Traffic Data Characterization for Road Rehabilitation: A Case Study of the Korogwe-Mombo Road Section in Tanzania

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ABSTRACT: Traffic loading is one of the key inputs for the structural design of pavements. For pavement design purposes, heavy vehicles are mostly used for the estimation of the traffic load spectra, as they cause the most structural damage to pavements. As part of the pavement design process, heavy vehicle volume and axle load surveys are typically carried out to assist with the accurate estimation of the cumulative traffic loading over a pavement design period. However, traffic volumes, axle loads and, ultimately, the cumulative traffic loading are often not uniform due to factors, such as varying motorist population and economic activities along the length of road. In this paper, a comparative assessment of traffic loading estimated during the rehabilitation design in 2005 and the actual measured site-specific traffic loading in 2015, as well as the projected future traffic loading were conducted for the Korogwe-Mombo road section along the T2 trunk road that connects Tanzania's business hub of Dar es Salaam with the northern regional cities. The T2 trunk road is also used by heavy vehicles travelling to and from the neighbouring countries of Kenya and Uganda. This study found inter alia that the cumulative traffic loading based on the 2015 measured site-specific traffic data is approximately 2.8 times higher than the design traffic loading based on the 2005 traffic data, which illustrates the importance of using the latest, most accurate and reliable traffic data during rehabilitation design. To improve the accurate determination of traffic loading, traffic studies should ideally be conducted over a long period (typically over one year), but this is not practical and cost effective when traditional manual methods are used. Hence, road agencies should consider installing portable or permanent automated traffic and Weigh-In-Motion (WIM) monitoring systems.

INTRODUCTION

The primary objectives of pavement structure are to provide smooth riding quality to vehicles and protect the weaker (lower) layers such as subgrade against the effect of traffic loading. Although pavement deterioration may be caused by other factors such as climatic conditions, heavy vehicle volumes and axle loads are considered to be the primary causes of pavement deterioration. As such, heavy vehicle traffic loading has traditionally been used as the key input for the structural design of pavements (TRH 4, 1996; MOW, 1999). Pavement damages caused by heavy vehicles depend not only on the Gross Vehicle Mass (GVM), but also on the mass (weight) distribution onto the pavement. The later in turn depends on several factors, such as the number of axles on the vehicle, axle and wheel configuration, as well as axle load, tyre inflation pressure and contact stress (De Beer et al., 1997; Al-Qadi and Wang, 2004; Greene et al., 2009; THM 14, 2014). As part of pavement design process, heavy vehicle volume and axle load surveys are conducted to assist with the estimation of the future traffic loading over a pavement design period - typically 20 years for most flexible pavements (TRH 16, 1991; TANROADS, 2003; TRL, 2004). The estimated traffic loading is used to determine the appropriate pavement design by taking into account the available material type and climatic conditions. However, traffic volumes, axle loads, and ultimately, the cumulative traffic loading are often not uniform due to varying motorist population and economic activities along the length of the road.

In 2005, the Tanzania National Roads Agency (TANROADS) identified a need for the rehabilitation of the Korogwe-Mombo road section (40 km long). The Korogwe-Mombo road section forms part of the North-East corridor (T2 trunk road), which is the main trunk road that connects Tanzania’s East Coast (including Dar es Salaam city and Tanga Port) with the northern regional cities of Kilimanjaro and Arusha. The T2 trunk road is also the main route that links Dar es Salaam and Nairobi, the major trade centres of Tanzania and Kenya, respectively. The rehabilitation design of the road section was undertaken in 2006, based on traffic counts and axle load surveys carried out in 2005 (TANROADS, 2006). The rehabilitation construction was initially planned to be completed in 2008. However, financial constraints delayed the construction works that only started in 2012 and were completed in 2014. Follow-up traffic counts and axle load surveys was carried out in 2015 after the road had been opened to traffic for a period of approximately one year. Together, the 2005 and 2015 traffic counts and axle load surveys constitute the basic data for the assessments conducted in this paper.

The objective of the current study was to conduct a comparative assessment of the initial traffic loading estimated during the rehabilitation design phase in 2005, the actual traffic loading determined after construction had been completed and the road had been opened to traffic in 2015, as well as the projected future traffic loading. The assessment provided an indication of the adequacy of the designed pavement and its expected future performance, and also highlighted the importance of measuring/collecting site-specific and accurate traffic volume and loading data.

