TRAFFIC LOADING CHARACTERISTICS OF SOUTH AFRICAN HEAVY VEHICLES

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ABSTRACT

Roads and railways are in a sense the arteries that keep the lifeblood of the economy flowing. Approximately 70 percent of freight moves by road in South Africa and it is growing by approximately four percent per annum. Data and information on heavy vehicle (HV) volumes and axle masses are therefore indispensable to road authorities for design and maintenance purposes.

Heavy vehicle data from three sources, namely 11 weigh-in-motion (WIM) scales at Traffic Control Centres (TCCs) on national roads N3 and N4, 34 WIM scales on some of the main national roads and 35 continuous traffic counting stations, was analysed.

Heavy vehicles were classified into 22 classes and average axle masses and spacings were calculated for these based on the N3 TCC data. Typical E_{80} values for the 22 classes were calculated using the average axle masses as well as the measured mass of each individual axle. It was found that the E_{80}-values from the latter method correspond well with the average values recommended in the TRH 16 (1991).

The composition of the HV population, i.e. percentage of 2-, 3-, 4-, 5-, 6- and 7+-axle HVs, was used to classify the main road network in SA into Low, Medium and High HV roads. On Low HV roads more than 55 percent of HVs are 2-axle HVs whereas on High HV roads less than 35 percent are 2-axle HVs. This classification can be used to transfer measured HV characteristics, such as E_{80}s/HV, from say one Low HV road to another Low HV road where such characteristics are unknown.

A methodology is also proposed on how to estimate traffic load spectra from the WIM data. Such load spectra can be used in the mechanistic design of road pavements.

Suggestions are also made on how the HV information can be used at weighbridges where HVs are visually directed to the weighbridge. Further analyses on HV data from other sources are recommended in order to confirm the conclusions in the paper or to modify them.

INTRODUCTION

Transport plays a significant role in the social and economic development of a country. After education it is the second most important catalyst in a country's economic and social development.

The Moving South Africa project (1998) adopted the view that transport should be seen as an enabling industry, i.e. it supports and enables government strategies for growth, development, redistribution and employment creation.

Roads and railways are the two physical infrastructure elements that constitute the backbone of land transport operations. In a certain sense they are the arteries which keep the lifeblood of the economy flowing.

In South Africa, like in many other countries, more freight moves by road than by rail. It is therefore essential that road design, construction and maintenance should keep track with the increase in heavy vehicle (HV) traffic and road freight tonnage.

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According to the Annual Transport Statistics (2002), South Africa's road network consists of more than 360 000 km of surfaced and unsurfaced roads. This represents one of the country's largest assets. Based on an average unit cost of R1,6 million/km for surfaced roads and R0,5 million/km for gravel roads the replacement cost of this asset is estimated at R250 billion. The distribution of axle masses of the heavy vehicles that will travel on the road network is therefore important information needed to protect and manage such an investment.

As part of the South African National Road Agency Limited (SANRAL)'s comprehensive traffic observation (CTO) programme, 45 weigh-in-motion scales (WIMs) were installed on those national roads carrying the most HV traffic. At these WIM sites data is collected on the number of HVs, the mass of each axle per HV class, axle spacings and date and time of arrival of the heavy vehicle.

The data from these WIM sites as well as from the Traffic Control Centres (TCCs) on the N3 (at Heidelberg) and the N4 (at Middelburg, Machadadorp and Komatipoort) and from ordinary traffic counting sites, are analysed in this paper with the aim of providing better information to road authorities to design, build and maintain a cost-effective and affordable road network.

OVERVIEW OF HEAVY VEHICLE TRAFFIC AND ROAD FREIGHT VOLUMES

Heavy vehicle traffic

According to the National Department of Transport's Annual Transport Statistics (2002) there is approximately 253,000 registered heavy vehicles with a gross vehicle mass(GVM) greater than 3.5t in South Africa. (Approximately 26 000 of these are buses). The number of HVs remained almost unchanged over the last three years and is equivalent to approximately 4 percent of all self-propelled vehicles in South Africa.

Road freight volumes

Approximately 70 percent of all freight in South Africa is carried by heavy vehicles. Figure 1 shows the trend of road and rail freight tonnage since 1974. Until 2000 road freight increased by approximately 4 percent per annum while rail freight only grew by 1,5 percent per annum.

