	11	8	4	4
3 – 10	20	80	0	0	40	60	27	12	10	-	-
All	31	54	15	0	31	69	26 (8)	11 (10)	9 (7)	5 (2)	4 (1)

Notes:

1. Brackets generally refer to number of sections that constitute statistic.
2. Average values/ class reported.
3. Age at time of last assessment.

4.2 Granular Base – Cemented Subbase Pavements

A total of 14 Granular Base with Cemented Subbase Pavements is included in the PPIS database. **Table 6** contains basic information regarding these sections and **Figure 9** presents the data graphically. A number of observations and trends are outlined below.

- The data generally exhibits a good correlation between the traffic loading accommodated and the calculated PN values. Two sections, namely P158-2 and MR174, are still in good condition and therefore the points representing these pavements are still "moving upward" and have not yet reached a terminal threshold. Of these two, MR174 is a relatively new pavement (11 years), while P158-2 has been exposed to low traffic intensities.
- Three HVS test sections are shown: P157-1, P157-2, and N3-4. Whilst matching LTPP sections exist for the two P157 sections, N3-4 received multiple overlays since early in its service life. For this reason, theN3-4 LTPP section is currently being considered as an asphalt base pavement and the comparison of performance with the HVS performance data is not valid
- The two P157 HVS test sections performed better than the corresponding LTPP sections. This is largely a result of construction as well as maintenance related problems. Both sections received only one reseal. By the time of the investigation, these seals were already 20 years old and both sections exhibited significant cracking. It can therefore be assumed that moisture ingress also played a role in the performance observed.
- It is known that short sections on Road P157-2 were reconstructed about 10 years after the initial construction. The P157-2 HVS section represents a reconstructed section while the P157-2 LTPP section represents the original structure. This LTPP section in particular has a history of problems related to poor construction and drainage.
- Based on the information provided, a relatively good comparison between LTPP and HVS sections exists.

Table 6: Granular Base – Cemented Subbase Sections

PPIS ID	Info Type	Road	Climate	Prob. MESA	PN	Structure				
3	LTPP	P158-2	Moderate	2.6	38	35AG	185G1	250C3	275G6	G6
4	LTPP	P158-2	Moderate	3.6	25	50AG	190G2	150C4	275G7	G7
5	LTPP	N4-3	Moderate	7.0	21	30AC	100G2	225C3	175G6	G7
9	LTPP	N2-31	Wet	1.6	8	S2	200G4	150C3	250G6	G6
10	LTPP	N2-31	Wet	2.5	8	S2	200G4	150C4	250G6	G6
11	LTPP	N12-19	Moderate	7.5	21	30AG	100G2	225C3	125G6	G6
19	HVS	P157-1	Mod*	25	21	35AG	200G2	100C4	200G6	G7
20	LTPP	P157-1	Moderate	17	26	50AG	200G2	150C3	150G5	G6
21	LTPP	P157-1	Moderate	17	21	35AG	200G2	150C3	150G6	G7
23	LTPP	N1-13	Dry	3	8	S4	200G4	150C3	150G5	G7
27	HVS	P157-2	Mod*	30	30	35AS	150G1	250C3	125C4	G9
28	LTPP	P157-2	Moderate	14	21	40AG	180G2	150C4	150G7	G7
29	HVS	N3-4	Wet*	15	26	50AS	200G2	150C3	250G7	G7
42	LTPP	MR174	Moderate	3.5	36	40AC	150G2	300C3	150G4	G7

Note: * Climatic indicators for HVS sections reflect the condition of the layer during testing. Where testing is conducted under natural in situ moisture conditions, testing was considered "Dry".

