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Evaluation of Vehicle Damage Factor in Overloading for Different Types of Loading

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Abstract:
This paper aims to study the analysis of the vehicle damage factor in overloading for different types of loading. Over loading by commercial trucks in India is a serious problem. The over loaded trucks stress the road structure beyond safe bearing capacity. Traffic load is dominant function on pavement design because the main function of pavement is to resist traffic load. Efforts to repair of the road damages have been done, but almost meaningless since the overloading trucks keep in progress, even reached twofold from the normal load. In this work vehicle damage factors (VDF) is determined for single, dual, or multi-axle trucks for different vehicle classification. The spectrum of axle load in terms of axle weights of single, tandem, tridem and multi-axle should be determined and compiled under various classes with class intervals of 10 kN, such as 10 kN, 20 kN and 30 kN for single, tandem and tridem axles respectively. VDF should be evaluated carefully by carrying out specific axle load surveys on the existing roads. The idea is to use axle load survey data to evaluate Equivalent Single Axle Load (ESAL) and the Vehicle Damage Factor and then further analyze the pavement to determine the required overlay thickness.

Keywords: Axle load survey, ESAL, vehicle classification

I. INTRODUCTION

The Vehicle Damage Factor (VDF) is a multiplier to convert the number of commercial vehicles of different axle loads and axle configuration into the number of repetitions of standard axle load of magnitude 80 kN. It is defined as equivalent number of standard axles per commercial vehicle. The VDF varies with the vehicle axle configuration and axle loading. The objective is to evaluate vehicle damage factor from overloading. The guidelines use Vehicle Damage Factor (VDF) in estimation of cumulative msa for thickness design of pavements.

- To carry out the axle load or truck weight survey.
- To evaluate load equivalency factor and equivalent standard axle load by using axle load survey data.
- To evaluate vehicle damage factor by using above variables.

Axle load survey should be carried out without any bias for loaded or unloaded vehicles. On some sections, there may be significant difference in axle loading in two directions of traffic. In such situations, the VDF should be evaluated direction wise. Each direction can have different pavement thickness for divided highways depending upon the loading pattern. The AASHO axle load equivalence, factors may be used for converting the axle load spectrum to an equivalent number of standard axles. For designing a strengthening layer on an existing road pavement, the vehicle damage factor should be arrived at carefully by using the relevant available data or carrying out specific axle load surveys

II.KEYWORDS OF THE PROPOSED EXPERIMENT

A. Axle load survey

The only effective way to compare the damaging effect of traffic on given roads is to measure the complete spectrum of axle loads and calculate the appropriate equivalence factors. The main purpose of the axle loads for trucks survey is to collect preliminary information regarding the range of heavy axle loads traversing the nation's main highways. With axle load calculation for trucks, road authorities can make better decisions on which stretch to repair and which part of the road or pavement to prioritize, in order to optimize traffic flow. The data helps reduce the effects of overloading and prevents accelerated damage to pavement. With a comprehensive study of axle loads for trucks road planning departments can ensure that existing roads are appropriately maintained so that they provide appropriate level of service for road users across a longer duration. These surveys also assist to improve existing road conditions to meet the necessary standards in order to enable them to carry prevailing levels of traffic with the desired level of safety.The total weight of the vehicle is carried by its axles. The load on the axles is transferred to the wheels and this load is ultimately transferred on the surface of the pavement in the contact with tyres. To keep wheel load induced stresses on pavement within allowable limit the total vehicle load is distributed onto wider areas of pavement by using more axles and wheels. This is the reason why more number of axles and wheels are fitted to heavy load carrying trucks. The VDF varies with the vehicle axle configuration and axle loading. There are following types of axles:-

- Single axle
- Tandem axle
- Tridem axle

When conducting an axle load survey the validity of the two following assumptions are made:

- The load on the wheels of an axle remains constant at all times, ie.remains the same as it was when the vehicle was originally loaded

– The load exerted on the road by any wheel of any vehicle, whether at rest or in motion, is constant and determined by the initial load distribution of the vehicle.

These assumptions disregard the fact that the load concentration on a wheel or an axle changes continuously when the vehicle is in motion.

Table.1. Heavy Vehicle Categories and definitions

Heavy vehicle Category	Definitions
Buses	Seating capacity of 40 or more
Medium goods vehicle (MGV)	- 2 Axles incl. steering axle - 3 tonnes empty weight or more
Heavy goods vehicle (HGV)	- 3 Axles incl. steering axle - 3 tonnes empty weight or more
	- 4 or more axles incl.
Very heavy goods vehicle	steering axle
(VHGV)	- 3 tonnes empty weight or
	more

B. Equivalent Single Axle Load

Although it is not too difficult to determine a wheel or an axle load for an individual vehicle, it becomes quite complicated to determine the number and types of wheel/axle loads that a particular pavement will be subject to over its design life. Furthermore, it is not the wheel load but rather the damage to the pavement caused by the wheel load that is of primary concern.

