RECOMMENDATIONS REGARDING HIGHER AXLE MASS LIMITS FOR AXLES FITTED WITH WIDE BASE TYRES

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Abstract

This paper presents the results of an investigation into possible higher axle mass limits for axles and axle units fitted with wide base tyres, i.e. tyres with nominal section widths of 385 mm, 425 mm and 445 mm, by comparing the road wear caused by single axles, tandem axle units and tridem axle units fitted with wide base tyres of various sizes and at different axle masses with the potential road wear caused by axles and axle units fitted with conventional single tyres and dual tyres loaded to the current permissible maximum masses. These comparisons are then used to arrive at recommended axle mass limits for axles and axle units fitted with wide base tyres, based on the principle of *equal road wear*. The road wear caused by the various axles fitted with the different size tyres are calculated in terms of Load Equivalency Factors (LEFs), which were calculated using the existing Mechanistic-Empirical Design Method (SAMDM) for flexible pavements through the application of the current mePADS software package. Based on the results of this study, axle and axle unit mass limits of 9 t for single axles, 18 t for tandem axle units and 24 t for tridem axle units are recommended for axles fitted with wide base tyres with a nominal section width of 425 mm or more.

1 INTRODUCTION

The currently agreed harmonised permissible maximum axle and axle unit masses for the Eastern and Southern Africa (ESA) Region are presented in Table 1–1. Member states of the Regional Economic Communities (REC) of the ESA Region, namely the Common Market for Eastern and Southern Africa (COMESA), the Southern African Development Community (SADC) and the East African Community (EAC) have all agreed to these limits.

These permissible maximum axle and axle unit masses are actually the "road wear limits", as the tyre manufacturer's ratings and the vehicle manufacturer's ratings for the axle and axle units should be taken into consideration to arrive at the real permissible axle or axle unit mass. The term "road wear limit" is therefore used in the paper to refer to these axle mass limits. Further, the term "axle or tyre mass" is preferred in this paper as the unit is kg, but may also be referred as "load" when unit is kN.

Table 1–1: Harmonised permissible maximum axle and axle unit masses in the ESA Region

No of Tyres/axle	Permissible Maximum Axle or Axle Unit Mass (kg)			
	Steering	Non-steering		
	Single Axle	Single Axle	Tandem Axle Unit	Tridem Axle Unit
Two	8 000	8 000	16 000	24 000
Four	n.a.	10 000	18 000	24 000

The limits presented in Table 1–1 are the same as the current South African regulations prescribing the permissible maximum mass values on axles and axle units in terms of road wear limits, with the exception of a single axle with dual wheels for which the current South African road wear limit is 9 000 kg.

The permissible axle and axle unit limits for axles fitted with single tyres all equate to a maximum mass of 4 000 kg per tyre. The smallest size tyre that can carry a load of 4 000 kg is a tyre with a nominal section width of 315 mm (315/80R 22.5). There is however a number of wide base tyres on the market, with nominal section widths of 385 mm; 425 mm and 445 mm - the so-called “super singles”, or lately “new generation wide base tyres” (NGWB). The tyre manufacturer’s ratings for these tyres allow axle masses from 9 000 kg to 11 600 kg at specified tyre inflation pressure, but such masses cannot be achieved due to the abovementioned current legal limits on axles fitted with single tyres.

Due to the wider base (tread width) of these tyres, the premise is that the contact area between wide base tyres and the road surface should be relatively larger and the tyre contact stress therefore lower compared with the conventional 315 mm tyres at the same axle mass and associated tyre inflation pressure. Axles fitted with wide base tyres should therefore cause less road wear at the same axle mass or alternatively, should be allowed higher axle masses if the road wear remains the same as that caused by axles fitted with regular single tyres. Requests for higher load limits for axles fitted with wide base tyres have therefore been made by the road transport industry from time to time.

This paper presents the results of an investigation into what such higher limits could be, by comparing the road wear caused by single axles, tandem axle units and tridem axle units fitted with wide base tyres of various sizes and at different axle masses with the potential road wear caused by axles and axle units fitted with conventional single tyres and dual tyres loaded to the current permissible maximum masses. These comparisons are then used to arrive at recommended axle mass limits for axles and axle units fitted with wide base tyres, based on the principle of *equal road wear*, namely that the road wear caused by axles fitted with wide base tyres may not exceed the road wear caused by axles and axle units that are fitted with conventional single tyres loaded to the current permissible maximum axle/axle unit mass. The recommended axle load limits for axles and axle units fitted with wide base tyres also take into account the potential road wear of these axles and axle units relative to that of equivalent axles and axle units fitted with conventional dual tyres.

This paper is based on a study done for TradeMark Southern Africa and the reader is referred to the study paper for more detail (Roux and Nordengen, 2010).

2 CALCULATION OF ROAD WEAR

The road wear caused by the various axles fitted with the different size tyres are calculated in terms of Load Equivalency Factors (LEFs), which are calculated using the Mechanistic-Empirical (M-E) Design Method (SAMDM) for flexible pavements through the application of the mePADS software (basics of method described by Theyse et al, 1996) software package. The calculations are done for two assumptions. The first assumption is that the tyre inflation pressure equals the tyre contact stress and the second assumption is that the maximum diameter of the contact area equals the nominal section width of the tyre. For both assumptions the contact area is considered to be of the traditional circular shape for the M-E analyses.

The approach followed to calculate LEFs is as follows:

1. Using an axle or axle unit with the actual tyre loads (unit kN) , tyre inflation pressure and tyre spacing as input, a full mechanistic-empirical analysis is done with mePADS to calculate the layer life for each pavement layer;
2. The pavement life under each axle or axle unit is then taken as being equal to the critical layer life (i.e. the particular layer in the pavement with the lowest life);
3. Using mePADS, the layer life for each road pavement layer under the Standard Axle (80 kN, 520 kPa) in the wet condition is calculated;
4. The bearing capacity of the specific pavement is then taken as being equal to the critical layer life (i.e. the particular layer in the pavement with the lowest life) under the Standard Axle;
5. The LEF for the particular axle/axle unit is then calculated using the following equation:

—————————————— **(Equation 1)**

where:

n = number of axles in axle or axle unit
Ncritical from Standard 80 kN/520 kPa Axle = Minimum layer life of pavement under the loading of the Standard axle of 80 kN and 520 kPa inflation pressure on 4 tyres (i.e. 20 kN per tyre @ 520 kPa contact stress (= inflation pressure))
Ncritical from $Axle_i$ *= Minimum layer life of pavement under the loading of* $Axle_i$ *of the axle or axle unit under consideration.*

This calculation is done for each axle/axle unit for each of five pavements, as described in Section 3, in both the dry and wet condition.

3 ROAD PAVEMENT TYPES EVALUATED IN THIS STUDY

The focus of the study was the North-South Corridor which runs between the port of Dar es Salaam in Tanzania to the Copperbelts of Zambia and DR Congo and down through

Zimbabwe and Botswana to the ports in South Africa (taking in ‘spur’ connections to the Great Lakes in the north and to Malawi in the east). The pavements analysed in this study were therefore selected to be representative of typical pavement structures on the North-South corridor. The following five flexible road pavements were included:

Pavement A: Structure: 50 mm asphalt surfacing, 150 mm G2 granular base, 150 mm C4 cemented sub-base, 150 mm G7 selected layer on the subgrade. Design traffic class: ES3.