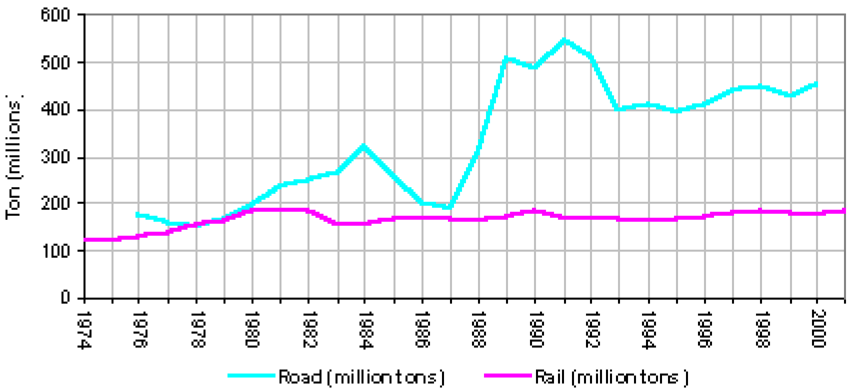

Figure 1. Road freight trends in SA.

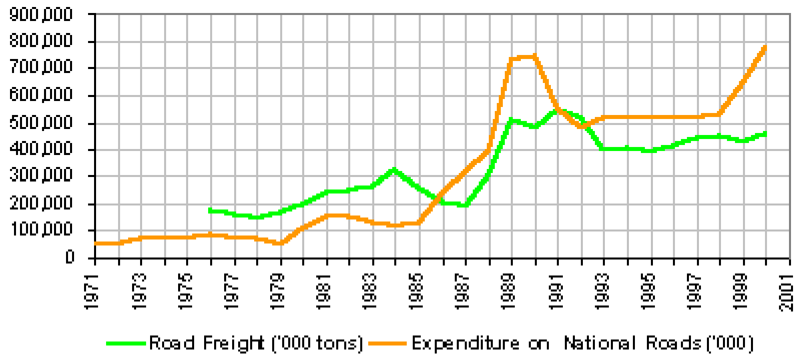

Figure 2. Correlation between expenditure on national roads and road freight.

Figure 2 implies that the road freight tonnage is closely related to the expenditure on national roads (correlation co-efficient = 0,9).

The above statistics, as well as the world trend in road freight movement, seem to indicate that it can be expected that heavy vehicles on South African roads will continue to grow.

This is further justification to use relevant and up to date heavy vehicle information for design and maintenance purposes of roads.

HEAVY VEHICLE DATA SOURCES

Heavy vehicle data from three sources was used, namely:

- The WIM scales at the TCCs at Heidelberg(N3), Middelburg(N4), Machadadorp(N4) and Komatipoort(N4) (also referred to as TCC WIM sites)
- The WIM scales at sites other than at TCCs (34 in total); and
- Continuous traffic counts at various sites on national roads (approximately 300).

The WIM data is regarded as the main data source and the traffic counts as a secondary source.

The data from the TCCs was used to classify the heavy vehicles into seven main classes consisting of various sub-classes. The same data was also used to calculate typical axle masses and axle spacings for each sub-class, E_{80}-values, and a full spectrum of traffic loads.

The data from the "non-TCC" WIM sites as well as from the traffic counting sites was used to classify the national road network according to HV composition and to determine which HV classes are more likely to be overloaded. Legal axle and gross vehicle masses are defined in Regulations 231 to 249 of Part IV of the National Road Traffic Regulations (2000).

HEAVY VEHICLE CLASSES

Schildhauer (2001) described four different vehicle classification systems being used in South Africa. The simplest of these, the Light/Heavy Classification System only distinguishes between light and heavy vehicles. The extended Light/Heavy Classification System classifies the heavy vehicles into Short, Medium and Long Heavy Vehicles. (A Short HV≤10m, 16.8m≤Medium HV>10m and a Long HV>16.8m.) The RSA Toll Classification System distinguishes between light vehicles, 2 axle heavy vehicles, 3 or 4 axle heavy vehicles and 5 or more axle heavy vehicles. The classification system used by SANRAL, which is different from the Toll Classification System, consists of 4 main classes that are divided into sub-classes resulting in 17 different sub-classes.

More than 2.1 million heavy vehicles have been weighed at the 11 WIMs on the N3 and N4 TCC sites between February 2002 and September 2003. More than 130 different axle configurations could be identified from the heavy vehicles weighed at these sites. For the purposes of this paper only axle configurations representing 0.5 percent or more of the total heavy vehicle population at a WIM site were used to compile a HV classification system.

The proposed classification system consists of seven main classes (i.e. 2, 3, 4, 5, 6, 7 and 8 axles heavy vehicles) which are divided into twenty-one sub-classes.

