VARIATION OF THE CHARACTERISTICS ON THE TRANSIT OF COMMERCIAL VEHICLES ALONG A HIGHWAY CORRIDOR IN NORTHERN COLOMBIA

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ABSTRACT

The important variation in the time that the traffic of commercial vehicles may suffer was possible to determinate, both in its relative composition, as in the value of the characteristic Truck Factor of the road corridor from this work, therefore, it is recommended to remain carefully in the exercise of assigning traffic parameters, such as the truck factor.

To determinate the truck factor year after year, it was necessary to conflate the available information about the counts made at the “La Apartada” toll station and the results of weighing operations realized between the years of 2003 and 2004 throughout the Caucasia - Planeta Rica highway, located in the northern part of Colombia.

Keywords: Trucks, cargo, damage factor, truck factor.


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1. INTRODUCTION

Based on the structural pavement design, the traffic estimation requires the calculation of several surrounding axes per lane and its distribution in different load groups during the design period [1]. For this purpose, pavement engineering has used the equivalent standard axis to represent this parameter, as has always been done, therefore, the calculation of the design traffic has as its main objective the cumulative number quantification of equivalent simple axes of 8.2 tons (N) that are going to circulate in the design lane during a determinate period, which normally ranges from 10 to 20 years, depending on the category of the road [2]. Lacing traffic as the most important factor when designing the pavement [3]; It is essential to make the appropriate appraisal to give results in a structure that is capable of offering performance levels that are consistent with the durability provided by the designer [4] although it is important to highlight that the transport determined for the traffic design corresponds to commercial vehicles such as long-loaded buses and trucks, that is why the effect generated by light vehicles (motorcycles, cars, campers, vans) is not taken into account since these have a minimal effect on the deterioration of the pavement [1], [2].

Where there is no historical traffic series or there are only a few data in a historical series, the quantification of the traffic would be carried out equivalently, using the information of traffic counts of one-week duration and growth trends representative of the project area [5]. In these cases, the design transit would be determined from the following equation [6], [7]:

\[
N_{8.2} = ADT_i \times \frac{A}{100} \times \frac{B}{100} \times 365 \times \frac{(1+r)^n-1}{\ln(1+r)} \times T.F. 
\]  

(1)

Where:

- \( N_{8.2} \): number of standard equivalent design axles
- \( ADT_i \): initial average daily traffic
- \( A \): percentage of commercial vehicles of the capacity
- \( B \): factor per lane, this can take the values set out in Table 1
- \( r \): the annual growth rate of transit
- \( n \): design period (in years)
- \( T.F. \): truck factor representative of commercial vehicles

Table 1, some reference values are shown, for the determination of the factor per lane [3], [8].

<table>
<thead>
<tr>
<th>Number of traffic lanes</th>
<th>Percentage of trucks in design lane</th>
</tr>
</thead>
<tbody>
<tr>
<td>In two directions</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>50</td>
</tr>
<tr>
<td>4</td>
<td>45 (35-48) a</td>
</tr>
<tr>
<td>6 or more</td>
<td>40 (25-48) a</td>
</tr>
</tbody>
</table>

\( a \): Probable range

Equation one (1), the truck factor (T.F.) allows to convert the total number of commercial vehicles expected in the design lane during the design period, in terms of equivalent axes of 80 KN, Taking into account that this axis represents the number of standard reference axes that would produce pavement damage equivalent to an average commercial vehicle traffic [6].

An important item to highlight in equation 1, concerns the truck factor (TF) that represents the number of equivalent simple reference axes (80 KN) that would cause pavement damage equivalent to the traffic of an average commercial vehicle [6].

The estimate assorted traffic should generate an effect which, expressed in terms of the number of equivalent standards simple axes, should follow two paths: the specific determination of the truck factor of the road corridor (from weighing operations carried out along the road corridor to intervene),
or through the damage factors that have been previously established by previous global studies and these factors are considered representative of the specific traffic conditions of the road under study [9].

