American Journal of Traffic and Transportation Engineering
2016; 1(4): 47-52
http://www.sciencepublishinggroup.com/j/ajtte
doi: 10.11648/j.ajtte.20160104.12

Traffic Assessment for Pavement Structural Design Using RN29, LR1132, and HD26/01 Methods

Nwakaire M. Chidozie*, Chukwu C. Joshua

Department of Civil Engineering, Nnamdi Azikiwe University, Awka, Nigeria

Email address:
cm.nwakaire@unizik.edu.ng (N. M. Chidozie)
*Corresponding author

To cite this article:
Nwakaire M. Chidozie, Chukwu C. Joshua. Traffic Assessment for Pavement Structural Design Using RN29, LR1132, and HD26/01 Methods. *American Journal of Traffic and Transportation Engineering.* Vol. 1, No. 4, 2016, pp. 47-52. doi: 10.11648/j.ajtte.20160104.12

Received: October 25, 2016; **Accepted**: November 7, 2016; **Published**: December 21, 2016

Abstract: Traffic surveys are means of obtaining information about the traffic characteristics of an area. The data collected is used for traffic assessment of the area for various Engineering purposes. This study was an attempt to conduct a traffic assessment for the purpose of pavement design. Three design methods: Road Note 29 (RN 29), Laboratory Report 1132 (LR 1132), and Design manual for Highways and Bridges (DMHB; HD 26/01), were adopted. Three locations along the Onitsha-Enugu expressway, a Nigerian interstate highway, were surveyed. The highest volume of commercial vehicles was observed at the Nkpor location with corresponding design traffics of 108msa, 304msa, and 92.92msa using RN 29, LR 1132, and HD 26/01 respectively. Computed design traffics for Nkpor, Awkuzu, and Kwata locations using LR 1132 were 304msa, 175msa, and 167msa respectively. These were found to be significantly higher than those computed using RN 29 and HD 26/01 due to the fact that a uniform damaging factor was computed for the entire traffic count without any form of categorization or weight impact discrimination. It was concluded that the traffic assessment method to be adopted for any pavement design purpose should be consistent with the design method to be used for the selection of pavement thicknesses.

Keywords: Traffic, Assessment, Pavement, Commercial Vehicles, Design, Million Standard Axle (msa)

1. Introduction

Transportation involves the movement of people and goods from one place to another. It is indispensable as it connects peoples' destinations. The activities in a particular location affect the volume of transport demand, hence transport is seen as a derived demand [1]. Humans engage in different activities, such as; trade, commerce, schooling e.t.c. for survival and these activities of man brought about the need to travel, hence transportation is actually not an end in its self but a means to an end. The amount of activities in an area as well as the number of people seeking access to the opportunities created by those activities brings about changes in the demand for traveling to that location. The transport subsystem includes the transport networks, the vehicles, operating regimes, policies, regulations and the infrastructures that facilitate effective movement of people and goods from their origins to their preferred destinations [2]. Roads or highways are transport infrastructures. They are key aspects of the transport system.

1.1. Highway Pavements

Roads are very significant infrastructures that are indispensable to mobility of people and freight. They are critical to the well-being, growth and expansion of any city, whether developed or developing. Such pavements are expected to be durable and resilient, and to perform satisfactorily throughout their service lives [3]. A pavement section can be generally defined as the structural material placed above a subgrade layer [4]. The objective of pavement design is to provide a structural and economical combination of materials to carry traffic loadings in a given period over the existing soil conditions for a specified time interval of design life. It also functions to receive and transmit traffic loads through the pavement layers to the sub-grade [5]. Hence, traffic loading is a key factor that affect pavement structural design. This design traffic is estimated using the Annual Average Daily Traffic (AADT) of a particular road whether for new design or for redesign purposes. Highway pavements, just like other Civil Engineering structures, is expected to be durable and resilient; so for it to perform satisfactorily through the design life, traffic assessment is crucial both for the pavement design, construction/rehabilitation activities.