Pavement B: Structure: Double seal, 150 mm G4 gravel base; 150 mm G7 gravel sub-base, 150 mm G7 gravel selected layer on the subgrade. Design traffic class: ES3.

Pavement C: Structure: Double seal, 150 mm C3 cemented base, 150 mm C4 cemented sub-base, 150 mm G7 gravel selected layer on the subgrade. Design traffic class: ES3.

Pavement D: Structure: Double seal, 150 mm C4 cemented base, 150 mm G6 gravel sub-base on the subgrade. Design traffic class: ES1.

Pavement E: Structure: Double seal, 150 mm C4 cemented base, 150 mm G6 gravel sub-base, 300 mm G8 gravel selected layer on the subgrade. Design traffic class: ES1.

Note: The material coding and traffic classes of above pavements are in accordance with TRH 4 (1985).

4 TYRE SIZES AND TYRE INFLATION PRESSURES APPLIED IN THE ANALYSIS

The following conventional tyre sizes were used in the analysis:

1. 9R22.5
2. 11R22.5
3. 315/80R22.5

The following wide base tyre sizes were used in the analysis:

1. 385/65R22.5
2. 425/65R22.5
3. 445/65R22.5

The maximum load carrying capacities and the associated tyre inflation pressures for the various size tyres were obtained from the ETRTO Standards Manual 2010 (ETRTO, 2010). For masses lower than the maximum load carrying capacity, the associated tyre inflation pressures were calculated using the following formula as published in the ETRTO Standards Manual 2010.

(Equation 2)

where:

Qr = load carrying capacity for an inflation pressure Pr
Qmax = maximum load carrying capacity
Pref = reference tyre inflation pressure compatible to the maximum load capacity Qmax at the relevant speed

Qmax and Pref for the various tyre sizes used in this analysis are summarised in Table 4–1.

Table 4–1: Maximum load carrying capacities and compatible tyre inflation pressures for tyres used in the study

Rim (inches)	Tyre Size	Load index		Axle Load (Qmax) (kg)		Max TiP (Pref) (kPa)
		Single	Dual	Single	Dual	
22.5	9R22.5	136	134	4 480	8 480	825
22.5	11R22.5	146	143	6 000	10 900	850
22.5	315/80R22.5	156	150	8 000	13 400	850
22.5	315/80R22.5	156	150	8 000	13 400	850
22.5	385/65R22.5	160		9 000		900
22.5	425/65R22.5	165		10 300		825
22.5	445/65R22.5	169		11600		900

5 AXLE AND AXLE UNITS INCLUDED IN THE ANALYSIS

Single axles and axle units fitted with conventional single and dual tyres were analysed at the current legal axle masses as presented in Table 1–1. The tyre sizes chosen were the smallest popular size that can carry the particular axle load in terms of the ETRTO standards. The required tyre inflation pressure at that axle load was also obtained from the ETRTO standards.

Single axles and axle units fitted with wide base tyres were analysed for axle/axle unit masses within ranges starting at a minimum axle load of 8 t for single axles, 16 t for tandem axle units and 24 t for tridem axle units up to the maximum allowable load for each tyre size obtained from the ETRTO standards.

In order to enable a further comparison of the impact of single versus dual tyres, axles and axle units fitted with conventional dual tyres were analysed at the axle masses above the current legal limits but within the ETRTO standards for the various tyre sizes.

One hundred and thirteen axles/axle units were analysed.

6 TYRE CONTACT STRESSES

In terms of Assumption 1, which is the default assumption in the mePADS analysis, it was assumed that the tyre inflation pressure is equal to the tyre contact stress and that the contact area is circular. The use of “Tyre Contact Stress” (which is proofed to be different than tyre inflation pressure) is discussed in detail by De Beer et al (1997, 1999, 2005). The diameters of the contact areas calculated based on this assumption are in all cases less than the width of the tyre (tread width). The analysis was therefore repeated in terms of

Assumption 2, in which it was assumed that the diameter of the contact area between the tyre and the road surface is equal to the nominal width of the tyre. The contact area is still assumed to be circular, as mePADS can currently only handle a circular contact area. Using this assumption, the tyre contact stress was calculated for each case using the following equation:

Where: *σ = Tyre Contact Stress in kPa*
P = Tyre load in kN
d = nominal width of tyre in m

The nominal tyre widths used in the calculations are summarised in Table 6–1.

Table 6–1: Tyre sizes and nominal tyre widths

Tyre Size	Nominal Tyre Width (mm)
9R22.5	230
11R22.5	280
315/80R 22.5	315
385/65R 22.5	385
425/65R 22.5	425
445/65R 22.5	445

Since 1994, the CSIR has conducted research on the measurement of tyre-pavement contact stresses for use on flexible (and rigid) road pavements in South Africa. This research is based on the well-known Stress-In-Motion (SIM) technology platform at the CSIR. Currently a basic database of twenty two (22) tyres with corresponding information on loading/inflation pressure exists at CSIR Built Environment. A tyre contact stress viewer software product dubbed “TyreStress” has been developed at CSIR Built Environment to view the data in the database. The TyreStress software provides 3 dimensional tyre contact stress data for both SIM measured cases as well as “interpolated” cases (i.e. tyre contact stress data not measured with SIM but generated by interpolation).

In order to relate the two assumptions made to the real situation, this software package was applied to determine equivalent uniform contact stresses based on the SIM measured tyre-pavement contact stresses for three applicable tyres included in the database, namely a 315/80R22.5 tyre from Michelin; a 425/65R22.5 tyre from Goodyear; and an 11R22.5 from Continental. A comparison has been made between the equivalent uniform contact stresses based on the SIM measured tyre-pavement contact stresses for the three applicable tyres and the two assumed values. The results of this comparison are summarised in Table 6–2.

Table 6–2: Comparison of Uniform Contact Stress based on two assumptions with value based on SIM measurements

Tyre Size	Wheel Load (kg)	TiP kPa	Uniform Contact Stress (kPa)		
			Assumption 1	Assumption 2	Measured
315/80R22.5	2 500	590	590	315	514
315/80R22.5	3 000	740	740	380	469
315/80R22.5	4 000	850	850	505	657
425/65R22.5	4 000	600	600	280	428
425/65R22.5	4 500	700	700	315	514
425/65R22.5	5 000	795	795	350	547
11R22.5	2 000	580	580	320	368
11R22.5	2 500	760	760	400	361

From Table 6–2, it can be seen that the true contact stress situation lies somewhere between the results of the analyses based on the two assumptions. The ideal would be to base all the calculations on SIM measured tyre stress information, but only a limited number of tyres are currently included in the TyreStress package. Only one wide base tyre size, namely a 425 mm tyre is currently included in the database. For this reason, the analyses were done based on the two assumptions and the results interpreted taking the information presented in Table 6–2 into account.

