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THE EFFECT OF LAW ENFORCEMENT AND TOLLING OF NATIONAL ROADS ON THE SOUTH AFRICAN RURAL ROAD NETWORK – A CASE STUDY.

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Abstract

The South African rural road network has deteriorated considerably over the last two decades. This deterioration is generally attributed to a lack of periodic maintenance. This paper shows that severe overloading occurs on some rural corridors that serve as alternatives to National roads which are tolled and have good law enforcement in place to prevent overloading. The magnitude of the increase in traffic loading on the alternative rural roads is shown to be of such a nature that there is no doubt that it contributes significantly to the accelerated deterioration of these rural roads. This case study show the importance of the use of road specific load measurements as input into rehabilitation designs and to avoid using average published load factors.

1. INTRODUCTION

The South African rural road network has deteriorated considerably over the last two decades. This deterioration is usually and perhaps justifiably, attributed to a lack of periodic maintenance and appropriate intervention actions. Consequently, the thin bituminous surfacings (seals) mostly found on the South African rural roads, crack due to the well-known effect of ageing as a result of environmental effects such as high levels of ultra violet radiation found on the Highveld areas. The cracking of the surfacing allows water to ingress into the road pavement structure. Water together with the effect of loading cause very high pore pressures to develop in the pavement layers that quickly lead to the breaking up of these layers and the formation of potholes. A scenario that is unfortunately too familiar on many of our rural roads.

An additional aspect which is often overlooked, may also contribute substantially to the fast deterioration of the South African rural road network. More and more heavy vehicles are seen on rural roads. These vehicles have previously mainly used the National road system that has been designed to accommodate heavy vehicle loads operating with high wheel pressures. However, in order to secure funds for essential upgrading and maintenance of these roads, many of the National roads have seen the introduction of tolling over the last decade. Together with the introduction of tolling, a system of Weight-in-Motion (WIM) and permanent weigh stations to enforce the law in terms of overloading have also been introduced. This system of law enforcement on the National roads has shown to be hugely successful. Recently publicized data (Nordengen, 2010) has shown a decrease in overloading on the South African road network over the last decade. However, this data is (with few exceptions) collected on the National roads and little data is available on the rural road network.

A recent study (July 2010) on a rural road corridor in the Free State has shown the effects of the introduction of tolling and law enforcement on the main National roads on alternative rural roads. WIM measurements were done on the corridor before the upgrading of the National road, in 2001. A permanent WIM station was installed on this corridor in 2004. This station collected all data between 2005 and 2008. Between 2001 and 2005 the National road and one rural alternative road adjacent to the National Road were upgraded, tolling introduced and WIM and weight bridges installed. Measurements taken between 2005 and 2008 on a second alternative rural road have shown a dramatic increase in heavy vehicles along the route. More pronounced is a dramatic increase in equivalent 80 kN axle loads per heavy vehicle (E80s/hv). Up to 40 per cent of the vehicles measured on this route were loaded above the legal limit of 9 tons per axle. The measured E80s/hv along this rural corridor is typical of that measured in countries with no or very little law enforcement in terms of overloading

This paper puts a new perspective on the accelerated deterioration of some of rural roads and the associated rehabilitation needs. The dramatic increases measured in the number of heavy vehicles and E80s/hv will contribute significantly to the accelerated deterioration of roads along routes which could function as alternatives to the National road system, especially in the absence of law enforcement in terms of overloading along these rural routes. This case study shows the importance of the use of road specific load measurements as input into rehabilitation designs and to avoid using average published load factors.

2. TRAFFIC LOADING AND ROAD PAVEMENT BEHAVIOUR

Road pavement design and rehabilitation design are based on the limitation of distress levels in relation to the expected traffic loading to be carried during the design period. It is fundamental to note that design is not done in terms of time, but in terms of the estimated/predicted traffic loading. It follows that traffic loading is fundamental to the expected pavement behaviour over the design period. Hence, any unexpected or unusual trends in traffic loading on any specific road could have a dramatic influence on the behaviour patterns of that road.