1.2. Pavement Design Considerations

Pavements are fundamentally designed against subgrade shear failure [6]. A highway pavement is a structure consisting of superimposed layers of selected and processed materials above the natural soil or subgrade, whose primary function is to distribute the vehicle applied load to the subgrade [7][8]. The aim is to ensure that the transmitted stresses due to wheel load are sufficiently reduced, so that they will not exceed bearing capacity of the subgrade. But apart from having sufficient knowledge of the geomechanical properties of each element of pavement structure, understanding the traffic loading for a road is very vital for adequate design and construction that will meet up the standard and serviceability required. Two types of pavements are majorly recognized, which are flexible and rigid pavements. A combination of the features of these two pavements led to what is referred to as composite pavements. The type and thickness of pavement layers are optimized to fulfil both structural and economical requirements based on the availability of local construction materials. During pavement design, there are three fundamental design parameters: material characteristics, traffic loading and environmental factors. These design parameters must be incorporated in the design.

1.3. Introduction to RN 29, LR 1132, and HD 26/01

Different design manuals have specified methods and models for traffic assessment. This study adopted the Rode Note 29 (RN 29), Laboratory Report 1132 (LR 1132), and the Design Manual for Highways and Bridges (DMHB; HD 26/01) methods. The RN29 was first published by the United Kingdom Department of Environment in 1973. It takes into account, increase in axle loads and vehicle volumes, increase in subgrade strength, as well as variation in roadbase materials [9]. The limitations of RN 29 in catering for increasing traffic volumes in the 1980's led to the development of LR 1132 which revised RN 29 by making provisions for higher pavement thicknesses that could ensure durability. Pavement failure was redefined and more contributing parameters were incorporated into the damaging factor model. The HD26/01 standard procedure was developed in 2001 by the Department of Transport, United Kingdom. It made some modifications and amendments on the LR 1132 methodology based on more resent innovative research and availability of new construction materials. For these design methods, traffic assessment is very important and primary. Reference [10] discussed different factors that influence the integrity of the highway pavements which include, environmental, structural, traffic, construction and maintenance factors. The traffic factors has to do with the volume, composition, distribution, and other characteristics of vehicular traffic experienced or encountered on the road. It also entails the expected traffic characteristics on a proposed new road. Traffic assessment is as old as pavement design. Pavement integrity is the ability of the pavement structures to uphold adequate serviceability, safety, and good riding quality at least within the design life.

1.4. Methods of Traffic Survey

Traffic surveys are means of obtaining information about traffic. This is a systematic way of collecting data to be used for various traffic engineering purposes [9]. Traffic counts are undertaken either automatically (with the installation of a temporary or permanent electronic traffic recording device) or manually by observers who visually count and record traffic on a hand-held electronic device or tally sheet. Any of these is acceptable by most Federal highway agencies. Reference [11] submitted that the major advantages of manual counting is that vehicle classification and turning proportions of traffic can easily be obtained. Such data can be used immediately after collection. The number of enumerators required depends on the length of counting period, the type of count being performed, the number of lanes or cross walks being observed, and the volume level of traffic. Besides, the method is not practicable for long durations like when a seasonal variation or weekly variation is envisaged. Contactless systems based on electrical, optical, ultrasound/infrared radar, microwave, close circuit television image processing methods are some advanced technologies that can be used in place of manual counting. They are justifiably employed when vehicle speeds are high and when traffic volumes are required without classification [12]. The manual counting was found to be most suitable for the current study do to the fact that the modal split is a key objective for traffic assessment.

1.5. Importance of Traffic Assessment

Traffic characteristics is a determining factor for about all transport systems engineering. Reference [13] defined Traffic Engineering as the science of measuring traffic and travel, the study of the basic laws relating to traffic flow generation and the application of this knowledge to the professional practices of planning, designing, and operating traffic systems to achieve safe and efficient movement of persons and goods. It is most significant for the evaluation of congestion, analysis of crash, computation of capacity, designing channelization, and signal timing [14]. Traffic Engineers and Planners need information about traffic for planning and designing traffic facilities, selecting geometric design standards, economic analysis and determination of priorities [8][15]. Information about traffic needs to be regularly updated to keep pace with ever changing transportation system [16]. This suggests that traffic data needs to be collected and analysed systematically to get a highly time-dependent information.

2. Methodology

The traffic data used for this study was gotten from the Enugu–Onitsha expressway, an interstate (trunk "A") highway in Nigeria. Figure 1 is the geographical map of Nigeria with the location of the study area highlighted.