7 COMPARISON OF AVERAGE LEFS FOR AXLES AND AXLE UNITS FITTED WITH CONVENTIONAL AND WIDE BASE TYRES AT CURRENT LEGAL AXLE MASS

In this section, the average LEFs calculated for single axles, tandem axle units and tridem axle units fitted with conventional single and dual tyres and loaded to current legal limits are compared with equivalent axles and axle units fitted with wide base tyres. The average LEF is the average of the LEFs calculated per pavement type and the two climatic conditions The current legal limits referred to are 8 t for a single axle with single tyres; 10 t for a single axle with dual tyres; 16 t for a tandem axle unit with single tyres; 18 t for a tandem axle with dual tyres; and 24 t for a tridem axle unit with single or dual tyres. Average LEFs for axles and axle units fitted with conventional dual tyres loaded to the limits for single tyres are also included to illustrate the road wear impact of single tyres versus dual tyres. The average LEFs calculated in terms of the two assumptions are summarised in Table 7–1, while the average LEFS calculated in terms of Assumption 1 is illustrated in Figure 7–1 and in terms of Assumption 2, in Figure 7–2.

Table 7–1: Average LEFs for axles and axle units fitted with conventional and wide base tyres at legal mass

Axle Type	Tyre Size	Single or Dual Tyres	Axle/ Axle Unit Load (kg)	Average LEF	
				Assumption 1	Assumption 2
Single	315/80R 22.5	Single Tyres	8 000	2.70	1.69
	385/65R 22.5	Single Tyres	8 000	2.54	1.00
	425/65R 22.5	Single Tyres	8 000	2.03	0.73
	425/65R 22.5	Single Tyres	10 000	4.01	1.54
	445/65R 22.5	Single Tyres	8 000	1.91	0.61
	445/65R 22.5	Single Tyres	10 000	3.84	1.32
	9R22.5	Dual Tyres	8 000	0.74	0.57
	11R22.5	Dual Tyres	8 000	0.65	0.42
	11R22.5	Dual Tyres	10 000	1.46	0.96
	315/80R 22.5	Dual Tyres	8 000	0.54	0.34
	315/80R 22.5	Dual Tyres	10 000	1.27	0.78
Tandem	315/80R 22.5	Single Tyres	16 000	5.35	3.34
	385/65R 22.5	Single Tyres	16 000	5.03	1.96
	385/65R 22.5	Single Tyres	18 000	7.08	2.88
	425/65R 22.5	Single Tyres	16 000	4.01	1.42
	425/65R 22.5	Single Tyres	18 000	5.86	2.13
	445/65R 22.5	Single Tyres	16 000	3.78	1.19
	445/65R 22.5	Single Tyres	18 000	5.57	1.77
	9R22.5	Dual Tyres	16 000	1.34	1.02
	11R22.5	Dual Tyres	16 000	1.16	0.74
	11R22.5	Dual Tyres	18 000	1.80	1.16
	315/80R 22.5	Dual Tyres	16 000	0.96	0.59
	315/80R 22.5	Dual Tyres	18 000	1.53	0.92
Tridem	315/80R 22.5	Single Tyres	24 000	8.00	4.99
	385/65R 22.5	Single Tyres	24 000	7.52	2.92
	425/65R 22.5	Single Tyres	24 000	6.00	2.10
	445/65R 22.5	Single Tyres	24 000	5.64	1.76
	9R22.5	Dual Tyres	24 000	1.93	1.46
	11R22.5	Dual Tyres	24 000	1.66	1.05
	315/80R 22.5	Dual Tyres	24 000	1.38	0.84

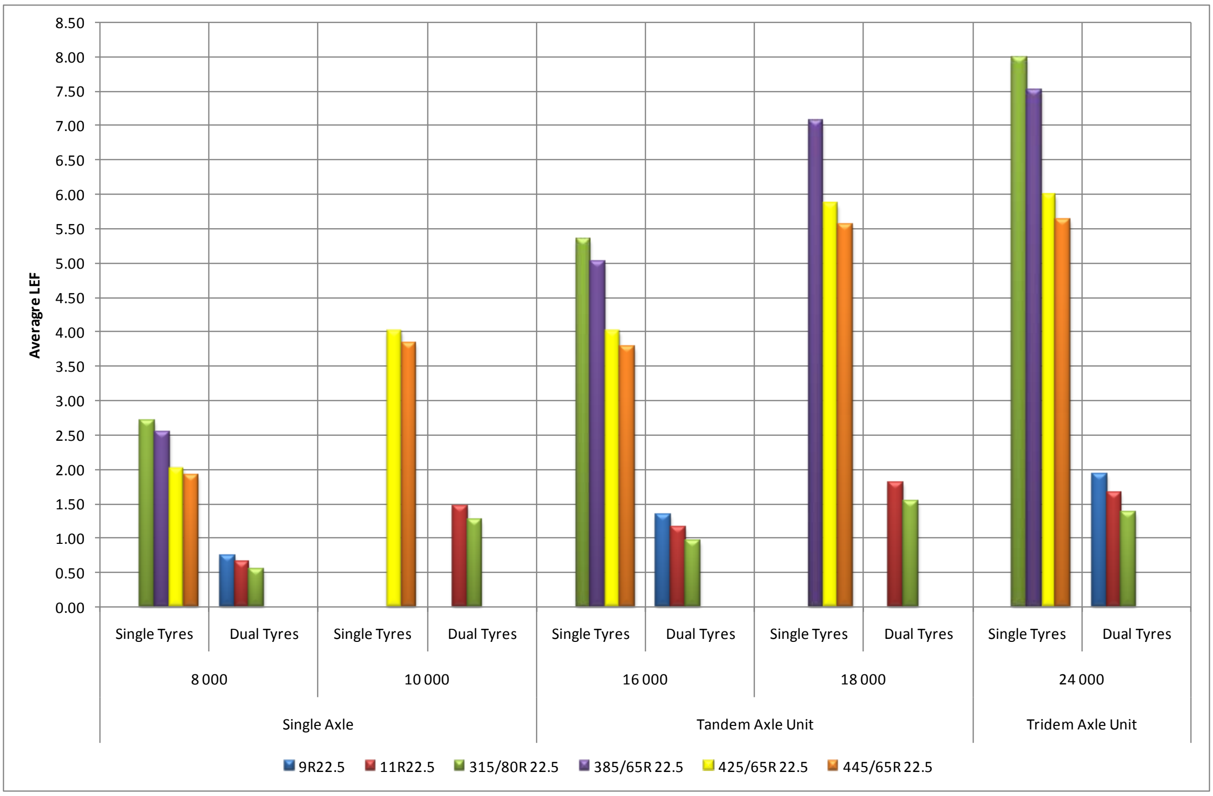

Figure 7–1: Average LEFs calculated in terms of Assumption 1 for axles and axle units fitted with conventional and wide base tyres at legal mass