The notation used in the paper to identify a particular heavy vehicle sub-class is as follows:

- A class 6:1-2-3 represents a six axle heavy vehicle consisting of a single front axle followed by a tandem axle unit (normally the truck-tractor) which is followed by a tridem axle unit (normally an articulated trailer).
- A class 3:1-1-1 for example is a three axle heavy vehicle consisting of three single axles. Axles two and three would probably have dual wheels.

Table 1. HV classes as a percentage of the total HV count at TCCS on the N3 and N4.

NO OF AXLES & HV CLASS		HV SUB-CLASS (%) AT DIFFERENT TCCs										
		HEIDELBERG (N3) (Feb'02-Sept'03)		**KOMATIPOORT (N4) (Mar'03-Sept'03)**		**MACHADODORP (N4) (Mar'03-Sep'03)**		**MIDDELBURG (N4)(Mar'03-Sep'03)**		**MIDWIT(R555/R575) (Mar'03-Sep'03)**		
		(N)	**(S)**	**(E)**	**(W)**	**(E)**	**(W)**	**(E)**	**(W)**	**(E)**	**(W)**	**(N)**
2	1-1	19,5	21,5	34	32	25,5	31	32	34,5	43,5	51	50
3	1-1-1	2	2,5	3,5	1,5	4	5,5	6	7,5	3	3,5	6
	1-2	4	5	6,5	10,5	4	4,5	6,5	5	4,5	4,5	4
4	1-1-1-1	1	1,5	2	2	1,5	1	1,5	0,5	0,5	0,5	0,5
	1-1-2	3,5	4,5	2,5	2	3	2,5	3	3,5	3	2,5	3
	1-2-1			0,5	0,5	0,5	0,5	0,5	0,5			0,5
	1-3										0,5	
5	1-1-2-1	0,5	1									
	1-2-1-1			1	1	0,5	0,5	0,5	0,5	0,5	0,5	0,5
	1-2-2	3,5	3,5	4	4,5	5	3,5	5,5	5,5	8,5	7,5	5
	1-1-3	1,5	1	0,5	0,5	1	1	3,5	2	11,5	9	7,5
6	1-1-2-1-1	0,5	1									
	1-1-2-2	0,5	1									
	1-2-1-2			0,5	0,5			0,5	0,5	0,5	0,5	0,5
	1-2-2-1	1	1			1	0,5	0,5	0,5			
	1-2-3	21	20	15	20	18	16,5	13,5	15	9	7	10
7	1-2-2-1-1	0,5	0,5			1	1		0,5	7,5	5,5	4
	1-2-2-2	36	32	19	22,5	29	25	17	17,5	6,5	5	7,5
	1-2-4			0,5	0,5							
8	1-2-2-3	1,5	1,5	0,5	1	1	1	0,5	1			
	1-2-3-2	2,5	2,5	0,5		3	3	2,5	2,5	0,5	0,5	1
	1-3-2-2			0,5								
TOTAL HV COUNT		**371 565**	**292 723**	**102 827**	**55 255**	**98 608**	**167 989**	**225 693**	**196 467**	**262 001**	**270 142**	**79 559**

red	**≥10%**
green	**≥5% <10%**
yellow	**>1% <5%**
white	**≤1%**

Typical axle masses and axle spacings of heavy vehicles in SA

Table 1 gives a summary of the HV sub-classes at the different TCCs. Each sub-class is expressed as a percentage of the total heavy vehicle population at the TCC. Percentages of 10 or more are shown in red. Percentages of 5 but less than 10 are shown in green. Those less than 5, but more than 1 are shown in yellow.

The following three HV classes represent 70 percent of all the HV traffic at the TCC WIM sites on the N3 and N4.

- Class 2:1-1
- Class 6:1-2-3
- Class 7:1-2-2-2

General

Traffic loads are the most important variable actions to be accounted for in the design of road pavements and bridges. Axle mass is probably one of the main factors that determine the effect of traffic loads on pavements. In the case of bridges it is not only the axle mass, but also the spacing between axles, that determines the effect of traffic loads on the different structural elements.

In the following sub-sections average axle masses and axle spacings will be determined for the HV classes in Table 1 as measured at the Heidelberg TCC(N3). (Similar calculations on the data from the other TCCs will be presented at the symposium).

Average axle masses and axle spacings

To determine average axle masses for a specific heavy vehicle class, say a 3:1-1-1, the masses of all the first axles of that HV class were grouped. Similarly the second and third axle masses were grouped together. From this it was then possible to determine various statistical parameters, such as the mean, median, standard deviation, skewness of the axle population and maximum and minimum axle masses.