3. CASE STUDY

This paper specifically reports on external influences on the traffic load measured on a rural corridor in the Free State province of South Africa as shown in Figure 1. Road pavement rehabilitation designs commissioned by the Free State Department of Police, Roads and Transport (FSDPRT) over the last decade along the Wesselsbron, Bultfontein and Soutpan to Bloemfontein rural road corridor have shown the dramatic effect the introduction of tolling between Kroonstad and Bloemfontein on the N1, and on the alternative Brandfort road.

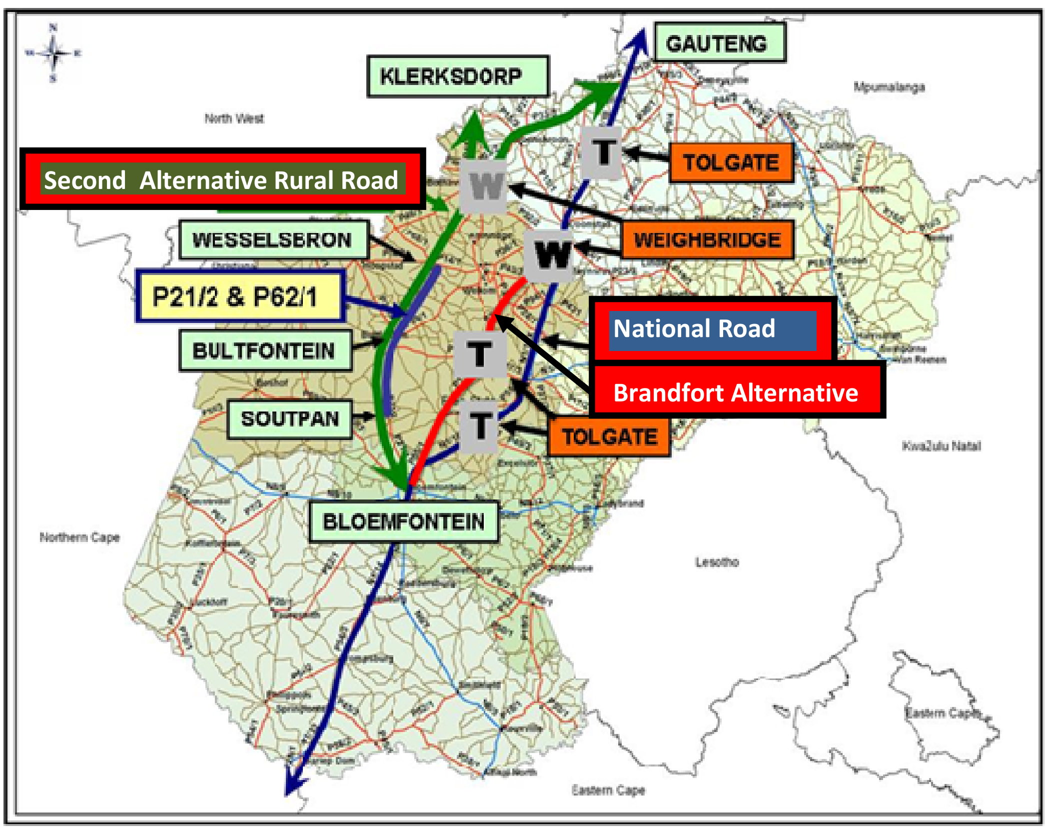

FIGURE 1
The position of the National road (tolled with weight bridge), the Brandfort alternative (Tolled) and the Second Alternative rural road

In addition to tolling, permanent WIM stations have been established on the National route and a fully operational weigh bridge is in place to enforce the law in terms of overloading. In contrast, the alternative rural corridor along Wesselsbron, Bultfontein and Soutpan has no operational weigh bridge and no law enforcement curtailing overloading. Figure 1 show the positions of the various tollgates and weighbridges. Although a weighbridge is shown on the alternative rural road, it is not in operation and not used for law enforcement to monitor and control overloading.

It should be noted that all measurements used in this study were measured after the change of the legal load limit in South Africa in 1996 when the permissible load for a single axle (4 tyres) were increased from 8200 kg to 9000 kg. Hence, the change in the legal load has NO influence on the measured increase in E80s/hv along the corridor.