OVERVIEW OF TRAFFIC COUNTS AND AXLE LOAD SURVEYS

Traffic Counts

Traffic counts for pavement design purposes can be performed by manual counts or automatic count methods such as the use of pneumatic tube counters. Each traffic count method requires different levels of effort and cost, and yields different levels of traffic detail. Regardless of the traffic count method used, the main purpose of traffic counts for pavement design is to obtain estimates of the base year traffic volumes. The actual composition of vehicles on a specific road section varies significantly, ranging from light passenger vehicles to buses and heavy vehicles transporting commercial goods. For pavement design purposes, the heavy vehicles portion of the traffic stream is commonly used, because light vehicles are considered to cause insignificant damage to the pavement (MOW, 1999; TRH 4, 1996; TRH 16, 1991). During traffic counts, heavy vehicles are grouped into different categories to facilitate the determinations of traffic loading and their contribution to pavement damage (as will be demonstrated later in this paper). For example, the current practice in Tanzania requires that heavy vehicles be grouped into four different categories, namely Medium Goods Vehicles (MGV), Heavy Goods Vehicles (HGV), Very Heavy Goods Vehicles (VHGV), and Buses (see Table 1) (TANROADS, 2003).

Manual traffic counts are carried out by observers at a carefully selected observation point or counting station along a road section. The traffic count survey is usually a classified count whereby each vehicle passing an observation point is recorded on a prepared sheet/form according to the vehicle type, and each travel direction is recorded separately. The manual traffic count is usually undertaken over a short period (typically seven days), as it is not practical and cost effective to undertake manual traffic counts over a long period (i.e. 24-hour throughout the year). To improve the reliability of the traffic data counts, it is recommended that shorter period traffic counts be undertaken during normal days (i.e. days on which traffic patterns are not significantly affected by public and school holidays, or other events) (TMH 14, 2014; TMH 3, 2015).

Table 1. Definition of Heavy Vehicle Categories (TANROADS, 2003)

Heavy vehicle categories	Definition
Medium Goods Vehicles (MGVs)	2 axles, including steering axle, and 3 tons empty weight or more
Heavy Goods Vehicles (HGVs)	3 axles, including steering axle, and 3 tons empty weight or more
Very Heavy Goods Vehicles (VHGVs)	4 or more axles, including steering axle, and 3 tons empty weight or more
Buses	Seating capacity of 40 or more

Automatic traffic count an alternative to the manual traffic count can measure traffic volumes continuously over a long period and allow for capturing affects such as the seasonal variation of traffic volumes. The commonly used automatic traffic count systems can be grouped into three broad types namely: pneumatic tube, magnetic wire loops and piezo systems (TRL, 2004). It is important to recognize that each of the available automatic traffic counting technologies has certain limitations that must be taken into account when establishing a traffic count station. Magnetic wire loop systems are the commonly used automatic traffic count systems in Southern Africa and are generally classified into two categories namely: intrusive loops (embedded or placed on the road pavement typically for long period traffic counts) and non-intrusive loops (placed on pavement surface and suitable for shorter period traffic counts) (TMH 3, 2015). Figure 1 show photos of typical intrusive and non-inductive traffic count installations.


(a) Intrusive loops (b) Non-intrusive ("stick on") loops

FIG. 1. Typical Intrusive and Non-intrusive Loop Systems

Axle Load Surveys

Traditionally, static weighing that use a fixed weighbridge or a portable weighpad (see Figure 2a) has been commonly used for the measurement of heavy vehicle axle loads. Alternatively, the measurement of heavy vehicle axle loads can be performed by Weigh-In-Motion (WIM) systems (FHWA, 2013; TMH 14, 2014). The bending plates (see Figure 2b) are some of the most widely used in WIM systems. It should, however, be mentioned that axle load measured using WIM systems involves of static and dynamic load components (TMH 14, 2014). Most of the available pavement design methods make use of static axle load data, and as such WIM axle load data may need to be processed to eliminate the dynamic load component.