A similar exercise was done for the axle spacings.

Average axle masses and axle spacings for the HVs measured at Heidelberg TCC are given in Table 2.

The distribution of axle masses of a Class 3:1-2 HV is shown in the histograms in Figures 3 (a) and (b).

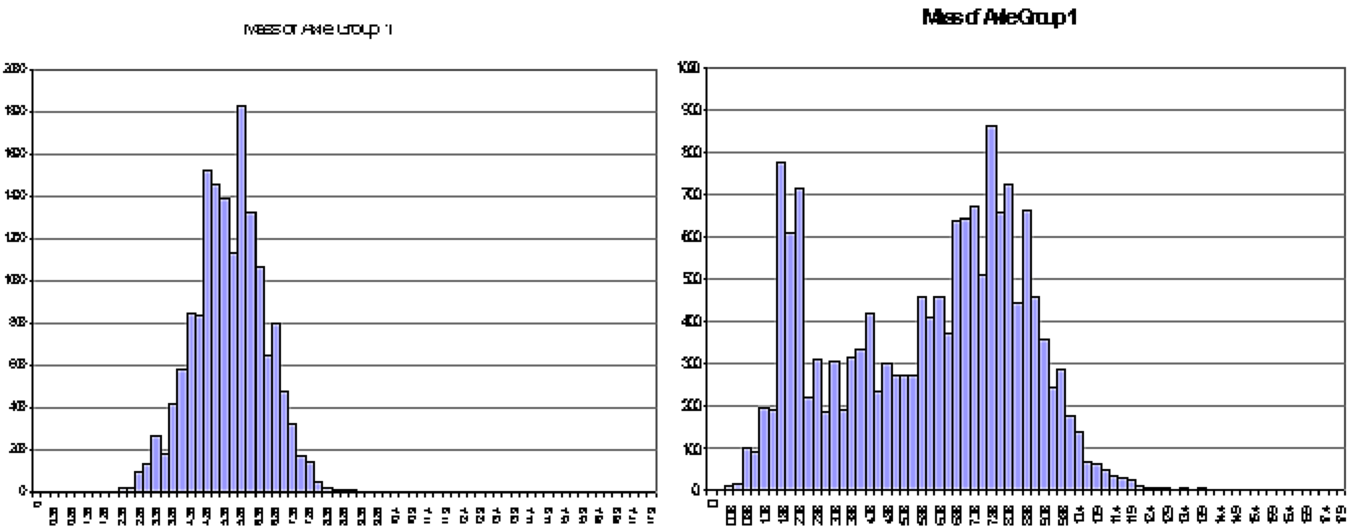

Figure 3a and b. Histograms of the mass of the first (a) and second (b) axles of all the Class 3: 1-2 HVs at Heidelberg.

The histogram of the first axle's (steering axle) mass of a Class 3:1-2 HV has a relative narrow base and a well defined peak at approximately 5,5 t with a standard deviation of approximately 1 t. Refer to Figure 3(a)

The histogram of the second axle's mass has a very wide basis and two peaks. The first peak of approximately 2,5 t represents the average mass of the second axle of an unloaded Class 3;1-2 unloaded HV.

The second peak at approximately 8,5 t represents the average mass of a loaded Class 3;1-2 HV. Refer to Figure 3(b)

The axle spacings of a Class 3;1-1-1 HV and a Class 3 :1-2 HV are combined and shown diagrammatically in the histograms in Figure 3(a) and(b).

Table 2. Average axle masses and axle spacings of heavy vehicles at the Heidelberg TCC.