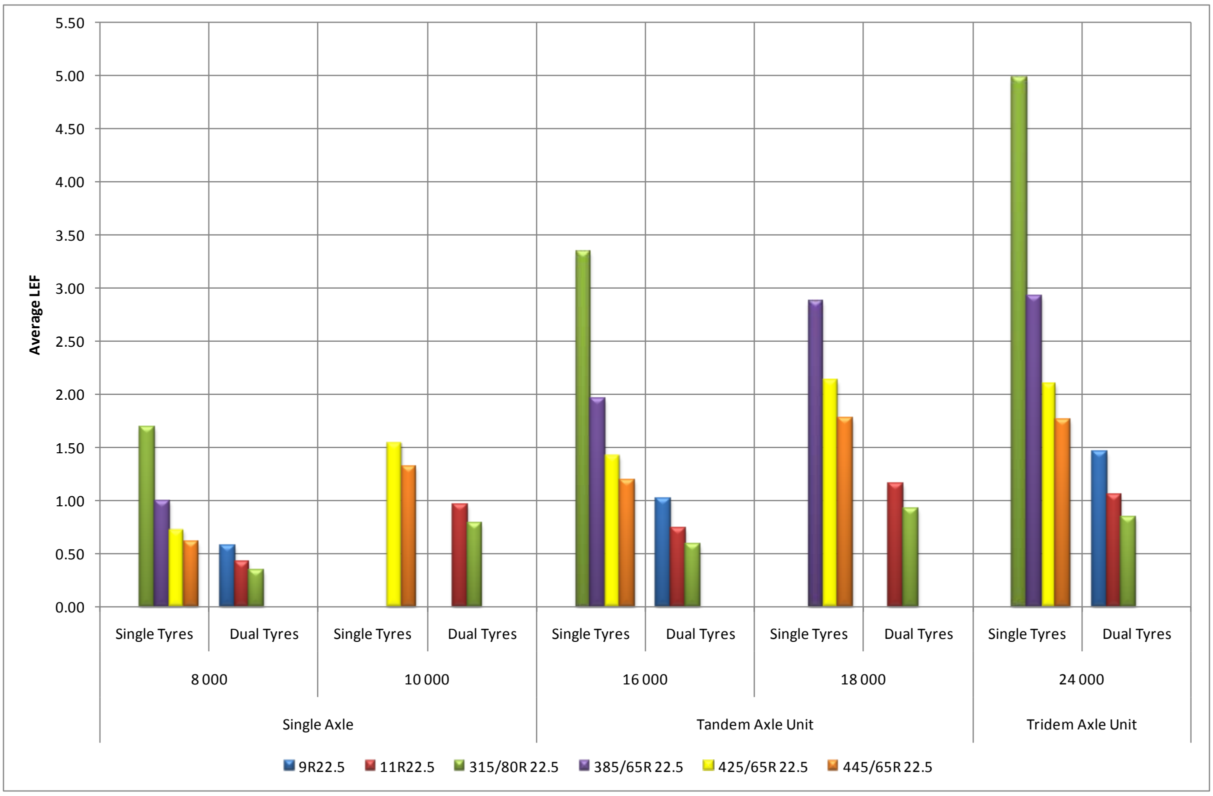

Figure 7–2: Average LEFs calculated in terms of Assumption 2 for axles and axle units fitted with conventional and wide base tyres at legal mass

The following observations can be made from the information presented in Table 7–1 and in Figure 7–1 and Figure 7–2.

- Axles and axle units fitted with wide base tyres cause less road wear than the equivalent legal axle or axle unit fitted with conventional single tyres at the same axle load;
- Axles and axle units fitted with wide base tyres cause more road wear than the equivalent legal axle or axle unit fitted with dual tyres at the same axle load;
- Axles and axle units fitted with conventional single tyres cause far more road wear than the equivalent axles and axle units fitted with conventional dual tyres at the same axle load
- Axles and axle units fitted with conventional single tyres cause more road wear than the equivalent axles and axle units fitted with conventional dual tyres at a higher axle load – for example, the LEF for a single axle fitted with single 315/80R22.5 tyres at an axle load of 8 t is 2.7 for Assumption 1, while for a single axle with dual 315/80R22.5 tyres at an axle load of 10 t, the LEF is 1.27 for Assumption 1 (53 % lower). In terms of Assumption 2, the difference is 54 %. This same trend is observed for tandem and tridem axle units;

Based on these observations, the following interim conclusions can be made:

- The use of axles and axle units fitted with conventional single tyres should be discouraged on vehicles transporting mass freight. This could be achieved by lowering the road wear limits for these axles and axle units to such an extent that their use would only be viable on vehicles transporting volume freight;
- If the road wear of axle and axle units fitted with wide base tyres are to be limited to the same road wear caused by current legal axles and axle units fitted with conventional single tyres, the road wear limits for axles and axle units fitted with wide base tyres could be higher than the current legal road wear limits for axles and axle units fitted with conventional single tyres; and
- The road wear limits for axles and axle units fitted with wide base tyres should not be higher than the limits for equivalent axles and axle units fitted with conventional dual tyres.

In the next section, the extent to which the axle load limits for axles fitted with wide base tyres can be increased is determined. The last bullet point under the above conclusions in effect means that the axle unit load limit for tridem axle units should remain at 24 t, even when fitted with wide base tyres, as this is the limit applicable to dual tyres as well. Tridem axle units are however still included in the next section for completeness.

8 DETERMINATION OF PROPOSED AXLE AND AXLE UNIT (LOAD) MASS LIMITS FOR AXLE AND AXLE UNITS FITTED WITH WIDE BASE TYRES

In order to determine the recommended higher axle mass for axles and axle units fitted with wide base tyres, the LEFs calculated for axles and axle units fitted with wide base tyres, conventional single tyres and conventional dual tyres are plotted against axle masses in the following figures. Figure 8–1 shows the information for single axles with LEFs calculated in terms of Assumption 1. The horizontal line in Figure 8–1 represents an LEF of 2.7 calculated for a single axle with single 315/80R 22.5 tyres at an axle load of 8 t, which is currently a legal axle. The axle load values at the points where the lines of the three wide base tyres intercept this line represent the axle masses at which a single axle fitted with the applicable wide base tyres would cause the same road wear as the current legal axle fitted with conventional single tyres. These values are approximately as follows:

- 385/65R 22.5: 8 150 kg
- 425/65R 22.5: 8 700 kg
- 445/65R 22.5: 8 900 kg

Figure 8–1 further shows that single axles fitted with conventional dual tyres cause far less road wear than single axles fitted with conventional or wide base single tyres. It also shows that a single axle fitted with dual 315/80R22.5 tyres has to be loaded to 12.5 t before it would cause the same road wear as a single axle fitted with single 315/80R22.5 tyres at an axle load of 8 t.