4. TRAFFIC LOADING STUDY 2001

4.1 Information Gathering

In 2001 the FSDPRT commissioned a rehabilitation design of the road section between Soutpan and Bloemfontein. As part of the design a detailed investigation into the past traffic loading and the future expected traffic loading for a design period of 10 and 20 years was done.

The following historical traffic count data was obtained from the following different sources and used for analysis purposes:

- Mikros Systems (Pty) Ltd Traffic Count Data (CTO stations 0026003753 and 0371703895) (1987),
- Free State Provincial Government, Department of Public Works, Roads and Transport, Traffic Management Systems Database (1995 to 2001), and
- Free State Provincial Government, Department of Public Works, Roads and Transport, Interim Report on Traffic Counts, Volume 2/2, Report Number B464/E, (October 1991).

In addition to the available historical data, a seven-day traffic count survey was commissioned and done by “Traffic Engineering Services” at km 1.1 on the P21/1 using WIM equipment.

The following information was obtained for the WIM survey, measured both on the North- and the South-bound lanes:

- Average Daily Traffic (ADT) volumes for the different vehicle classes,
- Average Daily Truck Traffic (ADTT) – classified according to different types of standard axle combinations,
- Split in trucks into short, medium and long trucks,
- Composition of the heavy vehicles (i.e. 2 axles, 3 axles, 4 axles etc),
- Directional split in traffic (distribution/composition of traffic flows),
- Percentage of heavy vehicles, and

- Current E80s/hv for the various vehicle classes (i.e. 2 axles, 3 axles, 4 axles, etc).

This data together with historical data was used as input to determine the past and future traffic loading on the road. Table 1 gives the average E80s/hv for the different vehicle configurations measured during the traffic count study done by Traffic Engineering Services (between 23 October 2001 and 31 October 2001) for both the North-bound (left) and South-bound (right) lanes.

TABLE 1: Average E80s/hv for Different Heavy Vehicle Configurations – Measured During the WIM Study in October 2001

Vehicle Type	Average E80s/hv North-Lane	Average E80s/hv South-Lane	Range in E80s/hv found at different sites in South Africa (TRH16, 1991)
2-Axle Trucks	0.38	0.33	0.30 – 1.10
3-Axle Trucks	1.13	0.96	0.80 – 2.60
4-Axle Trucks	0.95	1.00	0.80 – 3.00
5-Axle Trucks	1.74	1.81	1.00 – 3.00
6-Axle Trucks	1.93	1.47	1.60 – 5.20
7-Axle Trucks	3.35	3.16	3.80 – 5.00
8-Axle Trucks	2.41	2.40	3.80 – 5.00

From Table 1 it is seen that the E80s/hv measured on the North-bound lane are slightly higher than the E80s/hv measured on the South-bound lane. These results are contrary to the historical records along the route that clearly indicate that the South-bound lane carried the heavier traffic (in line with the condition of the lane). This anomaly is most probably due to seasonal variations in the transportation of agricultural goods etc. that could have influenced the results. A thorough analysis of all available historical traffic load data showed that the North-bound lane carried approximately 80 per cent of the traffic loading carried by the South-bound lane. This calculation is confirmed by the measured road pavement condition in terms of comparable rut depth measurements.

The averages of the calculated E80s/hv in Table 1 are 1.64 for the North-bound lane and 1.51 for the South-bound lane (2001). However, in order to take into account historically proven tendencies, these were adjusted for prediction purposes to 1.64 E80s/HV for the North-bound lane and 1.97 E80s/HV for the South-bound lane.

4.2 Growth Rates

4.2.1 Historical Growth Rates

All available historical traffic count data were used to calculate the past historical traffic and traffic load growth rates. The following growth rates were calculated for the period 1987 to 2001:

- Annual Average Daily Traffic (AADT) – 4.1 per cent per annum,
- Annual Average Daily Truck Traffic (AADTT) - 4.5 per cent per annum; and
- E80s/hv - 0.74 per cent per annum (1.48 E80s/hv in 1987 to 1.64 E80s/hv in 2001) (taking into account the change in legal axle loading as introduced in 1996).