HEAVY VEHICLE CLASS	AVERAGE MASSES (t) & *SPACINGS (m)***								E_{80}* PER HV CLASS
	1	2	3	4	5	6	7	8	
2:1-1	3.9	5.5							**0.32**
	5.1								
3:1-1-1	3.8	5.1	3.6						**0.30**
	4.2	***7.1***							
3:1-2	5.6	6.3	4.4						**1.1**
	5.3	***1.3***							
4:1-1-1-1	4.6	6.2	4.5	3.9					**0.70**
	5.1	***5.8***	***6.5***						
4:1-1-2	4.8	6.2	4.6	4.0					**0.82**
	3.8	***7.6***	***1.3***						
4:1-2-1	5.4	6.6	5.0	3.8					**1.25**
	5	***1.4***	***7***						
5:1-1-2-1	5.3	6.4	4.9	4.6	5.1				**1.24**
	3.4	***7.2***	***1.4***	***7.5***					
5:1-2-1-1	5.6	6.2	5.6	4.4	4.4				**1.42**
	5	***1.4***	***4.9***	***4.9***					
5:1-2-2	5.8	6.3	5.4	5.0	4.8				**1.67**
	3.7	***1.4***	***7***	***1.3***					
5:1-1-3	6.1	7.2	5.8	4.6	5.1				**2.00**
	3.5	***6.1***	***1.4***	***1.4***					
6:1-1-2-1-1	5.4	6.4	6.0	5.0	4.5	4.3			**1.56**
	3.6	***5***	***1.3***	***3.8***	***4.5***				
6:1-1-2-2	5.4	6.9	4.9	4.4	4.6	4.2			**1.46**
	3.5	***6***	***1.3***	***6.7***	***1.3***				
6:1-2-1-2	6.1	6.9	6.4	5.7	5.2	4.9			**2.54**
	4.0	***1.4***	***6.2***	***3.9***	***1.5***				
6:1-2-2-1	6.1	7.2	6.8	6.0	6.0	6.1			**3.37**
	3.2	***1.4***	***7.4***	***1.4***	***2.6***				
6:1-2-3	5.9	7.0	6.6	5.8	5.7	5.8			**2.94**
	3.3	***1.4***	***6.8***	***1.4***	***1.4***				
7:1-2-2-1-1	5.7	6.2	5.8	6.0	5.6	5.7	5.6		**2.47**
	3.3	***1.4***	***5.6***	***1.4***	***3.7***	***4.5***			
7:1-2-2-2	6.1	6.9	6.5	6.9	6.6	6.5	5.9		**3.78**
	3.2	***1.4***	***6***	***1.4***	***6.1***	***1.4***			
8:1-2-2-3	6.1	6.1	5.8	6.2	6.0	5.2	4.6	4.4	**2.78**
	3.2	***1.4***	***5.5***	***1.4***	***5.9***	***1.4***	***1.4***		
8:1-2-3-2	6.0	6.6	6.2	5.8	5.4	5.5	5.2	4.7	**2.93**
	3.2	***1.4***	***6.1***	***1.4***	***1.4***	***5.1***	***1.4***		
8:1-3-2-2	6.1	4.5	5.4	6.8	7.0	6.6	6.4	3.1	**3.57**
	2.7	***1.2***	***1.2***	***6.0***	***1.4***	***6.3***	***1.4***		

* Relative damage exponent used in power law = 4

** Figures in italics refer to axle spacing

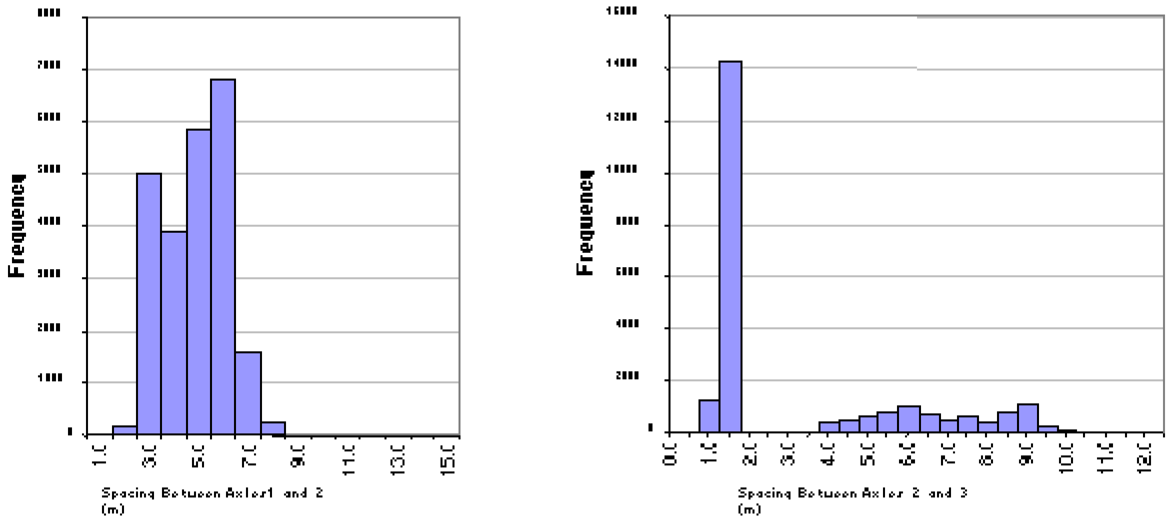

Figure 4a and b. Histograms of the axle spacing between the 1st and 2nd axles (a) and 2nd and 3rd axles (b) of all the Class 3: 1-1-1 and Class 3: 1-2 HVs at Heidelberg.