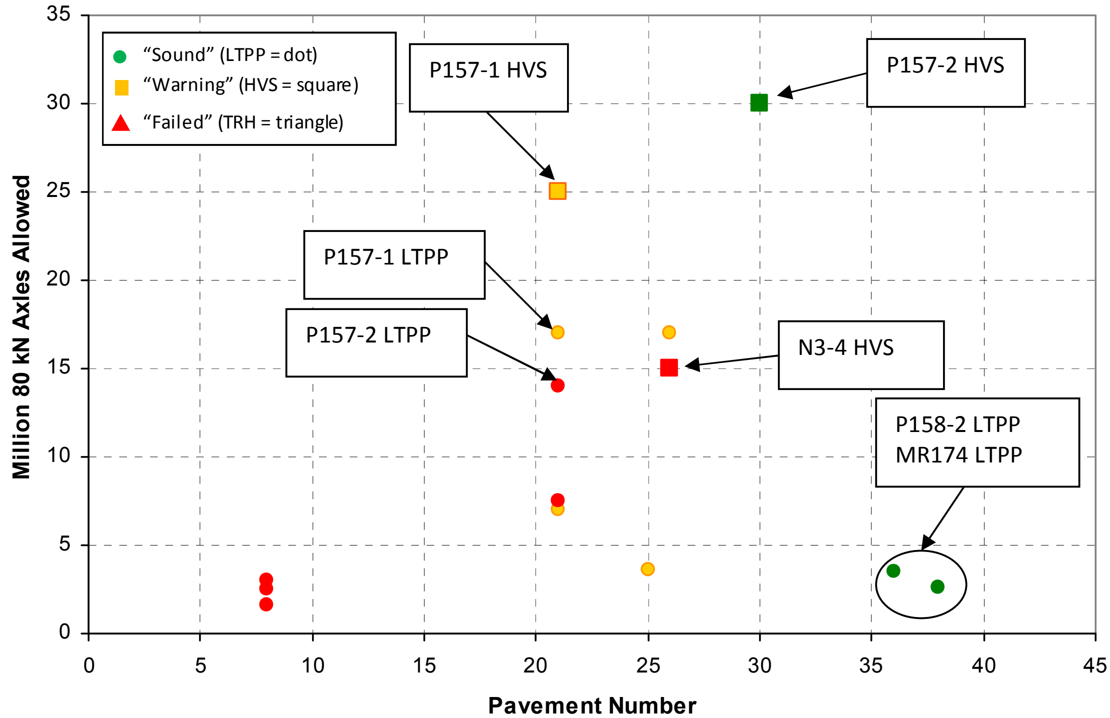

Figure 9: Granular Base – Cemented Subbase Pavements

The database of 14 sections were utilised to obtain the statistics presented in **Table** 7. Selected trends are summarised below.

- The highest traffic loading experienced by these pavements is between 10 and 30 MESA.
- Surfacing layers of all sections subjected to less than 3 MESA originally comprised bituminous double seals or Cape seals. Sections subjected to more than 3 MESA were all constructed with thin asphalt overlays of between 25 and 50 mm thick.
- As expected, the average layer structural qualities increase with an increase in traffic loading class.
- Most of the sections received first and second reseal actions, on average after 12 and 8 years, respectively. Some sections also received a 3rd treatment on average 4 years after the second treatment. It is evident that the frequency of required maintenance increases with time. Some sections were regarded as failed based on their maintenance requirements.

Table 7: Statistics for PPIS Granular Base – Cemented Subbase Pavements

General

Section Type	All	LTPP	HVS
Total	100% (14)[1]	79% (11)	21% (3)
Dry (D)	14% (2)	7% (1)	7% (1)
Moderate (M)	64% (9)	57% (8)	7% (1)
Wet (W)	21% (3)	14%(2)	7% (1)
Sound (S)	28% (4)	14% (2)	14% (2)
Warning (W)	28%(4)	28% (4)	0
Failed (F)	43%(6)	36% (5)	7% (1)
1 – 3 MESA	21%(3)	21% (3)	0
3 – 10 MESA	36%(5)	36% (5)	0
10 – 30 MESA	43% (6)	21% (3)	21% (3)