This work presents the stages of evolution that the truck factor has had over time located in the road corridor of Caucasia - Planeta Rica, northern Colombian zone. For this purpose, it is necessary to contrast the information given of two weighing operations realized along the road corridor during the years 2003 and 2004 and the annual average daily traffic obtained continuously between 2003 and 2018, located at an intermediate site within the same road sector under study at the “La Apartada” toll station.

2. MATERIALS AND METHODS

From the information on vehicle weighing, the damage factors were established for the different types of trucks affected by the National Roads Institute, as a result, the application was given to the Simplified Method of the AASHTO, also known as the Law of the Fourth Power, which is defined according to equation 2 [2].

\[ EALF = \left( \frac{W_1}{W_0} \right)^4 \]  

(2)

Where:

EALF: Equivalent Axle Load factor, for Flexible Pavements.
Wo: Standard Load
W1: Load which Equivalence with the Standard is to be determined

However, the damage factor of each commercial vehicle corresponds to the sum of the load equivalence factors of each of the axles making up the vehicle [2]:

\[ CVDF = \sum_{i=1}^{m} EALF \]  

(3)

Where:

m: Number of Axles of the Vehicle Configuration
EALF: Equivalent Axle Load Factor
CVDF: Commercial Vehicle Damage Factor

For analysis purposes, it was assumed that the damage factors would be kept unchanged for each class of vehicle throughout the time examined. Meanwhile, regarding the relative composition of the different types of commercial vehicles, these were obtained from the monthly summaries generated by the “La Apartada” toll station within the period 2003 to 2018.

The representative Truck Factor for each year was obtained from the weighted average of the damage factors of each class of truck, compared with the relative annual composition of trucks obtained at the toll station.

3. RESULTS AND DISCUSSION

Table 2 shows the ratio and number of trucks analyzed, which were weighed in operations realized during the years 2003 and 2004. Likewise, the damage factors representative of each type of vehicle is presented.
Table 2. List of heavy trucks and damage factors in the 2003 and 2004 operations

<table>
<thead>
<tr>
<th>TYPE OF TRUCK</th>
<th>NUMBER</th>
<th>FREQUENCY (%)</th>
<th>DAMAGE FACTORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>C2</td>
<td>36655</td>
<td>50.93</td>
<td>1.76</td>
</tr>
<tr>
<td>C3 – C4</td>
<td>5841</td>
<td>8.12</td>
<td>4.11</td>
</tr>
<tr>
<td>C5</td>
<td>12240</td>
<td>17.00</td>
<td>3.89</td>
</tr>
<tr>
<td>C6</td>
<td>17239</td>
<td>23.95</td>
<td>5.06</td>
</tr>
<tr>
<td>TOTAL</td>
<td>71975</td>
<td>100.00</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 3 shows the average annual vehicle composition during the years between 2003 and 2018; Information is taken uninterruptedly during this period at the “La Apartada” toll station, which is located within the road corridor under study.

As a relevant issue, it can be observed that in the last two years there has been a significant decrease in the transit of C2 trucks (two axles); while there has been a significant increase in the number C3 - C4 and C5 trucks.

Figure 1 shows the variation that the Truck Factor has suffered over the last fifteen years, during the road corridor study. On accordance with Figure 1, a truck factor significant variation has been presented during the period under study shows the need to be careful at the moment of assigning the characteristic truck factor of a particular road sector, because following equation 1, this corresponds to a unique value, which runs the risk of committing major errors in traffic estimation.

Table 3. Summary of average annual vehicle composition at the “La Apartada” toll station during the period from 2003 to 2018