The growth in E80s/hv was mainly due to a shift in truck split over the last 10 to 15 years prior to 2001. The percentage long vehicles (heavy) had increased from 20 per cent (1987) to ± 45 per cent (2001) while the short and medium trucks decreased from 49 per cent (1987) to ± 40 per cent and from 31 per cent to ± 15 per cent respectively. This trend is in line with previous observations (De Bruin and Jordaan, 2004) in SA for E80 growth rates, which, depending on the route, could vary between 0 and 12 per cent.

Up to 2001 the route mainly served the rural farming community and little growth potential in terms of traffic loading was experienced and foreseen. Hence, it was considered most likely that a relatively low traffic load growth rate had occurred over the past life of the road prior to 2001. For purposes of the calculation of past traffic loading (1968 to 2001), the following growth rates, for two different scenarios, were considered reasonable:

- 0 per cent (resulting in the probable maximum past traffic loading); and
- 3 per cent (representing a probable minimum past traffic loading).

4.2.2 Future Growth Rates

Future traffic loading should be based on past trends taking into account all additional information such as expected new developments (new tolling roads etc). Many unknown factors could influence these predictions and hence, a sensitivity analysis should be done to investigate low, medium and high scenarios.

Observations over the last 20 years in various countries have shown that a growth rate in E80s/hv occurs on most roads (De Bruin and Jordaan, 2004). This can, inter alia, be explained by improved vehicle technology, which allows heavier loads to be carried, and better utilisation of heavy vehicles with an increase in economic activity.

The growth in E80's depends on factors such as:

- Growth in total traffic volume,
- Growth in the percentage heavy vehicles as a percentage of total traffic; and
- Growth in E80s per heavy vehicle.

The first two factors can be combined as the growth in heavy vehicles (calculated as 4.5 per cent per annum between 1987 and 2001on the P21/1).

A sensitivity analysis was done for the P21/1 road to determine the growth in E80s/hv. The road mainly serves a rural farming community. No major developments were foreseen in 2001 and growth rates in traffic loading were expected to stay relatively low. Although the N1 between Kroonstad and Bloemfontein was known to soon be tolled (2001 scenario), this was expected to have little influence on the P21/1. Experience in South Africa has shown that about 20 per cent of vehicles will initially use alternative routes when tolling is introduced. It was expected that most of these vehicles will divert onto the shorter Theunissen – Brandfort – Bloemfontein (R30) route (at the time it was not foreseen that this road would also be tolled). At most it was expected that about 20 per cent of the tolling objectors could divert onto the P21/1 (5 per cent of the N1 traffic).

Experience has also shown that resistance towards the payment of tolling fees filters out over a period of 4 to 5 years. It follows, that the tolling of the N1 is expected to have a limited influence on traffic load forecasts along the P21/1 corridor. For the purpose of the rehabilitation design of the road the following growth scenarios were considered to be reasonable:

- Growth in heavy vehicles of between 2 to 4 per cent per annum, and
- Growth in E80s/hv of between 1 to 3 per cent per annum.

Low and high scenarios for a sensitivity analysis were developed as shown in Table 2.

TABLE 2: Sensitivity Analysis to Determine the E80 Growth Rates

			GROWTH IN HEAVY VEHICLES		
			LOW (2%)	**MEDIUM (3%)**	**HIGH (4%)**
GROWTH IN E80s/hv	**Low**	1.0%	3.02%	4.03%	5.04%
	Medium	2.0%	4.04%	5.06%	6.08%
	High	3.0%	5.06%	6.09%	7.12%

The E80s growth rate was calculated using the following formula:

E80s growth rate = [(1+h/100) x (1+v/100)-1] x 100

where:

h = heavy vehicles growth rate
v = E80s/hv vehicle growth rate

In order to estimate future traffic loading, influences on the maintainability of current trends and possible changes should be considered. For example, it was foreseen (in 2001) that 2001 growth rates to higher growth rates were likely in the short to medium term (due to economic forecasts), followed by medium to high E80/hv growth rate (as influenced by the N1 tolling). It was considered likely that some point of saturation would be reached and for the next 10-year period a more moderate E80/hv growth rate would be more likely (low –

medium). Similar arguments are applicable for the estimation of growth in heavy vehicles.