Original Surfacing Type

Traffic (MESA)	Climate (%)			Condition (%)			Single Seal	Double Seal	Cape Seal	Asphalt 25-50 mm	Asphalt 50-75 mm
	D	M	W	S	W	F					
1 – 3	33	0	67	0	0	100	0	67% (2)	33% (1)	0	0
3 – 10	0	100	0	40	40	20	0	0	0	100% (5)	0
10 – 30	20	80	20	33	33	33	0	0	0	100% (6)	0
All	14	64	21	28	28	43	0	14% (2)	7% (1)	79% (11)	0

Compositional and Structural

Traffic (MESA)	Climate (%)			Condition (%)			Base Thickness (mm)[2]	Base Material[2]	Subgrade Cover (mm)[2]	Subgrade Material[2]
	D	M	W	S	W	F				
1 – 3	33	0	67	0	0	100	200	G4	575	G6
3 – 10	0	100	0	40	40	20	145	G2	610	G7
10 – 30	20	80	20	33	33	33	190	G2	560	G7
All	14	64	21	28	28	43	175	G2	580	G7

Maintenance Frequency

Traffic (MESA)	Climate (%)			Condition (%)			Age (years)[2, 3]	1st Action (years)[2]	2nd Action (years)[2]	3rd Action (years)[2]	4th Action (years)[2]
	D	M	W	S	W	F					
1 – 3	33	0	67	0	0	100	26	11 (3)	9 (3)	2 (2)	1[4] (2)
3 – 10	0	100	0	40	40	20	25	10 (4)	7 (4)	7 (1)	1 (1)
10 – 30	20	80	20	33	33	33	29	14 (3)	12 (1)	-	-
All	14	64	21	28	28	43	27	12 (10)	8 (8)	4 (3)	1 (3)

Notes:

1. Brackets generally refer to number of sections that constitute statistic.
2. Average values/class reported.
3. Age at time of last assessment.
4. Frequent maintenance required.

5. CONCLUSIONS AND RECOMMENDATIONS

A total 61 performance sections were documented and data included in the PPIS database. The information system includes selected LTPP and HVS field sections, representing the performance of different pavement types, namely: full-depth granular pavements, granular base with cemented subbase pavements, cemented base pavements, asphalt base pavements, and bitumen stabilised pavements. The selection of the sections to study was determined by the available information, age, traffic accommodated and pavement structure. Frameworks for data collection and documentation were established, and is described in this paper. Performance summaries were produced for all sections and available project data captured in spreadsheet format. A user-friendly web-based database system was developed to make this information available to the industry. The data can be viewed and downloaded from the SANRAL PPIS website at www.sapdm.co.za. The paper demonstrates the potential use of the performance data by investigating some of the trends observed. Performance trends exhibited corroborate the validity of the approach and highlights the value of utilizing historical data from available systems. Industry can benefit from the PPIS in the following ways:

- Key trends in the performance data can be used to validate the basic behaviour models assumed for the development of the updated mechanistic-empirical design method. This process can be used to validate discrepancies in the design method at an early stage. Without the PPIS, the design method outcomes and its underlying models cannot be easily or readily verified and is likely to remain contentious and untested indefinitely.
- Through internet access to the PPIS, practitioners are able to test planned designs against the information in the performance database. The database therefore forms the basis to explicitly validate the performance that can be expected from a design concept.
- The PPIS also provides road owners with more certainty regarding the suitability and reliability of a proposed design.
- It is believed that the outputs from this study may also provide a platform from which the deterioration models for Pavement Management Systems can be developed and calibrated.

Since the data collection methodology was designed to tap into the project life-cycle, the process is ideal to implement in the long term utilizing available systems. Long term implementation of the system should increase the accuracy of observed performance trends; ensure that the data keeps up with changing traffic demands, materials, and operational trends; stimulate ongoing calibration of design models; and establish continued feedback between design and construction.

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