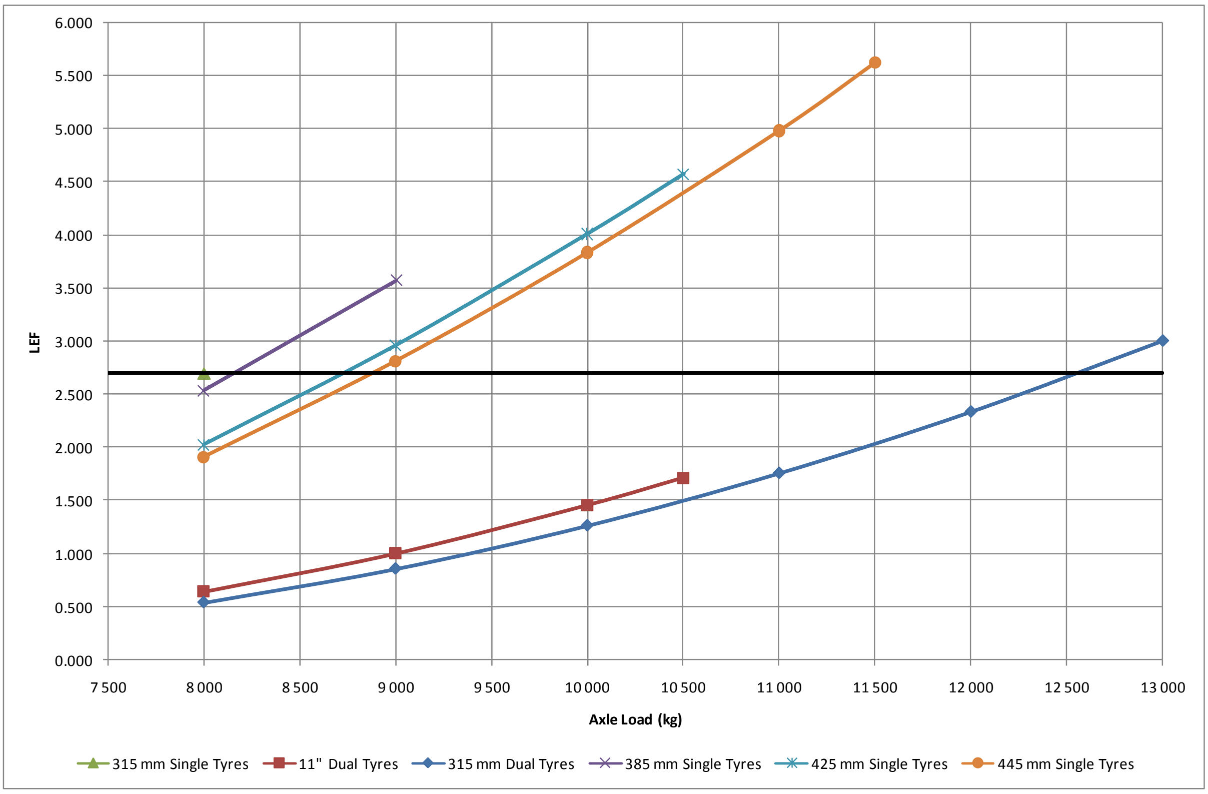

Figure 8–1: LEFs for single axles at different axle masses (Assumption 1)

Figure 8–2 shows the information for tandem axle units with LEFs calculated in terms of Assumption 1. The horizontal line in Figure 8–2 represents an LEF of 5.4 calculated for a tandem axle unit fitted with single 315/80R 22.5 tyres at an axle unit load of 16 t, which is currently a legal axle unit. The axle unit load values at the points where the lines of the three wide base tyres intercept this line represent the axle unit masses at which a tandem axle unit fitted with the applicable wide base tyres would cause the same road wear as the current legal tandem axle unit fitted with conventional single tyres. These values are approximately as follows:

- 385/65R 22.5: 16 300 kg

- 425/65R 22.5: 17 500 kg
- 445/65R 22.5: 17 800 kg

Figure 8–2 further shows that tandem axle units fitted with conventional dual tyres cause far less road wear than tandem axle units fitted with conventional or wide base single tyres. It also shows that a tandem axle unit fitted with dual 315/80R22.5 tyres has to be loaded to 26 t before it would cause the same road wear as a tandem axle unit fitted with single 315/80R22.5 tyres at an axle unit mass of 16 t.

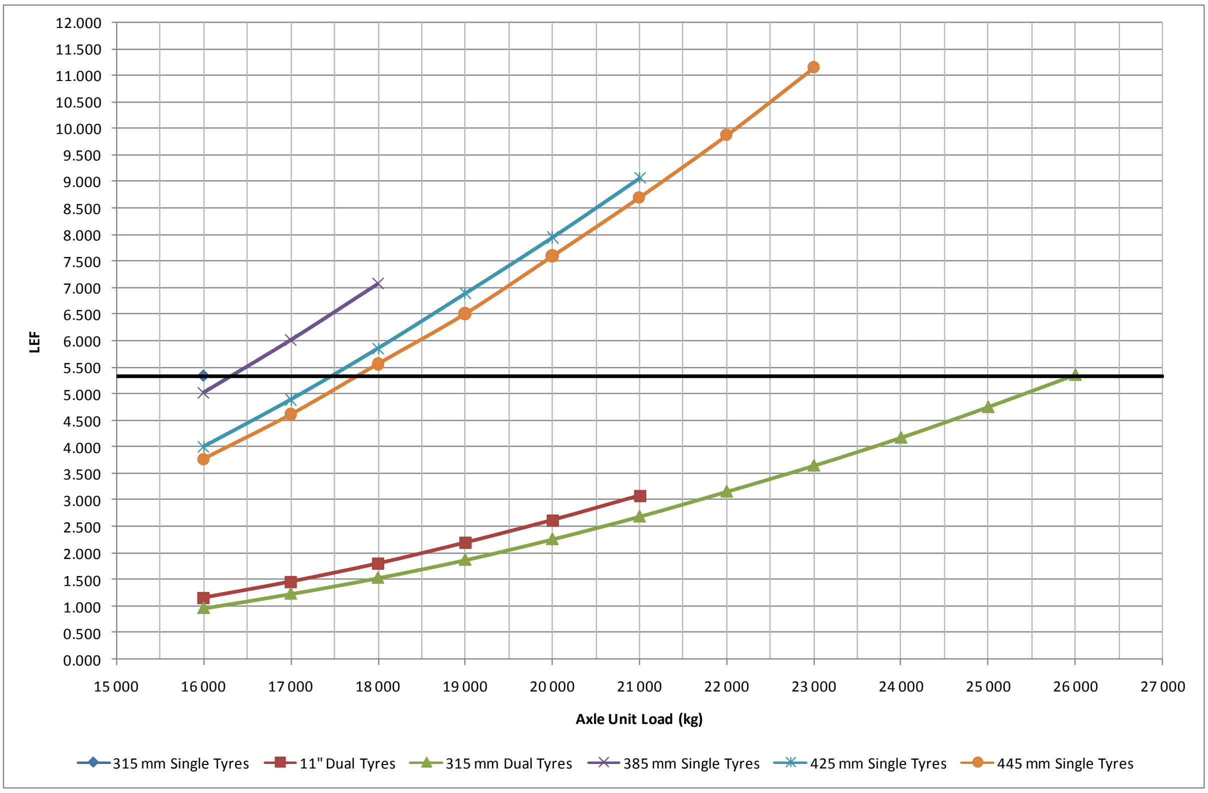

Figure 8–2: LEFs for tandem axle units at different axle unit masses (Assumption 1)