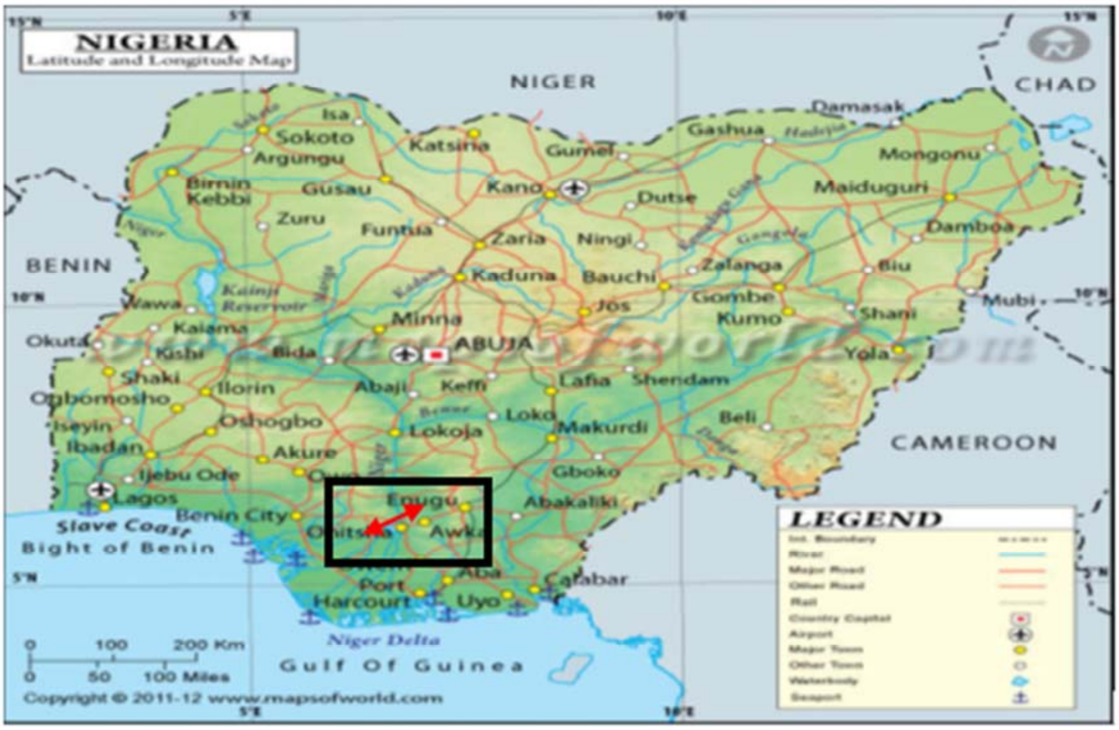

Figure 1. *Map of Nigeria Showing the Study Area.*

The traffic count was done by manual counting and the commercial vehicles counted were classified thus; Buses and Coaches, 2-axle rigid, 3-axle rigid, 4-axle rigid, 3-axle articulated, 4-axle articulated, 5-axle articulated, and 6-axle articulated. The traffic assessment was done to establish design traffic for highway pavement design using RN29, LR1132, and HD26/01 methodologies to determine the design traffic in million standard axle (msa).

The design traffic was computed based on RN29 using equations 1 and 2 below.

$$T_f = T_o(1+r)^n \quad (1)$$

Where

T_f=Estimated Future Traffic

T_o=Present traffic on the road

n=Design life in years

r=commercial vehicle growth rate (%)

$$\text{Design traffic, } T_D = T_f \times n \times 365 \quad (2)$$

Using LR1132, the total number of commercial vehicles and its damaging factors were computed before arriving at the determination of design traffic, using equations 3 to 6 below;

$$T_n = 365 Fo \frac{((1+r)^n - 1)}{r} P \quad (3)$$

Where F_o=initial daily flow

r=commercial vehicle growth rate

n=design life

P=proportion of vehicles using the slow (nearside) lane.

$$\text{Damaging factor} = \frac{0.35}{0.93^t + 0.082} - \left(\frac{0.26}{0.92^t + 0.082}\right)\left(\frac{1.0}{3.9^{(Fm \div 1550)}}\right) \quad (4)$$