Based on the above, it was estimated that the E80 growth rate for the first 10 years would vary between 5.0 per cent (low) and 7.0 per cent (medium to high – refer Table 2). Using the available information, the following E80 growth rate scenarios were considered reasonable for the first 10 years of the 20-year design period:

- Low estimate : 5.0 % growth in E80s
- Medium estimate: 6.0 % growth in E80s
- High estimate : 7.0 % growth in E80s

The heavy vehicle growth rate for the last 10 years of the 20 year design period was estimated at between 4.0 per cent and 6.0 per cent. Using the available information, the following E80 growth rates were considered reasonable for the last 10 years of the 20 year design period:

- Low estimate : 4.0 % growth in E80s
- Medium estimate: 5.0 % growth in E80s
- High estimate : 6.0 % growth in E80s

4.2.3 Traffic Loading

4.3.3.1 Past Cumulative Traffic Loading

The past cumulative traffic loading (estimated E80s) were calculated for the period 1968 to 2001 as:

- **North bound lane**: 1.16×10^6 E80s (3% growth), and
  1.76×10^6 E80s (0% growth).

- **South bound lane**: 1.39×10^6 E80s (3% growth), and
  2.11×10^6 E80s (0% growth).

4.3.3.2 Future Design Traffic Loading

The design traffic loadings (2001) for the two lanes of the P21/1 between Bloemfontein and Bultfontein were based on a sensitivity analysis using the scenarios and growth rates as discussed. The cumulative sum of E80s for a low, medium and high growth scenarios for periods of 10 and 20 years were calculated to be:

- North-bound lane: 10 year design period – 0.90×10^6 E80s
  20 year design period – 2.3×10^6 E80s

- South- bound lane: 10 year design period – 1.08×10^6 E80s
  20 year design period – 2.7×10^6 E80s
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5. TRAFFIC LOADING STUDY 2010

5.1 Information gathering

In 2010 the FSDPRT commissioned a rehabilitation design of the road section between Bultfontein and Soutpan on the same rural corridor as shown in Figure 1. As part of the design a detailed investigation on the past traffic loading and the future expected traffic loading for a design period of 15 and 20 years was done.

A permanent WIM station was installed on the P21/1 (Soutpan to Bloemfontein) road by the Free State Provincial Government, Department of Public Works, Roads and Transport, Traffic Management Systems database in early 2005. This station provided detailed traffic load information for the period 2005 to 2008 (365 days a year).

The following WIM information was obtained from this permanent station on both the North-bound and the South-bound lanes:

- Average Daily Traffic (ADT) volumes for the different vehicle classes,
- Average Daily Truck Traffic (ADTT) - different types of standard axles trucks that use the road classified,
- Split in trucks (short, medium and long),
- Composition of the heavy vehicles (i.e. 2 axles, 3 axles, 4 axles etc),
- Directional split in traffic (distribution / composition of traffic flows),
- Percentage of heavy vehicles,
- Current or equivalent standard 80 kN dual wheel axle loads (E80s) for the various vehicle classes (i.e. 2 axles, 3 axles, 4 axles, etc).

The data from the WIM measurements taken from the station at km 1.1 on Road P21/1 from 2005 to 2008 on the South-bound lane (the critical lane carrying the higher load) is summarized in Table 3.

Table 3: WIM data collected on the South-bound lane of the P21/1 (P21/2 corridor) from 2005 to 2008.

PERIOD	*hv*	*TOTAL E80S*	*TOTAL E80s > 9 T*	*EAL/hv*	*% E80s > 9 T*
01/04/2005 – 31/03/2006	43 517	234 559	177 252	5,73	75,6
01/04/2006 – 31/03/2007	42 494	196 929	139 728	4,66	71,0
01/01/2007 – 01/01/2008	50 324	311 219	251 488	6,19	80,8
01/04/2007 – 31/03/2008	51 869	336 565	277 543	6,53	82,5