Figure 8–3 shows the information for tridem axle units with LEFs calculated in terms of Assumption 1. The horizontal line in Figure 8–3 represents an LEF of 8 calculated for a tridem axle unit fitted with single 315/80R 22.5 tyres at an axle unit load of 24 t, which is currently a legal axle unit. The axle unit load values at the points where the lines of the three wide base tyres intercept this line represent the axle unit masses at which a tridem axle unit fitted with the applicable wide base tyres would cause the same road wear as the current legal tridem axle unit fitted with conventional single tyres. These values are approximately as follows:

- 385/65R 22.5: 24 500 kg
- 425/65R 22.5: 26 200 kg
- 445/65R 22.5: 26 650 kg

Figure 8–3 further shows that tridem axle units fitted with conventional dual tyres cause far less road wear than tridem axle units fitted with conventional or wide base single tyres. It also shows that a tridem axle unit fitted with dual 315/80R22.5 tyres has to be loaded to approximately 39.5 t before it would cause the same road wear as a tandem axle unit fitted with single 315/80R22.5 tyres at an axle unit load of 24 t.

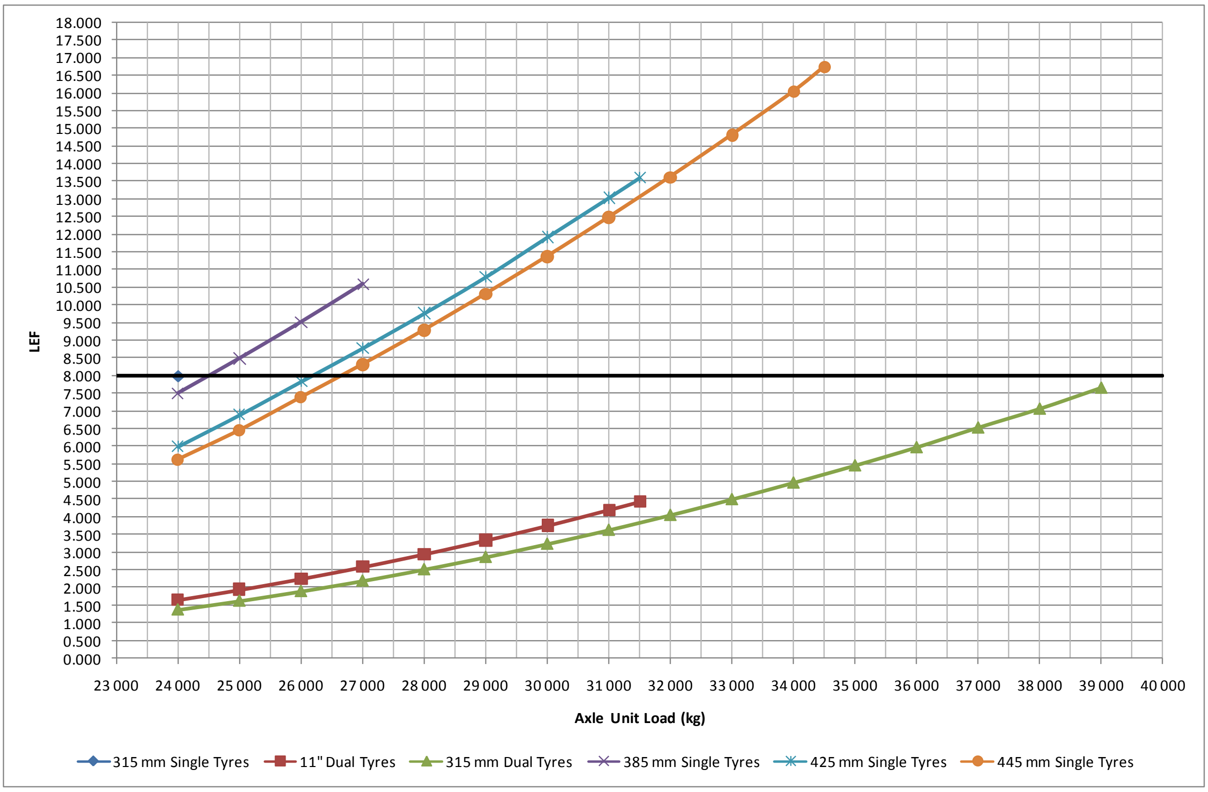

Figure 8–3: LEFs for tridem axle units at different axle unit masses (Assumption 1)

Figure 8–4 shows the information for single axles with LEFs calculated in terms of Assumption 2. The horizontal line in Figure 8–4 represents an LEF of 1.7 calculated for a single axle with single 315/80R 22.5 tyres at an axle mass of 8 t, which is currently a legal axle. The axle load values at the points where the lines of the three wide base tyres intercept this line represent the axle masses at which a single axle fitted with the applicable wide base tyres would cause the same road wear as the current legal axle fitted with conventional single tyres. These values are approximately as follows:

- 425/65R 22.5: 10 300 kg
- 445/65R 22.5: 10 900 kg

The maximum axle load for a single axle fitted with 385 mm wide base tyres as specified by the manufacturer, is 9 000 kg. At this axle load, it causes less damage than a single axle fitted with single 315/80R 22.5 tyres at an axle mass of 8 t.

Figure 8–1 further shows that single axles fitted with conventional dual tyres cause less road wear than single axles fitted with conventional or wide base single tyres. It once again shows that a single axle fitted with dual 315/80R22.5 tyres has to be loaded to 12.5 t before it would cause the same road wear as a single axle fitted with single 315/80R22.5 tyres at an axle mass of 8 t.