(a) Portable static weigh pads (b) WIM bending plates

FIG. 2. Typical Portable Static Weigh pads and WIM Bending Plates

Heavy vehicle axle loads are also affected by other factors such as changes to the legal axle load limits, the level of enforcements, as well as mechanical design and load carrying capacity of the vehicle. Table 2 shows the legal axle load limits for Tanzania (Government Notice No. 30, 2001), alongside the legal axle load limits for South Africa (Government Notice R225, 2000) and the East African Community (EAC) Vehicle Load Control Act (2013). It can be seen that in certain axle type/groups, the maximum permissible axle load limits for Tanzania are slightly higher than those for South Africa and the East African Community Vehicle Load Control Act. It is further noted that the maximum permissible load limit for the traditional dual tyres triple axle non-steering configuration (12 tyres) is the same as that of triple axle wide-base single (super single) tyres [6 tyres] for Tanzania (i.e., 24 tons), which may cause accelerated pavement damage. On the other hand, the East African Community Vehicle Load Control Act has reduced the legal load to 22.5 tons for triple axle wide-base single tyres to compensate for the damaging effects of the wide-base tyres, while South Africa does not encourage the use of wide-base single tyres (i.e. use 24 tons legal load for triple axle non-steering [12 tyres], regardless of whether they are normal or wide-base tyres).

Traditionally, dual tyres have been used to limit pavement damage by efficiently distributing the axle loads over a larger contact area than single tyres, hence reducing the contact stresses on the pavement. Due to economic, safety and other benefits, the wide-base single (super single) tyres are increasingly used in the trucking industry. However, research studies demonstrate that wide-base single tyres cause more damage to pavements than do traditional dual tyres (Al-Qadi and Wang, 2004; Greene et al., 2009; Abu Abdo, 2017).

Table 2. Legal Axle Load Limits for Tanzania, South Africa and East African Community (EAC)

Type of axle/axle group	**No. of tyres**	**Maximum permissible load on axle/axle group (tons)**		
		Tanzania	**South Africa**	**EAC**
Single steering drive operated	2	8	7.7	-
Two steering drive operated	4	14	-	-
Single steering draw bar controlled	4	9	-	-
Single non-steering	2	8	8	8
Single non-steering	4	10	9	10
Tandem non-steering	4	12	16	-
Tandem non-steering	6	15		-
Tandem non-steering	8	18	18	18
Tandem steering (dolly)	8	16	-	-
Triple non-steering	10	21	-	-
Triple non-steering	12	24	24	24
Triple super single tyres	6	24	-	22.5

STUDY APPROACH

Description of the Case Study

The road section considered in this study, an approximately 40 km-long single carriageway with one lane in each direction, is located between Korogwe and Mombo towns in Tanzania's Tanga region. The Korogwe-Mombo road section forms part of the North-East corridor (T2 trunk road), which is the main trunk road that connects Tanzania's East Coast (including Dar es Salaam city and Tanga Port) with the northern regional cities of Kilimanjaro and Arusha. The T2 trunk road is also the main road that links Dar es Salaam and Nairobi, the major trade centres of Tanzania and Kenya respectively. In addition, the road is used by heavy vehicles travelling to and from the neighbouring country of Uganda.

Traffic Counts

The first traffic counts that were carried out in 2005 along the Korogwe-Mombo road included classified manual traffic counts. The classified manual traffic counts were carried out over seven consecutive days continuously for 12 hours for the first four days, followed by 24-hour counts for the next three days. Vehicles passing the counting point were recorded separately for each direction. The traffic counts data was used for the structural design of the pavement for rehabilitation of the road section in 2006 (TANROADS, 2006).

The second set of traffic counts was carried out in 2015 for the same Korogwe-Mombo road section after the rehabilitation of the section had been completed and the road had been opened to traffic (O'Connell et al., 2016). The data set consisted of manual classified traffic counts conducted over seven consecutive days for 24 hours. During the traffic counts for both 2005 and 2015, the heavy vehicles were grouped into four categories (MGVs, HGVs, VHGVs and Buses), as recommended in the Tanzania Field Testing Manual (TANROADS, 2003).

For pavement design and analysis purposes, heavy vehicle traffic count data is usually expressed in terms of the Annual Average Daily Traffic (AADT). The current study analyzed traffic count to determine AADT, and Equation 1 used the AADT values based on 2005 traffic counts to compute the expected future traffic volumes in 2015. The traffic growth rates used for the computation of future traffic were 7.0% for Buses and 6.0% for MGVs, HGVs and VHGVs. These rates were estimated based on the recommendations contained in Tanzania's traffic growth baseline survey report (TANROADS, 2009), and they were similar to those used during the rehabilitation design of the Korogwe-Mombo road.

$$Projected\ \ AADT = Initial\ \ AADT \times \left(1 + 0.01 \times j\right)^{n} \qquad \text{(Equation 1)}$$

Where: *j* is traffic growth rate (%) and *n* is the time in years between the determination of traffic volume and the projection year.