The histogram of the axle spacing between the first and second axles has a relatively narrow base with a peak at approximately 5 m. This implies that the average spacing between the first and second axles of the two 3-axle classes is not that much different. In fact it differs by 1.1 m only (4.2 m for a 3:1-1-1 and 5.3 m for a 3:1-2 HV). Refer to Figure 4(a).

The histogram of the axle spacing between the second and third axles has two peaks. One at approximately 1.4 m which represents the 3:1-2 HV class and another peak at approximately 7 m which represents the 3:1-1-1 HV class. Refer to Figure 4(b).

APPLICATIONS OF THE HEAVY VEHICLE DATA

General

The HV data and information from the TCCs, WIM sites and the continuous traffic counts can be used by road authorities and road designers in a variety of ways. Three such applications are discussed in the following sub-sections, namely:

- Classification of the road network
- Traffic loadings on road pavements
- Overload control

Road network classification

A road classification system depends largely on the purpose of the classification. For transport planning purposes roads may be classified as urban, rural or recreational. For traffic purposes roads can be classified in terms of traffic volumes (e.g. roads with low traffic volumes, roads with medium traffic volumes and roads with high traffic volumes).

Bosman (1988), classified the major roads in South Africa in terms of the HV composition. He proposed two main classes, namely roads carrying light HV traffic and roads carrying heavy HV traffic. Each class was subdivided into two sub-classes. The light classes carried more 2-, 3- and 4-axles HVs and the heavy classes carried more 5-, 6-, 7- and 8-axle HVs.

Using the data from the TCCs on the N3 and N4 and from the "non-TCC" WIMs, Bosman's proposal was verified to establish if it was still relevant. In general it was found that the heavier HVs (5- to 8-axle HVs) increased and that the lighter HVs also carried more freight.

It is thus proposed now that the major roads in South Africa could be classified in three classes, namely:

- Low HV roads(L-Roads), i.e. roads on which the 2-axle HVs are more than 55 per cent of the HVs;
- Medium HV roads(M-Roads), i.e. roads on which the 2-axle HVs are more than 35 per cent, but less than 55 per cent of the HVs; and
- High HV roads(H-Roads), i.e. roads on which the 2-axle HVs are equal to or less than 35 per cent of the HVs.

The average composition on these roads is shown in Table 3 below.

Table 3. HV composition on low, medium and high hv roads as measured at the 45 wim sites.

AXLES/HV	HV COMPOSITION (%)		
	LOW	MEDIUM	HIGH
2-Axle	56	41	29
3-Axle	13	10	9
4-Axle	6	5	5
5-Axle	8	9	8
6-Axle	10	14	19
7-Axle	7	21	30

The significance of the proposed road classification is that it enables the planner and designer to transfer measured heavy vehicle characteristics from one road class to another. For example if a section of road, which is classified as a High HV road, is to rebuild then the E_{80}values/HV and the HV compositions in Tables 4 and 3 can be used which could save the cost of an axle mass survey.

The proposed Low-, Medium-, and High- Road classification is shown in Figure 5 below.