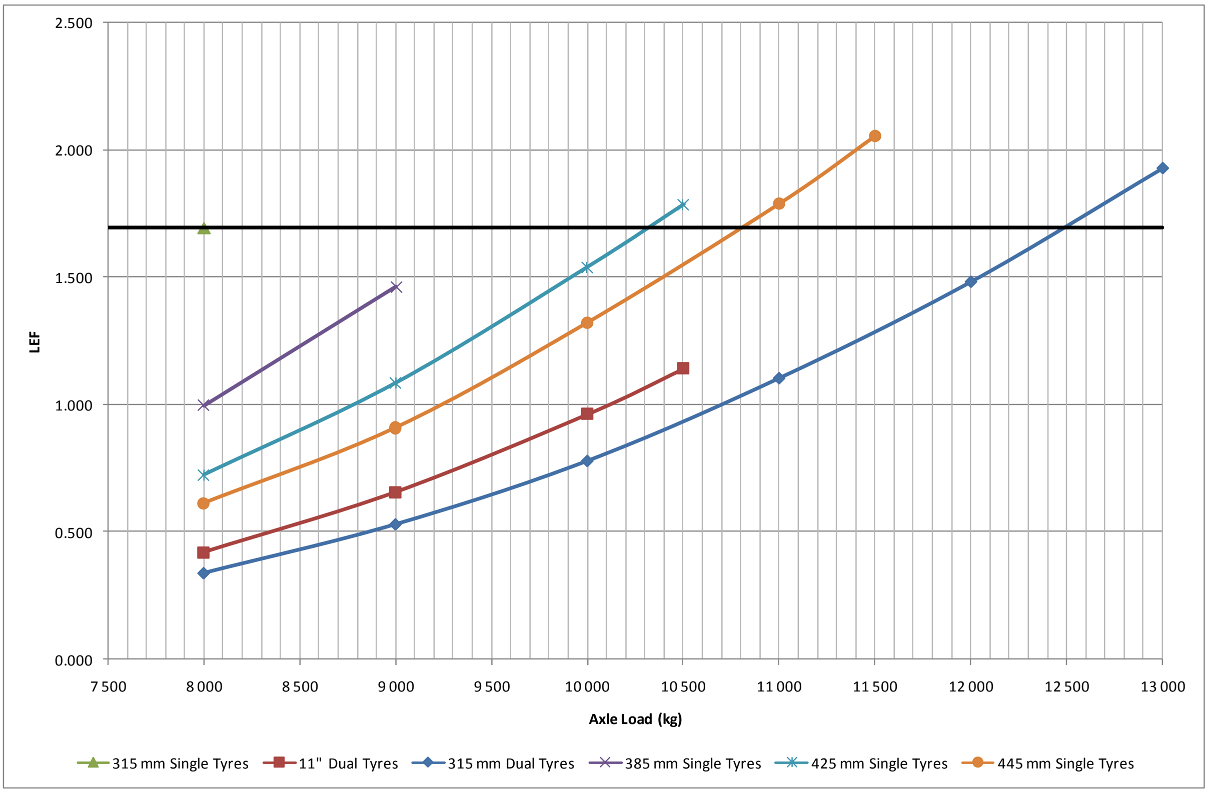

Figure 8–4: LEFs for single axles at different axle masses (Assumption 2)

Figure 8–5 shows the information for tandem axle units with LEFs calculated in terms of Assumption 2. The horizontal line in Figure 8–5 represents an LEF of 3.3 calculated for a tandem axle unit fitted with single 315/80R 22.5 tyres at an axle unit mass of 16 t, which is currently a legal axle unit. The axle unit load values at the points where the lines of the three wide base tyres intercept this line represent the axle unit masses at which a tandem axle unit fitted with the applicable wide base tyres would cause the same road wear as the current legal tandem axle unit fitted with conventional single tyres. These values are approximately as follows:

- 425/65R 22.5: 20 700 kg
- 445/65R 22.5: 21 700 kg

The maximum axle unit mass for a tandem axle unit fitted with 385 mm wide base tyres as specified by the manufacturer, is 18 000 kg. At this axle unit mass it causes less road wear than a tandem axle unit fitted with single 315/80R 22.5 tyres at an axle unit mass of 16 t.

Figure 8–5 further shows that tandem axle units fitted with conventional dual tyres cause less road wear than tandem axle units fitted with conventional or wide base single tyres. It once again shows that a tandem axle unit fitted with dual 315/80R22.5 tyres has to be loaded to 26 t before it would cause the same road wear as a tandem axle unit fitted with single 315/80R22.5 tyres at an axle unit mass of 16 t.

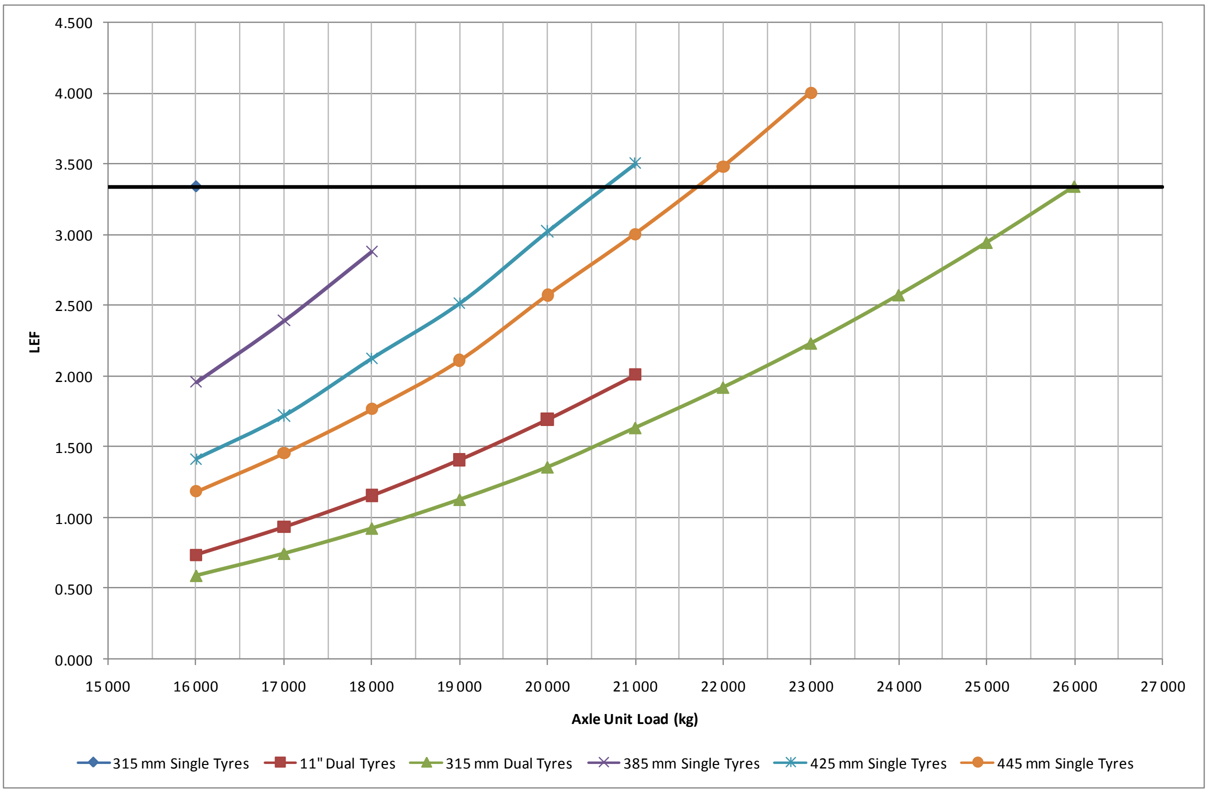

Figure 8–5: LEFs for tandem axle units at different axle masses (Assumption 2)

Figure 8–6 shows the information for tridem axle units with LEFs calculated in terms of Assumption 2. The horizontal line in Figure 8–6 represents an LEF of 5 calculated for a tridem axle unit fitted with single 315/80R 22.5 tyres at an axle unit mass of 24 t, which is currently a legal axle unit. The axle unit mass values at the points where the lines of the three wide base tyres intercept this line represent the axle unit masses at which a tridem axle unit fitted with the applicable wide base tyres would cause the same road wear as the current legal tridem axle unit fitted with conventional single tyres. These values are approximately as follows:

- 425/65R 22.5: 31 000 kg
- 445/65R 22.5: 32 600 kg

The maximum axle unit mass for a tridem axle unit fitted with 385 mm wide base tyres as specified by the manufacturer, is 27 000 kg. At this axle unit mass, it causes less road wear than a tridem axle unit fitted with single 315/80R 22.5 tyres at an axle unit mass of 24 t.