Axle Load Surveys

Similar to the traffic counts, two sets of axle load measurements were carried out in 2005 and 2015 respectively. Both axle load measurements were conducted over seven consecutive days for 24 hours, using a portable static weigh pad. The axle load surveys grouped the heavy vehicles into four categories: MGVs, HGVs, VHGVs and Buses. In addition to the axle load measurements, an Origin-Destination (OD) survey was also performed during the 2015 axle loads survey, including the type of the load/goods transported.

An Axle Equivalency Factor (AEF) is generally used to process the axle load survey data and assist with estimating the traffic loading for pavement design and analysis. The AEF represents the damaging effect of an axle passing over the pavement and is calculated using Equation 2, as recommended in the Tanzania Field Testing Manual (TANROADS, 2003).

$$\mathit{Axle\ Equivalency\ Factor\ (AEF)} = \left[\frac{\mathit{Axle\ Load\ (kg)}}{\mathit{8160}}\right]^{4.5} \qquad \text{(Equation 2)}$$

For most pavement design purposes, the full axle load distribution is usually not available. As such, the concept of “E80 per heavy vehicle” (E80/HV) or Vehicle Equivalency Factor (VEF) is used. VEF is a factor that converts different truck loads to an equivalent number of standard axles (i.e. 8160 kg per axle). Equation 3 was used to process the axle load survey data of the individual heavy vehicles and determine VEF.

$$Vehicle\ Equivalency\ Factor\ (VEF) = \sum_{2}^{i} AEF \qquad \text{(Equation 3)}$$

In Equation 3, *i* is the total number of axles, and *AEF* is the Axle Equivalency Factor that was computed using Equation 2. The VEF values of each heavy vehicle were subsequently used to determine the average VEF for each of the heavy vehicle categories. The average VEF was calculated separately for each direction/lane.

ANALYSIS RESULTS AND DISCUSSIONS

Assessment of Heavy Vehicles Volume

As mentioned earlier, for pavement design and analysis purposes, heavy vehicle traffic counts data are usually expressed in terms of the AADT. Figure 3 presents the AADT for each of the heavy vehicle categories for traffic counts carried out in 2005 and 2015. As theoretically expected, the AADT values for the 2015 traffic count are higher than those for 2005. For both 2005 and 2015 traffic count surveys, the AADT in both directions appears to be similar, with the exception of the MGV category for the 2015 survey (i.e. AADT for Korogwe to Mombo direction is 94, whereas the AADT for the opposite direction is 112). The traffic count data also shows that in 2005 the AADT for Buses was highest followed by VHGV, MGV and HGV categories. In contrast, the 2015 traffic count data indicates that the AADT for VHGV was the highest followed by Buses, MGVs and HGVs.