Where F_m=number of commercial vehicle per day in one direction (mid-term year)

$$= F_o(1+r)^{\frac{n}{2}} \quad (5)$$

t=mid-term year minus 1945

N=cumulative number of standard axle

$$=(T_n \text{ X } D) \quad (6)$$

For HD26/01 methodology, the weighted annual traffic is first computed before then the design traffic using equations (7) and (8).

$$WAT = AADT \text{ x } G \text{ x } W \quad (7)$$

Where WAT=Weighted Annual Traffic

AADT=Annual Average Daily Flow

G=Growth Factor

W=Wear Factor

$$\text{The Design Traffic}=Y \times P \times \sum WAT \quad (8)$$

Where Y and P are design life and proportion of commercial vehicles in the near side lanes respectively [17]. Whereas the AADT is gotten from traffic survey, G, W, and P are chosen from empirically developed chats, the design life is set at 20 years for the purpose of this study. This is typical for most flexible pavements and the case study highway is constructed as flexible pavement.

3. Results and Discussion

A one directional traffic count was conducted manually at three locations along the selected highway. Following the design methods explained in section 2 above, three different design traffics were estimated for using each design method. Tables 1 and 2 shows the traffic assessment parameters and design traffics for RN 29 and LR 1132 respectively.

Table 1. *Traffic Assessment Parameters using RN 29.*

Location	Nkpor	Awkuzu	Kwata
T_o (Cv/d)	6763	3909	3729
n (years)	20	20	20
Growth rate (%)	4	4	4
T_f (Cv/d)	14819	8565	8171
Design Traffic (msa)	108	63	60

Table 2. *Traffic Assessment Parameters using LR 1132.*

Location	Nkpor	Awkuzu	Kwata
$T_n \times 10^6$	73.5	42.5	40.5
N (years)	20	20	20
t	82	82	82
P	1	1	1
D	4.13	4.11	4.11
F_m	10010	5786	5520
Design Traffic (msa)	304	175	167

The data presented in the tables show that there is a very high proportion of heavy goods vehicles at Nkpor than Awkuzu and Kwata. This is obviously as a result of high industrial and commercial activities at the Nkpor area. This suggests that high volume of commercial vehicles has been the reason for the frequent maintenance of the road pavement in the Nkpor area over the years. Though Awkuzu and Kwata junctions have similar traffic characteristics, based on the computed design traffics, the Awkuzu junction still has higher volume of traffic than Kwata. This suggests that the farther away from commercial areas, the lesser the number of heavy goods vehicles expected, as a result of diversion to other available routes.

Tables 3 to 5 is the traffic assessment data using the HD 26/01 method for the three different locations respectively. The various components and classes of the commercial vehicles using the road have been presented. The growth factors and wear factors were gotten from relevant charts in HD 26/01.

Table 3. *Nkpor Traffic Data and Analysis Using HD26/01 Traffic Assessment Method.*

Commercial vehicle class	AADT (F)	Growth Factor (G)	Wear Factor (W_M)	Weighted Annual Traffic=$365\times F \times G \times W \times 10^{-6}$
PSV				
Buses and coaches	5096	1.09	2.6	5.271
OGV1				
2 axle rigid	1170	1.09	0.4	0.186
3 axle rigid	114	1.09	2.3	0.104
OGV2				
3 axle articulated	76	1.27	3.0	0.106
4 axle rigid	31	1.27	1.7	0.024
4 axle articulated	83	1.27	1.7	0.065
5 axle articulated	145	1.27	2.9	0.195
6 axle articulated	48	1.27	3.7	0.083
Total Daily flow (cv/d)	6763	Total weighted annual traffic		6.034
		Percentage of vehicle in heaviest traffic lane (P)		77%
		Design Period (Y)		20
		Design Traffic (T)		92.92 msa

Table 4. *Awkuzu Traffic Data and Analysis Using HD26/01 Traffic Assessment Method.*

Commercial vehicle class	AADT (F)	Growth Factor (G)	Wear Factor (W_M)	Weighted Annual Traffic=$365\times F \times G \times W \times 10^{-6}$
PSV				
Buses and coaches	2998	1.09	2.6	3.101
OGV1				
2 axle rigid	359	1.09	0.4	0.057
3 axle rigid	138	1.09	2.3	0.126
OGV2				
3 axle articulated	7	1.27	3.0	0.010
4 axle rigid	3	1.27	1.7	0.003
4 axle articulated	173	1.27	1.7	0.136
5 axle articulated	186	1.27	2.9	0.250
6 axle articulated	45	1.27	3.7	0.077
Total Daily flow (cv/d)	3909	Total weighted annual traffic		3.760
		Percentage of vehicle in heaviest traffic lane (P)		85%
		Design Period (Y)		20
		Design Traffic (T)		63.92msa

Table 5. Kwata Traffic Data and Analysis Using HD26/01 Traffic Assessment Method.