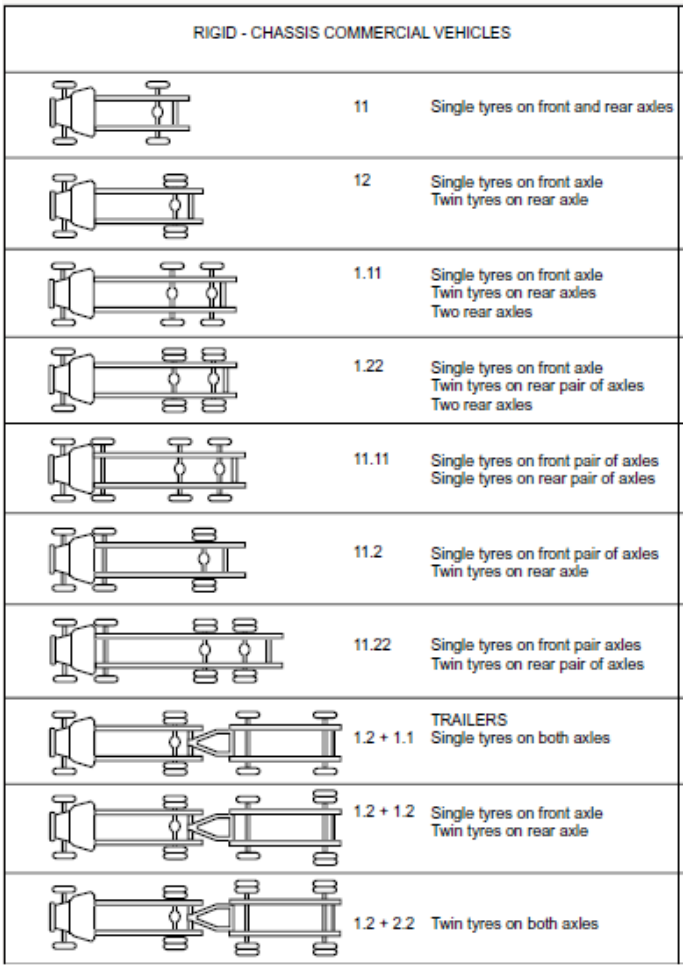
The most common historical approach is to convert damage from wheel loads of various magnitudes and repetitions ("mixed traffic") to damage from an equivalent number of "standard" or "equivalent" loads. The most commonly used equivalent load. is the 18,000 lb (80 kN) equivalent single axle load (normally designated ESAL). At the time of its development it was much easier to use a single number to represent all traffic loading in the somewhat complicated empirical equations used for predicting pavement life.

Equivalent single axle load is calculated by using the load equivalency factors (LEF) from AASHTO Guide for Design Pavement and Structure and then multiplying it to the frequency of the vehicle class. It will give the Equivalent Single Axle load for desired Average axle load.

C. Vehicle Classification

The classification of vehicle is done on the basis of the load carrying capacity of the vehicle. The heavy vehicle category is useful for our experiment and it is further categorized by number of axles and load carrying capacity. The overloaded vehicle causes more damage to the pavement which directly affects the maintenance cost of the road. The vehicle classification for the heavy vehicle category:-

Table.2. Rigid chassis commercial vehicles



III. METHODOLOGY

A. Evaluation of the vehicle damage factor

To evaluate the vehicle damage factor the first step is to carry out the axle load survey. The axle load survey gives us the data to evaluate the equivalent single axle load and then further by using load equivalency factors, the vehicle damage factor is evaluated. Since the axle load survey is carried out only for the heavy vehicle category, the vehicle damage factor values increases. The reason for selected the heavy vehicle category is that the major damage done to the pavement of highway is by this category only. Thus it is not necessary to weigh vehicles of less than 1.5 tones weight, for example; motorcycles, cars, small buses or small trucks with single rear tyres. Sometimes large buses have quite high axle loads and therefore should be weighed in the survey. The product of average axle load and the load equivalency factor gives the equivalent single axle load which further results in vehicle damage factor

$$\text{VDF} = \frac{\sum_{i=1}^{N} [V_i \times \text{LEF}_i]}{N}$$

where, V_i = Traffic volume of the ith vehicle load-class
LEF_i = Load equivalency factor of ith vehicle load-class
N = Total number of vehicles weighed

B. Permissible Axle Loads in India

The policy at National level for the road system in India with regard to the Registered Laden Weight (RLM) limit (Govt. of India 1992) was as follows:

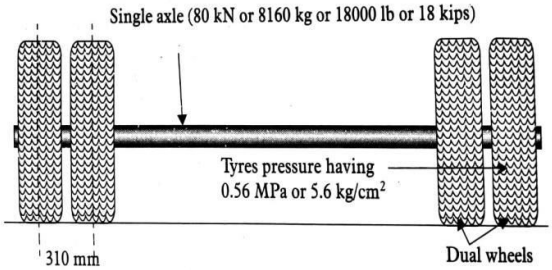
- Maximum Single Axle Load (with 2 Tyres) – 60 KN (6.0 T)
- Maximum Single Axle Load (with 2 Tyres) – 60 KN (6.0 T)
- Maximum Tandem Axle Load (with 8 Tyres) – 180 KN (18.0 T)