Figure 8–6 further shows that tridem axle units fitted with conventional dual tyres cause less road wear than tridem axle units fitted with conventional or wide base single tyres. It once again shows that a tridem axle unit fitted with dual 315/80R22.5 tyres has to be loaded to approximately 39.5 t before it would cause the same road wear as a tridem axle unit fitted with single 315/80R22.5 tyres at an axle unit mass of 24 t.

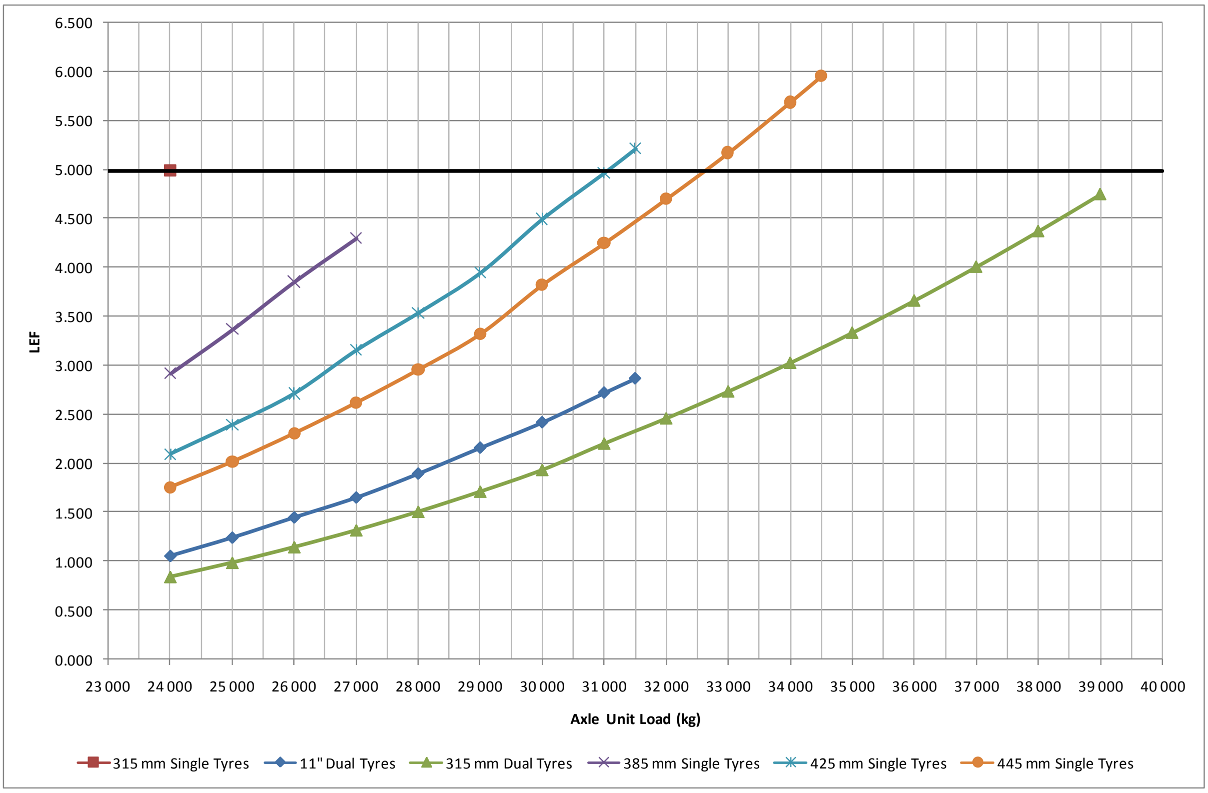

Figure 8–6: LEFs for tridem axle units at different axle masses (Assumption 2)

9 CONCLUSIONS AND RECOMMENDATIONS REGARDING THE USE OF WIDE BASE TYRES

Based on the principle of equal road wear, namely that axles and axle units fitted with wide base tyres should not cause more road wear than axles and axle units fitted with conventional single tyres at the current legal mass limits of 8 t for single axles, 16 t for tandem axle units and 24 t for tridem axle units, such possible higher axle and axle unit mass limits have been determined. These possible higher axle and axle unit masses as determined from the analysis of road wear in terms of LEFs are summarised in Table 9–1. The values determined in terms of both assumptions are presented.

Table 9–1: Summary of possible higher axle and axle unit mass limits for axles and axle units fitted with wide base tyres

Axle/ Axle Unit	Tyre Size	Possible Permissible Maximum Axle/Axle Unit Mass (kg)	
		Assumption 1	Assumption 2
Single Axle	385/65R 22.5	8 150	9 000
Single Axle	425/65R 22.5	8 700	10 300
Single Axle	445/65R 22.5	8 900	10 900
Tandem	385/65R22.5	16 300	18 000
Tandem	425/65R22.5	17 500	20 700
Tandem	445/65R22.5	17 800	21 700
Tridem	385/65R22.5	24 500	27 000
Tridem	425/65R22.5	26 200	31 000
Tridem	445/65R22.5	26 650	32 600

It has however been shown that at the same axle/axle unit mass, axles and axle units fitted with wide base tyres cause more road wear than the equivalent axles and axle units fitted with conventional dual tyres. For this reason it was concluded that the road wear limits for axles and axle units fitted with wide base tyres should not be higher than the limits for the equivalent axles and axle units fitted with conventional dual tyres.

Taking into account the possible limits presented in Table 9–1, the above conclusion as well as the illustration that the true situation regarding tyre contact stresses lies somewhere between the Assumption 1 and Assumption 2, the road wear mass limits as presented in Table 9–2 can conservatively be recommended for axles and axle units fitted with wide base tyres:

Table 9–2: Recommended road wear limits for axles and axle units fitted with wide base tyres

Axle/ Axle Unit	Tyre Size	Recommended Axle/Axle Unit Mass Limits (kg)
Single Axle	385/65R 22.5	8 500
Single Axle	425/65R 22.5	9 000
Single Axle	445/65R 22.5	9 000
Tandem	385/65R22.5	17 000
Tandem	425/65R22.5	18 000
Tandem	445/65R22.5	18 000
Tridem	385/65R22.5	24 000
Tridem	425/65R22.5	24 000
Tridem	445/65R22.5	24 000

In addition it has been shown that the current legal axle and axle units fitted with conventional single tyres cause far more road wear than legal axles and axle units fitted with dual tyres at the same or even at higher axle masses and it is therefore recommended that the use of axles and axle units fitted with conventional single tyres should be discouraged on vehicles transporting mass freight. This could be achieved by lowering the road wear limits for these axles and axle units to such an extent that their use would only be viable on vehicles transporting volume freight.

It is important to note that the road pavements analysed in this study were selected to be representative of typical road pavement structures on the North-South corridor and are not necessarily representative of the pavement structures found in a specific country.

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