Commercial vehicle class	AADT (F)	Growth Factor (G)	Wear Factor (W_M)	Weighted Annual Traffic=365$\times F \times G \times W \times 10^{-6}$
PSV				
Buses and coaches	2978	1.09	2.6	3.081
OGV1				
2 axle rigid	544	1.09	0.4	0.087
3 axle rigid	33	1.09	2.3	0.030
OGV2				
3 axle articulated	11	1.27	3.0	0.019
4 axle rigid	14	1.27	1.7	0.009
4 axle articulated	33	1.27	1.7	0.026
5 axle articulated	80	1.27	2.9	0.108
6 axle articulated	36	1.27	3.7	0.062
Total Daily flow (cv/d)	3729	Total weighted annual traffic		3.422
		Percentage of vehicle in heaviest traffic lane (P)		83%
		Design Period (Y)		20
		Design Traffic (T)		56.81 msa

The different classes of the commercial vehicles using the highway are shown in the tables 3 to 5, together with their observed numbers. At all locations, buses and coaches were the highest with a count of 5096, 2998, and 2978 at Nkpor, Awkuzu, and Kwata respectively. Majority of passenger commuting along this highway is by this mode. Some goods, ranging from heavy to light weight, are also carried by buses and coaches. Besides, specific industrial products like table water, cement, frozen foods etc are mostly carried by OGV1's and OGV2's. The highest category of OGV using the road is two axle rigid with up to 1170 AADT at Nkpor. Generally, a high volume of heavy vehicles were observed on the road due to the fact that there is no alternative means of transportation of freight in the study area. There are neither railways nor waterways, transportation of freight and people within South-East Nigeria is generally by road. This has resulted in very high number of various vehicle classes along all roads, with trunk A roads (Federal highways) carrying the highest volumes.

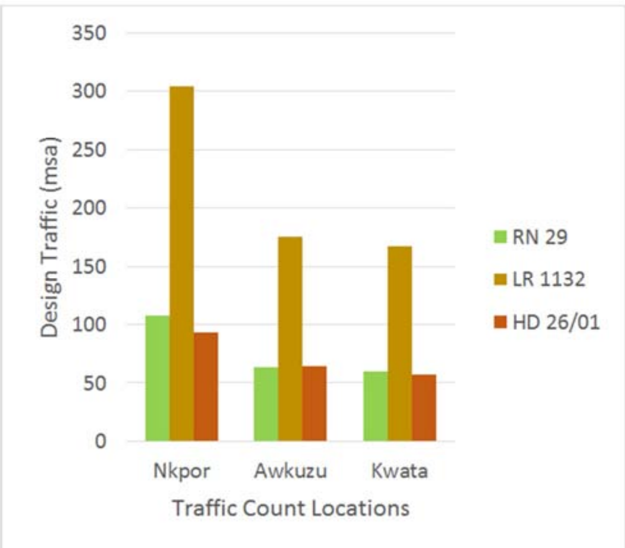

Figure 2. *Computed Design Traffics Using the three Design Methods.*

The design traffics computed with HD 26/01 were found to be less than those computed using RN 29 and even far less than the ones computed using LR 1132. Figure 2 shows the variation in design traffic with the three different traffic assessment methods at the three locations.

The design traffic from LR 1132 is quite high due to the fact that a uniform damaging factor was computed for the entire traffic count without any form of categorisation or weight impact discrimination. The usual assumption that all commercial vehicles use the heaviest trafficked lane (near side lane) for both RN 29 and LR 1132 is another major contributor to the high computed design traffics. The estimation of proportion of commercial vehicles in using the near side lane by empirical means is another major reason for a lesser design traffic from HD26/01. In any case, the traffic assessment method to be adopted should be consistent with the design method to be used for the pavement thicknesses.