5.2 Growth Rates

5.2.1 General

From the data in Tables 1 and 3 it is seen that a dramatic shift in the number of heavy vehicles and the E80s/hv per heavy vehicle (E80s/hv) occurred between 2001 and 2005 and again from 2007 to 2008. This increase in traffic loading coincides with the construction on the N1 and later, the construction of the new Brandfort roads and the introduction of tolling on these roads and the operation of the weigh bridge as shown in Figure 1. The weigh bridge on the N1 is fully operational. In comparison the weigh bridge on the P21/1 corridor is non-operational. It is of importance to note that the E80s/hv as measured between 2005 and 2009 on the alternative rural corridor is considerably higher than that measured on the N1 during the comparable period (4.7 to 6.5 E80s/hv on the rural alternative compared to 2.2 E80s/hv on the N1) and much higher than the normal recommended values shown in Table 4 (De Bruin and Jordaan, 2004) and in TRH16 (CASRA, 1991) as shown in Table 4 (TRH16 was published before the legal limit was increased in 1996, but has never been updated and is still widely used). In addition, the percentage overloading measured (dual wheel single axles above the legal limit of 9000kg) on the rural corridor of up to 40 per cent (South-bound) is considerably higher than the average as measured on the National roads (Nordengen, 2010). Truck operators have clearly identified this rural corridor as not only an alternative to the toll roads, but also as an opportunity to avoid law enforcement in terms of overloading.

TABLE 4 (De Bruin and Jordaan, 2004): E80 factors for different heavy vehicle groupings

HEAVY VEHICLE GROUPING	TRH 16 (1991)			SATCC (1998)			CTO STATIONS (1986-1992) HSWIM#		
	Low	Med	High	Low	Med	High	Low	Med	High
2 + 3 Axles	0.6	**1.2**	1.9	0.4	**1.8**	2.5	0.7	**2.0**	2.5
>3 Axles	1.6	**3.0**	4.1	1.2	**4.1**	5.5	1.9	**3.7.**	5.0
Short	0.3	**0.7**	1.1	0.3	**1.5**	2.0	0.3	**0.9**	1.7
Medium	0.8	**1.8**	2.8	0.6	**2.3**	3.3	1.0	**2.1**	3.1
Long	2.1	**3.4**	4.4	1.4	**4.6**	6.2	2.2	**4.2**	5.6

Low, medium and high values may be associated with the following situations:

Low - Mostly empty (Category farm to market

Medium - 50% laden, 50% empty (Category A or B, major inter urban roads)

High - >70% laden (Category A or B roads) main arterials or major industrial roads

It follows that the calculation of past and future traffic loading along this route should clearly distinguish between the periods up to 2005 and the periods after 2005.

TABLE 5: ESTIMATION OF E80S PER HEAVY VEHICLE (TRH16, 1991)

Loading of Heavy Vehicles (or type of road)	E80/Heavy Vehicle
Mostly unladen (category, farm to market)	0,6
50 % laden, 50 % unladen (category A or B, major interurban)	1,2
> 70 % fully laden (category A or B, main arterials or major industrial routes)	2,0

5.2.2 Historical Growth Rates

All available historical traffic count data was used to calculate the past or historical traffic growth rates (as previously discussed) for the period 1987 to 2001. These traffic load growth rates are assumed applicable up to the end of 2004. The WIM measurements done on the P21/1 at km 1.1 from 2005 to 2008 are used to determine the past traffic loading from 2005 to 2010. The measured data as contained in Table 3 is used to calculate the Past Traffic Loading from 2005 to 2010. The estimated past traffic loading (1968 – June 2010) is summarized in Table 6.

Table 6: Summary of the estimated past traffic loading from 1968 to June 2010

PERIOD	NORTH BOUND		SOUTH BOUND	
1968-2004	1,66 x10^6 (1 %)	1,21 x 10^6 (3 %)	1,97 x10^6 (1 %)	1,44 x 10^6 (3 %)
2005	0,09 x 10^6	0,09 x 10^6	0,23 x 10^6	0,23 x 10^6
2006	0,126 x 10^6	0,126 x 10^6	0,197 x 10^6	0,197 x 10^6
2007	0,139 x 10^6	0,139 x 10^6	0,234 x 10^6	0,234 x 10^6
2008	0,172 x 10^6	0,172 x 10^6	0,409 x 10^6	0,409 x 10^6
2009	0,172 x 10^6	0,172 x 10^6	0,41 x 10^6	0,41 x 10^6
2010 JUNE	0,086 x 10^6	0,086 x 10^6	0,20 x 10^6	0,20 x 10^6
TOTAL	**2,44 x 10^6**	**1,995 x 10^6**	**3,65 x 10^6**	**3,72 x 10^6**