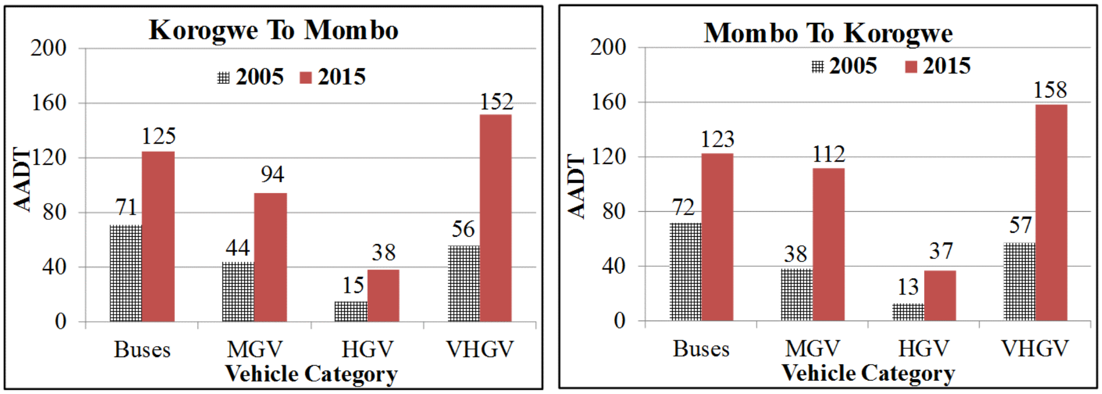

FIG. 3. AADT for 2005 and 2015 Traffic Counts

Figure 4 compares the actual traffic volumes obtained during the 2015 traffic counts and the volumes projected based on the 2005 traffic counts (using Equation 1). With the exception of Buses, the AADT projections based on the 2005 traffic count data are generally lower than the actual AADT determined on the basis of the actual 2015 survey. For instance, while the projected AADT for Buses is approximately 12% higher than the actual AADT in the Korogwe-Mombo direction, the projected AADT for MGVs, HGVs and VHGVs is lower than the actual AADT by approximately 16%, 29% and 34% respectively. The difference is significantly higher for the VHGVs category. The Origin-Destination (OD) survey performed as part of the axle loads survey indicated that most of the VHGV transport cement from the Tanga cement factory to the northern regions of Kilimanjaro and Arusha, and hence they may not have been accounted for during the 2005 traffic counts. Additionally, the general traffic growth trends over a 10-year period could be a contributing factor.

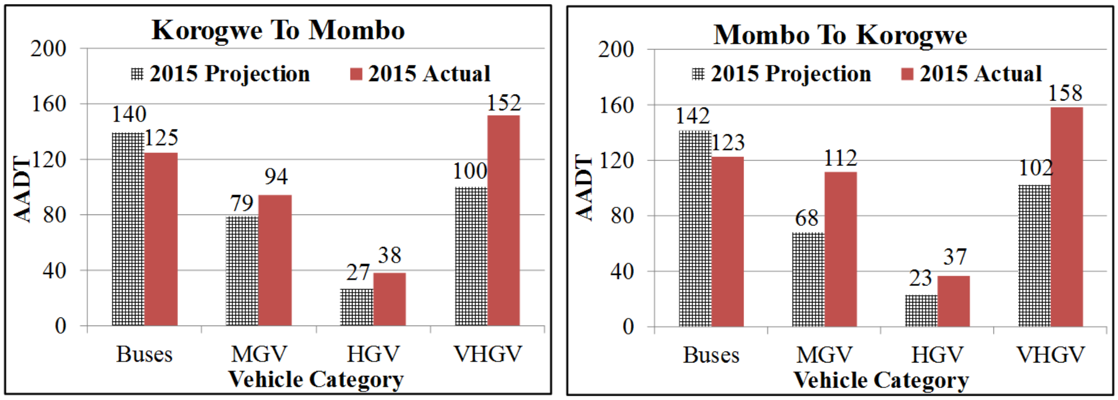

FIG. 4. Comparison of Actual and Projected 2015 AADT

The comparison of the actual and projected traffic suggests that the generic traffic growth rates obtained from the Tanzanian traffic growth baseline survey report should be used cautiously, as they may not be realistic for some roads. It further demonstrates the need to accurately determine site-specific traffic data for pavement structural design purposes, as opposed to using generic traffic growth rates generally derived from the expected growth in Gross Domestic Product (GDP) of a country. It should, however, be mentioned that both the 2015 and the 2005 traffic counts were carried out over a short period (seven days), hence the effects of seasonal variation of traffic may not have been accounted for.

Assessment of Axle Loads

Figure 5 compares the average VEF for each of the heavy vehicle categories that were determined using the 2005 and 2015 axle load surveys. For both 2005 and 2015 surveys, the VEF values determined for the Korogwe-Mombo direction are higher than those for the opposite direction (i.e. Mombo-Korogwe). This observation is in agreement with the Origin-Destination (O-D) survey data, which indicated that the heavy vehicles travelling in the Korogwe-Mombo direction are loaded more heavily than those travelling in the Mombo-Korogwe direction. The O-D survey indicated that the most common loads/goods transported by the heavy vehicles were cement (mostly from the Tanga cement factory), diesel/petrol, shop supplies, wheat flour, fertilizer, gas, building materials and farm produce to the northern regions of Tanzania and neighbouring countries of Kenya and Uganda. This observation demonstrates the importance of undertaking axle load surveys for each road direction separately, as traffic loading in opposite directions may differ significantly. It is further observed that the VEF values determined from the 2015 surveys are higher than those determined from the 2005 survey. Hence the VEF determined from the 2005 axle load survey data is more likely to underestimate the cumulative pavement traffic loading, as will be shown in the next section.