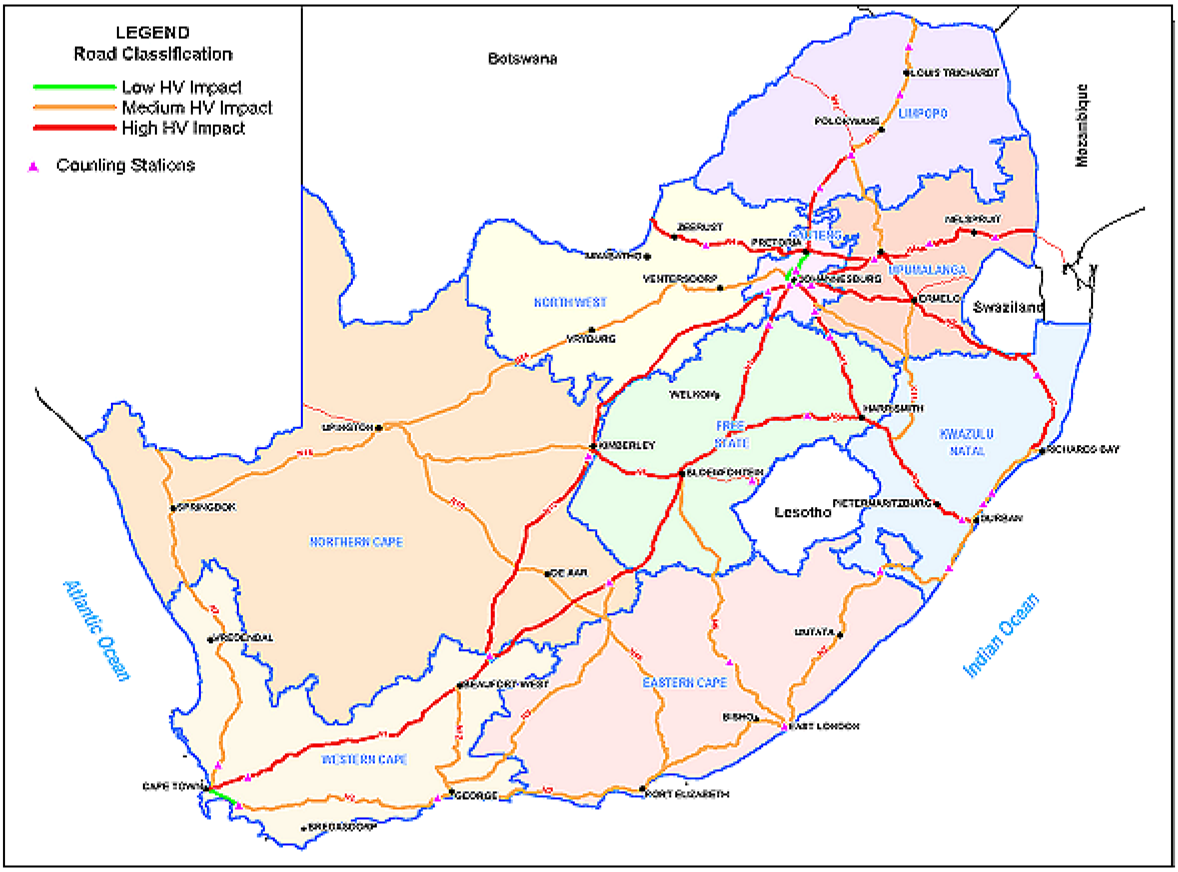

Figure 5. Proposed road classification according to HV composition (This study).

Pavement loading

Equivalent standard axle

Most pavement designs in South Africa still apply the equivalent standard axle load concept. A standard axle load of 80 kN (or 8,2 t) is commonly used and the damage caused by the actual spectrum of axle loads is estimated in E_{80}s.

The TRH 16 (1991) document which deals with the methodology for obtaining reliable traffic loading information, recommends the following sources that can be used to obtain traffic loading for design purposes:

- Tabulated average E_{80}-values;
- Published results of surveys;
- Estimation procedures based on visual observations
- Weighing methods.

Using the average axle masses in Table 2 average E_{80} values per HV class were calculated as shown in the table.

Table 4. Estimated e_{80}-values: using different methods.

HEAVY VEHICLE CLASS	**ESTIMATED E_{80}-VALUES**		
	AVERAGE AXLE MASS	**INDIVIDUAL AXLES**	**TRH 16 (1991)**
2:1-1	**0.32**	**0.78**	**0.30 - 1.10 (0.72)**
3:1-1-1	**0.30**	**0.68**	**0.80 – 2.60 (1.70)**
3:1-2	**1.10**	**1.80**	
4:1-1-1-1	**0.70**	**1.06**	**0.80 – 3.00 (1.80)**
4:1-1-2	**0.82**	**1.31**	
4:1-2-1	**1.235**	**2.25**	
5:1-1-2-1	**1.24**	**1.56**	**1.00 – 3.00 (2.20)**
5:1-2-1-1	**1.42**	**2.13**	
5:1-2-2	**1.67**	**2.85**	
5:1-1-3	**2.00**	**3.33**	
6:1-1-2-1-1	**1.56**	**5.21**	**1.60 - 5.20 (3.50)**
6:1-1-2-2	**1.46**	**1.93**	
6:1-2-1-2	**2.54**	**3.77**	
6:1-2-2-1	**3.37**	**4.19**	
6:1-2-3	**2.94**	**3.52**	
7:1-2-2-1-1	**2.47**	**4.18**	**3.80 - 5.00 (4.40)**
7:1-2-2-2	**3.78**	**5.63**	
8:1-2-2-3	**2.78**	**3.83**	**Not available**
8:1-2-3-2	**2.93**	**4.29**	
8:1-3-2-2	**3.57**	**5.26**	

These values can be regarded as average tabulated values based on weighing methods. Two aspects should be borne in mind:

- The axle masses in Table 2 are average masses and since the simplified formula to calculate E_{80}s raises the actual axle mass divided by 80 kN to the power of 4 (generally used in SA), average axle masses will not give a "true" answer; and
- The axle masses were weighed dynamically and could have an error of ± 15 percent.