5.2.3 Future Growth Rates

An extraordinary high growth in E80s is seen in 2005 and again in 2008, due to unnatural circumstances as previously discussed. The E80/hv factors of between 4.7 and 6.5 as shown in Table 3 are typically found in countries where no law enforcement in terms of vehicle overloading is present. It is shown that 71 per cent to 82 per cent of the total E80s measured during 2005 to 2008 are due to weight carried on axles loaded in excess of 9 tons. Were these illegal E80s carried on legally loaded trucks it would have meant an increase in heavy vehicles, but a considerable decrease in E80s/hv. The data contained in Table 3 is reprocessed assuming the enforcement of the law and assuming the weight over 9 tons is carried on additional 9 ton axles. The average number of axles per vehicle measured over the period is used to calculate the additional trucks to carry the weight in excess of 9 tons. The data in Table 3, assuming to represent a scenario without law enforcement is reprocessed in Table 7 to represent a scenario with law enforcement.

From Table 7 it is seen that the E80s/hv is reduced to between 2.6 and 2.9 in an "assumed law enforced" scenario. These values are more comparable to that measured on the parallel N1 where law enforcement of overloading is in place. It is clear that the controlling of overloading will result in a considerable decrease in E80s on the alternative rural road corridor.

Table 7: Comparable data from Table 3 representing a scenario of law enforcement

Period	Total HV	Total E80s	E80s/hv	% E80 increase (compared to Table 3) due to the carrying of the overloaded weight on leagally weigthed vehickles (9000 kg axle loads)
01/04/2005 – 31/03/2006	56 989	156 159	2,87	50,2
01/04/2006 – 31/03/2007	53 868	138 333	2,58	43,4
01/01/2007 – 01/01/2008	70 150	200 428	2,86	55,3
04/04/2007 – 31/03/2008	73 057	209 309	2,89	60,8

A sensitivity analysis was done for the P21/2 road to determine the growth in E80s/hv. It is considered highly unlikely that the very high growth rates as seen from 2005 will be maintained. However, if no law enforcement is in place a very severe case of overloading will continue and could even worsen. The movement of heavy vehicles as a result of the introduction of tolling gates on alternative routes have already taken place. In fact, the opening of the weigh bridge on the P21/2 corridor will most likely result in a scenario closely representing that shown in Table 7 or even show a reverse of the observed trends with heavy vehicles moving back to the use of the N1 corridor. Experience has also shown that resistance towards the payment of toll fess filters out over a period of 4 to 5 years. It follows, that the tolling of the N1 is expected to have a limited future influence on traffic load forecasts along the alternative rural corridor.

Locally, the road mainly serves a rural farming community. Similar to the 2001 study, no major developments are foreseen in this area and growth rates in locally generated traffic loading are expected to stay relatively low. For the purpose of this study the following growth scenarios are considered to be reasonable:

Scenario A: No law enforcement (current measured trends to continue) with tolling on alternative routes (data in Table 3 used as a basis for predictions):

- Growth in heavy vehicles of between 8, 9 and 10 per cent per annum,

- Growth in E80/hv of 0, 0,5 and 1,0 per annum, and
- Basis yeas E80s/hv of 5,64.

Scenario B: Law enforcement in place with tolling on alternative routes (data in Table 7 used as a basis for predictions):

- Growth in heavy vehicles of between 8, 9 and 10 per cent per annum,
- Growth in E80/hv of 0, 1 and 2 per cent per annum, and
- Basis year E80s/hv of 2,80.

Scenario C: Law enforcement with no tolling on alternative routes (data from the 2001study used as a basis for predictions):

- Growth in heavy vehicles of between 2, 3 and 4 per cent per annum,
- Growth in E80/hv of 1, 2 and 3 percent per annum, and
- Basis year E80s/hv of 1,97.