<table>
<thead>
<tr>
<th>YEARS</th>
<th>I (A)</th>
<th>II (B)</th>
<th>II (C-2)</th>
<th>III (C-3 - C-4)</th>
<th>IV (C-5)</th>
<th>V (C-6)</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>52.8%</td>
<td>6.7%</td>
<td>22.9%</td>
<td>3.5%</td>
<td>6.1%</td>
<td>8.0%</td>
<td>100.0%</td>
</tr>
<tr>
<td>2004</td>
<td>55.5%</td>
<td>15.5%</td>
<td>11.8%</td>
<td>4.0%</td>
<td>5.6%</td>
<td>7.6%</td>
<td>100.0%</td>
</tr>
<tr>
<td>2005</td>
<td>54.1%</td>
<td>8.0%</td>
<td>20.3%</td>
<td>4.1%</td>
<td>5.3%</td>
<td>8.2%</td>
<td>100.0%</td>
</tr>
<tr>
<td>2006</td>
<td>52.3%</td>
<td>7.8%</td>
<td>20.4%</td>
<td>4.6%</td>
<td>4.8%</td>
<td>10.1%</td>
<td>100.0%</td>
</tr>
<tr>
<td>2007</td>
<td>50.4%</td>
<td>8.6%</td>
<td>19.6%</td>
<td>5.5%</td>
<td>4.4%</td>
<td>11.6%</td>
<td>100.0%</td>
</tr>
<tr>
<td>2008</td>
<td>50.7%</td>
<td>8.1%</td>
<td>20.2%</td>
<td>5.3%</td>
<td>4.2%</td>
<td>11.5%</td>
<td>100.0%</td>
</tr>
<tr>
<td>2009</td>
<td>52.4%</td>
<td>9.8%</td>
<td>19.1%</td>
<td>5.2%</td>
<td>3.7%</td>
<td>9.9%</td>
<td>100.0%</td>
</tr>
<tr>
<td>2010</td>
<td>49.2%</td>
<td>7.5%</td>
<td>21.7%</td>
<td>5.7%</td>
<td>4.4%</td>
<td>11.5%</td>
<td>100.0%</td>
</tr>
<tr>
<td>2011</td>
<td>49.4%</td>
<td>6.6%</td>
<td>22.1%</td>
<td>5.7%</td>
<td>4.5%</td>
<td>11.7%</td>
<td>100.0%</td>
</tr>
<tr>
<td>2012</td>
<td>50.8%</td>
<td>6.6%</td>
<td>20.8%</td>
<td>6.1%</td>
<td>4.4%</td>
<td>11.4%</td>
<td>100.0%</td>
</tr>
<tr>
<td>2013</td>
<td>51.0%</td>
<td>7.0%</td>
<td>20.3%</td>
<td>6.2%</td>
<td>4.4%</td>
<td>11.0%</td>
<td>100.0%</td>
</tr>
<tr>
<td>2014</td>
<td>49.6%</td>
<td>10.1%</td>
<td>17.7%</td>
<td>6.1%</td>
<td>4.4%</td>
<td>12.1%</td>
<td>100.0%</td>
</tr>
<tr>
<td>2015</td>
<td>54.4%</td>
<td>4.9%</td>
<td>21.1%</td>
<td>4.9%</td>
<td>4.0%</td>
<td>10.7%</td>
<td>100.0%</td>
</tr>
<tr>
<td>2016</td>
<td>52.1%</td>
<td>5.2%</td>
<td>12.5%</td>
<td>11.3%</td>
<td>8.9%</td>
<td>10.0%</td>
<td>100.0%</td>
</tr>
<tr>
<td>2017</td>
<td>50.8%</td>
<td>5.4%</td>
<td>3.8%</td>
<td>18.3%</td>
<td>13.7%</td>
<td>7.9%</td>
<td>100.0%</td>
</tr>
<tr>
<td>2018</td>
<td>59.2%</td>
<td>3.4%</td>
<td>4.4%</td>
<td>15.3%</td>
<td>11.3%</td>
<td>6.4%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

Figure 1. Variation of the truck factor over time
In the case given, there is an increasing trend in the value of the truck factor characteristic of the road sector under study.

4. CONCLUSIONS
As stated by the results obtained in the present work, it can be confirmed that the traffic of commercial vehicles can present an important variation over the years, in their relative composition, which can generate substantial changes in the value of the factor Truck over time. This can result in an estimate of the traffic away from reality, especially for those cases in which there is no historical information related to the volumes of traffic, discriminated in its different components. For these cases, the determination of the design transit is subject to the results obtained from a timely counting carried out in a year.

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REFERENCES