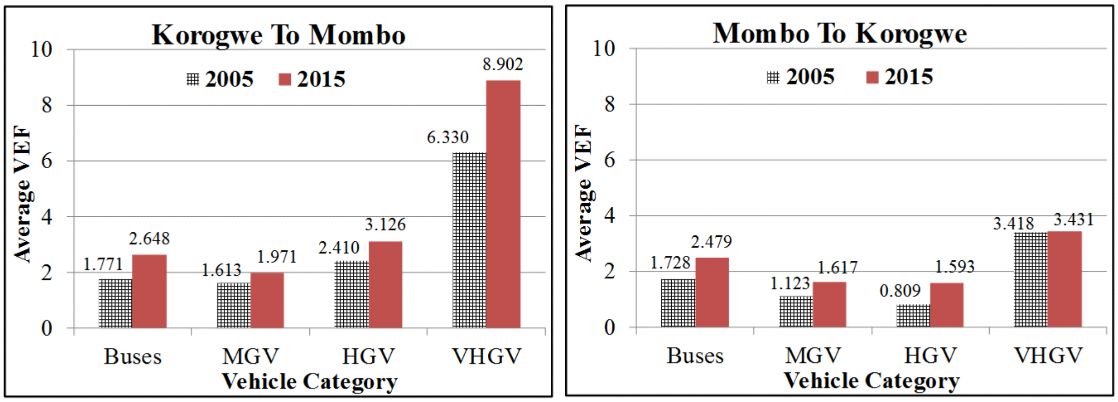

FIG. 5. Average Vehicle Equivalency Factors (VEFs).

Comparison of Traffic Loading

The determined VEF values for the Korogwe-Mombo direction were used in combination with the AADT to determine the cumulative pavement loading (E80s). Because the values were higher than in the Mombo-Korogwe direction, they were critical for pavement design (i.e. the heavily loaded direction). A 20-year design period was assumed, which is the same as the design period used during the rehabilitation design of the road section. The commutative pavement traffic loading was computed using traffic counts and axle load survey data for both 2005 and 2015. As indicated earlier, the traffic growth rates used were 7.0% for Buses and 6.0% for MGVs, HGVs and VHGVs. The following three different scenarios were considered:

- Scenario 1: Use of the traffic counts and axle load survey data for 2005 to determine the 20-year traffic loading, with 2008 as the base year. This is similar to the approach used during the design of the rehabilitated road (i.e., the construction was originally planned to be completed by 2008).

- Scenario 2: Use of traffic counts and axle load survey data obtained in 2005, with 2015 as a base year. This means that the recommended traffic growth rates were applied to the actual 2005 traffic counts to project AADT for the year 2015 and then compute the 20-year traffic loading.
- Scenario 3: Use of the actual traffic counts and axle load survey data for the 2015 survey to determine 20-year traffic loading.

Tables 3 presents the calculated 20-year cumulative pavement traffic loading (E80s) for scenarios 1 to 3 above as 9.7, 14.8 and 27.2 million respectively. As theoretically expected, due partly to traffic growth over a 10-year period, the cumulative traffic loading that was calculated based on the 2015 data (Scenario 3) is significantly higher than the estimated traffic loading based on the 2005 survey data using Scenarios 1 and 2 (i.e. approximately 2.8 times and 1.5 times higher compared with Scenarios 1 and 2 respectively). This was expected due to the higher AADT and VEF values obtained during the 2015 traffic counts and axle load survey respectively. Thus, the traffic loading that was computed based on the 2005 survey data may underestimate the actual expected future traffic loading, and it illustrates the importance of using the latest, most accurate and reliable traffic data during rehabilitation design.

Table 3. Cumulative Traffic Loading for Korogwe-Mombo Direction.