4. Conclusion

This research work has presented three different procedures for traffic assessment for the purpose of highway pavement design. The procedures are RN 29, LR 1132, HD 26/01. The traffic survey was done by manual counting. The results at the three selected stations show variations in commercial vehicle volumes with Nkpor having the highest AADT and consequently the highest computed design traffic. The was found to be as a result of high commercial and industrial activities going on at Nkpor as well as its nearness to Onitsha main market. The next largest volume was encountered at Awkuzu and the least at Kwata, suggesting that the farther away from commercial areas, the lesser the volume of commercial vehicles encountered, due to traffic diversions to other available routes. The highest values of computed Design traffics were gotten from LR 1132, this is as a result of imposition of a uniform traffic damaging factor and the assumption that all commercial vehicles use the near side lane.

In any case, it could be concluded that the traffic assessment method to be adopted for any pavement design purpose should be consistent with the design method to be used for the pavement thicknesses as switching design methods will obviously lead to poor design. Besides, traffic volume is ever dynamic, therefore its data ought to be regularly updated and systematically analyzed. Hence, in as much as this assessment is representative of Onitsha Enugu expressway, it is yet highly time dependent. A reassessment is recommended at any time either for the purpose of new design or reconstruction.

References

[1] K. Button. “Transport Economics”. 3rd Edition, Edward Elgar, Cheltenham, UK (2010).

[2] M. L. Manheim. “Fundamentals of Transportation Systems Analysis”. Volume 1, MIT Press, Cambridge (1976).

[3] L. Qiang, M. Leslie, and M. Sue. “The Implication of Climate Change on Pavement Performance and Design”. A Report Submitted to the University of Delaware Transportation Centre (UD-UTC), 2011.

[4] J. W. Adrox and W. R. Woods. “A General Characterization of Pavement System Failures with Emphasis on a Method for Selecting Repair Process”. *Journal of Construction Education,* 7 (1), (2002) pp 58- 62.

[5] L. R. Kadiyali. “Highway Engineering”. 3rd edition. CBS Publishers and Distributors Pvt Ltd. New Delhi (1989).

[6] R. L. Carvalho. “Implementation of the NCHR 1-37A”. Design Guide Final Report Volume 1, 2006. [Online] Assessed from http://designtransportation.org/Document/MDSHA Assessed on 29th January 2016.

[7] C. M. Nwakaire. “Pavement Design; Considerations, Criteria, and Concepts”. Lecture 11, Highway and Transportation Engineering II. Department of Civil Engineering, Nnamdi Azikiwe University, Awka, 19th January, 2016.

[8] C. A. O’Flaherty. “Highways: The Location, Design, Construction, and Maintenance of Pavements”. Butterworths and Heinemann, Oxford United Kingdom (2012).

[9] M. Rogers. “*Highway Engineering”*. Second Edition, Blackwell Publishing, Oxford, UK (2012).

[10] R. Haas, L. C. Falls, D. MacLeod and S. Tighe. “Climate Impacts and Adaptations on Roads in Northern Canada”. Cold Climates Conference, Regina, (2004).

[11] H. D. Robertson. (ed). “Volume Studies”. Manual of Transportation Engineering Studies, Prentice Hall, Inc, 6-31 (1994).

[12] D. R. Middleton, R. T. Parker, and R. R. Longmire “Investigation of Vehicle Detector Performance and ATM Interface”. Texas Transportation Institute, Unite States (2007).

[13] B. L. Gupta and A. Gupta. “Highway and Bridge Engineering”, Standard Publishers Distributors, Delhi, India (2008).

[14] W. S. Homburger, J. W. Hall, R. C. Loutzenheiser, and W. R. Reilly. “Volume Studies and Characteristics*”.* A Lecture Not on the Fundamentals of Traffic Engineering. Institute of Transportation Studies, University of California, Berkeley (1996).

[15] J. P. Rodrigue. “*The Geography of Transport Systems”*, Third Edition. Routledge, New-York (2013).

[16] J. D. Ortuzar and L. G. Willumsen. “Modelling Transport” 4th Edition, John Willey and Sons Ltd, Chichester, West Sussex, United Kingdom, (2011).

[17] Design Manual for Roads and Bridges (DMRB). “Traffic Assessment”, HD06/part 1, Vol. 7, Section 2. The Department of Transport, London, UK. February 1996.