Table.3. Data Analysis for Axle Load Survey

Serial number	Vehicle Category	Number of Axles	Total number of vehicles (5 days)	Single axle with single wheel	Single axle with dual wheel	Tandem Axle	Tridem Axle	(Axle load in kg/6500)^4	(Axle load in kg/8000)^4	(Axle load in kg/14800)^4	(Axle load in	Total Load Equivalency factor (E.F)	Number of vehicles* E.F	Average Equivalent Factor
				1	2	3	4	1	2	3	4			
1	Buses	2	165	6095	6750	-	0	0.773	0.506	0	0	1.279	211.035	2.80 ~ 3
2	Medium Trucks	2	6050	6240	6480	-	0	0.849	0.430	0	0	1.279	7737.95	
3	Heavy Trucks	3	1605	7850	10500	20650	0	2.127	2.967	3.789	0	8.595	13794.97	
4	Very Heavy Trucks	4/5	156	7540	8050	15550	0	1.810	1.025	1.21	0	4.045	631.02	
			7976										22374.97	A/B
			B										A	

C. Overloaded Axles

Generally, the load carried by one truck is not the same as that carried by an axle. Each axle load will impart a certain amount of damage or distress on the pavement. The degree of distress caused by different loads of axle will increase as the magnitude of load and repetitions increase. Under mixed traffic conditions, repetitions of different axles having different loads, plying on a road will not indicate any meaningful value related to how much damage has been caused to the pavement due to their combined action. Different axle loads will cause different degree of damages.

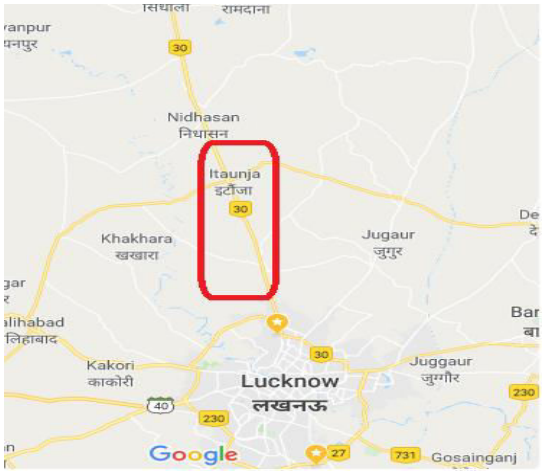


The above picture shows the details of the Indian standard axle. With the standard axle of 80 kN resting on dual tyres on axle configuration, it can be assumed that the axle on single tyres is 6.5 kN. In line with above assumptions to the data of table no 3, the respective overloaded axles are computed as:

3 – Axle 3 (1605) + for 4 – axle 2(156) = 5127

Total number of buses and trucks axles = 2(165) + 2(6050) + 3(1605) + 4(156). = 17869. Therefore, the proportion of overloaded axle for trucks = 5127/17869 =28.69% for entire commercial vehicle. The axle weight conversion shown in table number 3 shows an average equivalent factor of 3 which is about 3 times the standard axle weight for road pavements.

D. Location of the study



The location of the study is near Itaunja toll plaza connecting Lucknow to Delhi via Sitapur.

IV. CONCLUSIONS

From the analysis of vehicle damage factor using axle load survey data, the following conclusions can be drawn:-

- The axle weight conversion shown in table 3 shows that the vehicle damage factor is about 3 times more than the average vehicle damage factor used for the Heavy Commercial Vehicles (HCV), due to this amount of overloading, the pavement deterioration is 3 times faster than the normal.
- The strength of the pavement structure is decreases by overloading of single axle truck. The more overloading results in more decrease of the strength of pavement structure.
- Almost 30% of overloaded vehicle were moving on the pavement.
- The individual load equivalency factor of 3 axle vehicles is more as compared to the remaining commercial vehicles which is 26.94%
- Since the haulage cost is reduced by overloading and it results in the economic benefit but it causes the earlier failure of the road pavements. The premature failure of the pavement causes loss of billions of rupees invested in road infrastructure.
- There are many factors which results in overloading and heavier axle loads on the road ,one of the reason is that the new introduction of the more spacious trucks which eventually alter the axle load distribution on the road. In order to compete and keep themselves in the market by keeping the haulage cost at minimum, the truck owner generally overload their vehicle much beyond the their rated capacity. To carry extra load, the vehicle owner strengthens the vehicle body and adds extra suspension springs to increase the height of the vehicle's body

To solve the current situation here are the following suggestions

- To construct or improve road built quality to withstand heavier loads.
- To Impose axle load limit and strict enforcement. This seems to be the only viable solution for saving our road infrastructure from the deterioration due to overloading and bringing it at par with international standards. Most of the highway engineers believe that unless a limit of axle load is imposed, no matter how strong pavements are built, would fail under the prevailing heavy loaded vehicles. The vehicle overloading is seriously handicapping the improvement of road network in many developing countries.

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