To overcome the concern in (i) above to some extent the histograms for each axle can be used to calculate "weighted" E_{80} values. Alternatively each individual axle could be used to calculate an average weighted E_{80}-value per HV class. These values, together with the average E_{80}-values (from Table 2) and the values recommended by the TRH16 (1991) are summarized in Table 4.

The average E_{80}-values calculated from individual axles' compare favourably with the average values in the TRH16 as is shown in Table 5.

It should be borne in mind that the above calculations of E80-values are based on data collected on roads with high HV traffic, i.e. H-Roads. These values may not apply directly to L- and M-Roads. This can only be confirmed once the WIM data from the "non-TCC" WIM sites has been analysed.

Table 5. Comparison of average e_{80}-values.

AXLES/HVLES	INDIVIDUAL AXLE METHOD	TRH16(1991) RECOMMENDATION
2-Axles	0.78	0.70
3-Axles	1.24	1.70
4-Axles	1.54	1.80
5-Axles	2.46	2.20
6-Axles	3.76	3.50
7-Axles	4.64	4.,40

Axle load spectra

The current pavement designs, which are mainly based on the equivalent standard axle load (ESAL) method, have served well for four decades. This method has certain limitations relating, among others, to the traffic loads carried by present-day pavements, the geographic location where the AASHO Road Test was done and the construction materials used at that time.

Applying the AASHTO procedure to modern traffic volumes, means that the designer was often projecting the design methodology far beyond the data and experience providing the basis for the procedure.

McGhee (1999) stated that AASHTO's proposed 2002 Pavement Design Guide is based on mechanistic-empirical principles and the old ESAL approach is no longer used.

Traffic is considered in terms of axle load spectra. The full spectra for single, tandem and tridem axles is considered.

The computational software which is necessary to carry out a mechanistic analysis of a pavement is generally available. However, one of the input values, namely the axle load spectra, is not always readily available.

From the analysed axle mass data measured at the TCCs it could be possible to estimate the axle load spectra. Such a procedure is described below, using the Class 3:1-2 data from the Heidelberg TCC.

The mass distribution of the front axle of this HV class is as follows:

- 2-4 t = 67%
- 4-6 t = 59%
- 6-8 t = 33%
- 8-10 t = 1%

Since a total number of 15,185 Class 3:1-2 heavy vehicles were counted it is then possible to determine the axle mass spectrum for the front axle of this particular HV.

Similarly the spectra for the other axles and other HV classes can be estimated.

Overload control

Overloaded heavy vehicles are a serious threat to the road network. Overload control is currently still done on an ad hoc basis in South Africa. Many reasons can be cited for this situation but the most common one is probably the high capital and operational costs of permanent overload control facilities.

Many road authorities (especially provincial) have static weighbridges that are operated on a random basis. Heavy vehicles are visually directed to the weighbridge.

An analysis of the WIM data with regard to overloading produced the results as shown in Table 6. The table shows that, for example, on a Low HV Road approximately 9 percent of the HVs could be overloaded. It further indicates that if the 2-, 5-, 6- and 7-axle HVs are to be weighed on any road, approximately 80 percent of the overloaded HVs can be apprehended.

Table 6. Overloaded HVS on low, medium and high HV roads.

ROAD CLASS	**% OF HV CLASS THAT IS OVERLOADED**							**% OL HVs**
	2-AXLE	**3-AXLE**	**4-AXLE**	**5-AXLE**	**6-AXLE**	**7-AXLE**	**8-AXLE**	
LOW	28	16,5	7	17	13,5	12,5	2	9
MEDIUM	21,5	6	6	11	16	33,5	3	12,5
HIGH	23	6	6,5	13	17,5	31	4	7,5

CONCLUSION

Roads and railways are in a sense the arteries that keep the lifeblood of the economy flowing. Approximately 70 percent of freight moves by road in South Africa and it is growing by approximately four percent per annum. Data and information on heavy vehicle (HV) volumes and axle masses are therefore indispensable to road authorities for design and maintenance purposes.

The analysis of HV data as presented in the paper indicates that valuable information for planning and design purposes can be derived from existing HV data.

The application of the HV data as proposed in the paper is not extensive and serves only as examples. Many other applications, such as the verification of bridge loading codes, could be possible.

It is therefore recommended that HV data from as many sources as possible in South Africa be analysed in order to confirm or modify the conclusions in the paper.

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