	Heavy vehicle category	**Buses**	**MGV**	**HGV**	**VHG**
Scenario 1	AADT	87	52	18	67
	E80 per heavy vehicle/VEF	1.771	1.613	2.410	6.330
	E80s per day	154	85	43	422
	Traffic growth rate (%)	7.0	6.0	6.0	6.0
	E80s for 20 years (million)	2.3	1.1	0.6	5.7
	Total E80s for 20 years (million)	**9.7**			
Scenario 2	AADT	127	79	24	87
	E80 per heavy vehicle/VEF	1.771	1.613	2.410	6.330
	E80s per day	225	127	58	551
	Traffic growth rate (%)	7.0	6.0	6.0	6.0
	E80s for 20 years (million)	3.4	1.7	0.8	7.4
	Total E80s for 20 years (million)	**14.8**			
Scenario 3	AADT	125	94	38	152
	E80 per heavy vehicle/VEF	2.648	1.971	3.126	8.902
	E80s per day	331	185	119	1353
	Traffic growth rate (%)	7.0	6.0	6.0	6.0
	E80s for 20 years (million)	5.0	2.5	1.6	18.2
	Total E80s for 20 years (million)	**27.2**			

Implications for Structural Pavement Design

According to the Tanzania Pavement Design Manual (1999), the traffic loading that was computed based on the 2005 traffic counts and axle load survey data falls under Traffic Loading Class-TLC 10 (i.e. cumulative traffic loading between 3 and 10 million E80s) for scenario 1 and TLC 20 (between 10 and 20 million E80s) for Scenario 2. On the other hand, the outcomes of the latest traffic and axle load surveys (conducted in 2015 after construction completion and the opening of the road to traffic) indicate that the road section is more likely to carry traffic loading that is equivalent to TLC 50 (between 20 and 50 million E80s) over the 20-year design life. The structural design for the rehabilitation of the road section was undertaken using TLC 10, which may have underestimated the expected future traffic loading.

Although a detailed evaluation of the structural adequacy of the pavement structure used for the rehabilitation of the Korogwe-Mombo road section falls outside the scope of this paper, the traffic loading analyses indicate that the pavement structure may have been under-designed and may require further structural strengthening before the end of the desired 20-year service life. However, monitoring the long-term performance of the road section may be needed to ascertain the extent to which an inaccurate determination of the traffic loading may shorten the pavement service life. It is also important to emphasize that the performance of pavements is not only dependent on the accurate determination of the expected future traffic loading. Other factors such as the quality of construction, supervision, design, materials, and climatic conditions may also affect the expected performance of the pavement.

CONCLUSIONS AND RECOMMENDATIONS

By using the Korogwe-Mombo road section in Tanzania as a case study, this paper presented a comparative assessment of the traffic loading estimated during the rehabilitation design, the currently measured site-specific traffic loading, and the projected future traffic loading. Based on the results and discussions contained in this paper, the following conclusions are drawn and recommendations made:

- The assessments that were conducted demonstrated the need for good quality and reliable up-to-date traffic data to ensure an accurate determination of traffic loading for pavement design purposes.
- The common practice to conduct traffic studies over a short period of time (usually seven days) may cause significant errors in the prediction of design traffic loading due to the inability to capture seasonal variation of traffic; traffic pattern changes resulting from short- to medium-term changes in economic policies; transportation regulations; legal axle load limits; the level of enforcements; etc.
- The generic traffic growth rates used to determine traffic loading should be applied cautiously. Traffic volumes may vary over time due to, for instance, fluctuation in economic trends. Furthermore, the growth rates should not be assumed to be the same for different heavy vehicle categories, as traffic patterns may fluctuate for a specific heavy vehicle category.
- To improve the accurate determination of traffic loading, traffic studies should

be conducted over long periods. Road agencies should also consider investing in the installation of permanent automated traffic and WIM-monitoring systems.

- In situations where significant time delays are expected from the rehabilitation design up to the start of construction, it is recommended that updated traffic studies be conducted to ascertain the traffic figures, as short- to medium-term changes in economic activities may affect traffic patterns (such as the cement factory influencing one direction in this paper).

Overall, this study has demonstrated the importance of periodic traffic surveys to measure and accurately quantify the changes and growth trends in traffic patterns, both in terms of volume counts and axle loads. In lieu of manual traffic surveys, use of more accurate automated traffic and WIM-monitoring systems is strongly recommended to ensure accurate traffic data characterization for optimal pavement design, rehabilitation and planning purposes. While costly permanent traffic and WIM-monitoring systems can be stationed on selected highway sites, portable WIM technology offers a cost effective alternative for deployment and traffic data measurements on any desired highway location.

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