5.3 Traffic loading

The various scenarios discussed are used in a sensitivity analysis to determine estimates of low, medium and high design traffic loadings for the road along the rural corridor. The design traffic loading for a design period of 20 years (base year 2011) for the 3 scenarios are summarized as follows:

Scenario A (20 years design traffic loading):

- Low Scenario - 18.5×10^6 E80s
- Medium Scenario - 23.0×10^6 E80s
- High Scenario - 28.6×10^6 E80s

Scenario B (20 years design traffic loading):

- Low Scenario - 9.2×10^6 E80s
- Medium Scenario - 12.3×10^6 E80s
- High Scenario - 16.6×10^6 E80s

Scenario C (20 years design traffic loading):

- Low Scenario - 3.3×10^6 E80s
- Medium Scenario - 4.3×10^6 E80s
- High Scenario - 5.7×10^6 E80s

6. DISCUSSION

Scenario C (2001 scenario), as shown above, is not applicable to the rehabilitation design of the road anymore. The alternative routes had been tolled and the situation will not be reversed. However, the data is still applicable for comparison with alternative B to give an indication of the effect on the alternative rural corridor of the introduction of tolling on the main roads.

It is the Government's responsibility to ensure that the law is abided by. Hence, alternative B should be considered as the scenario applicable to the road for design purposes. However, should law enforcement not take place the current situation with regard to overloading is likely to continue. The design consequences of the continuation of no law enforcement are determined by also considering Scenario A for design purposes.

From Table 3 it is seen that the percentage contribution of the loading in excess of 9 tons to the total E80s has increased from 75 per cent in 2005 to more than 82 per cent in 2008. This growth is not likely to continue indefinitely, ever without law enforcement, as a point of saturation is expected to be reached. However, if vehicle technology continues to improve, the shift to vehicles with more axles is also expected to continue. Hence, the growth in E80s/hv will continue for the short to medium term. In this case, the most likely scenario in the case of no law enforcement (current case – Scenario A) is a design Traffic loading of between the medium and high Scenarios.

The following design traffic loadings are considered for Scenario A (no law enforcement) for comparison and could be used to determine the cost of continued overloading:

- 20 year design traffic loading - 26.0 x 106 E80s

Scenario B is considered the scenario applicable for the rehabilitation design of the rural corridor with law enforcement in place and overloading limited. In this case a medium scenario is considered most applicable. The design traffic loading to be used for rehabilitation design is:

- 20 year design traffic loading - 12.3 x 106 E80s

It is seen that adequate law enforcement introduced on the alternative rural corridor will reduce the 20 year expected traffic loading by more than half.

7. CONCLUSIONS

The South African rural road network has deteriorated considerably over the last two decades. This deterioration is usually and perhaps justifiably attributed to a lack of periodic maintenance and appropriate intervention actions. An additional aspect which is often overlooked, may also contribute substantially to the fast deterioration of the South African rural road network. More and more heavy vehicles are seen on rural roads. These vehicles have previously mainly used the national road system that has been designed to accommodate heavy vehicle loads operating with high wheel pressures. However, in order to secure funds for essential upgrading and maintenance of these roads many of the national roads have seen the introduction of tolling over the last decade. Together with the introduction of tolling, a system of Weight in Motion (WIM) and permanent weigh stations to enforce the law in terms of overloading has also been introduced.

A recent study (July 2010) on a rural corridor in the Free State has shown the effects of the introduction of tolling and law enforcement on a National Route on roads along an alternative rural corridor. The data clearly show a dramatic increase in heavy vehicles as well as a dramatic increase in overloading of the heavy vehicles on the alternative rural corridor. The over loading contributes to up to 80 per cent of the E80s along the corridor. This dramatic increase in loading on the alternative rural corridor is of such magnitude that there is little doubt that it is a major contributor to the deterioration of these and similar rural roads in the country.

This study also shows the importance of site specific heavy vehicle measurements during rehabilitation design investigations. Substantial errors are possible by assuming average E80s/hv factors as published for example, in the TRH16 (CASRA, 1991) that is still widely in use.

8. ACKNOWLEDGEMENTS

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9. REFERENCES

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KEY WORDS

Traffic loading, overloading, law enforcement, tolling influence