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Evaluation of vehicle overloading along Muar-Melaka road

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Abstract. Vehicle overloading is considered as one of the most substantial concerns in road transport due to a possible road surface damage. This paper investigates the vehicle overloading at the Muar-Malacca roads. The main objectives for this study were to determine types of vehicles overloaded, the percentage of overloaded vehicles and an average equivalency (EF) for all vehicles. Secondary data were collected from fixed weighbridge station by considering gross vehicle weight, maximum permissible gross vehicle and axle load for the period of two years. The results show that heavy vehicle with 2 axles was the most overloaded vehicle. Category 1% - 25% overloaded vehicles had the highest percentage. The calculated EF was 3.14 higher than standard EF. Thus, the road needs to be redesigned in order to resist current load to prevent road damage in short term.

1. Introduction

An overloading is defined as a load that exceeds the legal truck limit. According to [1], overload vehicles are expected to contribute more dramatically to the accumulative damage and the damage ratio is 384 442 to when comparing an 80 000 pound (36 288 kg) heavily loaded truck on five axles with a 2000 pound (908 kg) compact size passenger car. This is especially true when these heavier loads happen frequently. The increase in the overload occurrences was found to cause a noticeable increase in damage done to pavements [2]. Since the greater percentage of goods transported by road is increasing, it is expected that heavy vehicles will remain a common sight on our roads in the foreseeable future. Careful attention should therefore be given to optimizing the use of heavy vehicles and to the damage to the road structure caused by them.

Heavy vehicles travelling from origin to destination use the public road network. If the size and mass of vehicle are not controlled, heavy loads may cause excessive damage to the road infrastructure. Consequently, legal load limitations have been imposed. The repetition of load and overloading of heavy vehicles allegedly affect the road pavements, the design life of the pavements becomes shorter, although the same quality standard is used during design and construction [3-5]. In previous study stated that by allowing the axle loads to be increased from 10 to 13 tones, the pavements will last to only one half of its design life compared to the 10 tons [6].

Research in the USA and South Africa has shown that damages to road pavement caused by overloading increased out of proportion, e.g. an axle load that doubled the legal limits can cause 4 to 60 times as much damage as the legally loaded axle, depending on the structure and type of the road. Heavy vehicle wheel load, tyre pressure, frequency and duration together with environmental factors are all important to the performance of the pavements. However, the most significant parameter is the axle load. The main factors responsible for pavement damage caused by heavy vehicle such as dynamic axle



load, number and type of axles (e.g. single, tandem), tyre properties (e.g. wide-base, dual) and pavement properties (e.g. pavement type, thickness, temperature and roughness) [1, 8-9].

Malaysia's road is divided into three main categories namely toll expressway (1,700km), federal roads (17,500km) and state roads (61,100km) and the life spans are between 10 to 15 years [8], however the damages on the pavements still occurs earlier than expected. One of the recent issues related to road transport in Malaysia is the behaviour of overload usually leads to the truck out of control and at the same time these roads not able to carry the load with the specified design life especially in industry areas [9]. Finding from the study, North-South Expressway it was found that overloaded axles formed a considerable percentage of the total volume; they formed 12% of the total weighted axles [10]. The majority of the overloaded axles weighted between 12 and 16 tons. They formed 10% of the total volume, while the remaining 2% of the overloaded axles weighted more than 16 tons.

Overloaded vehicles could put road user's lives at risk. Overloaded vehicles are difficult to steer, less stable and they require a longer stopping distance; which make them very dangerous especially in sharp curves and steep slopes. Besides, overloading also can cause several detrimental impacts on pavement structural integrity. It does not only shorter the life of pavement itself but also could cause bad damage that could lead to accidents [11].

Due to these problems, further investigation is needed. Thus, the main objectives for this study were to determine types of vehicles overloaded, the percentage of overloaded vehicles and an average equivalency (EF) for all vehicles.

2. Methodology

This study focused on overloading situation at Muar-Malacca federal road segment, that was a two-way four lane divided (4/2 D) flexible pavement. The length of this road section was approximately 46km. The vehicle overloading measurement was taken at the existing fixed weighing bridge located at Road Transport Department (JPJ), Jalan Kesang Muar. This study only employed secondary data, which is consisted of Gross Vehicles weight and maximum permissible gross vehicles weight, vehicle weight that overloading was occurred (especially trucks) and axle weights per vehicles.

The overloaded vehicles were considered in this study include rigid and articulated vehicles with 2 axles, 3 axles, 4 axles and 6 axles. Percentage of vehicles overloading and an average equivalency factor (EF) for each type of vehicles as secondary data obtained was analysed. Percentage of vehicles overloading were analysed in terms of types of overloaded vehicles and percentage of overloading per vehicles in the year of 2011 and 2012. Meanwhile, the method of analysis follows the guidelines for calculating the equivalence factor [12].

3. Results and Discussion

3.1 Overloading by types of vehicles

For types of overloaded vehicles, it was analysed by comparing the data between 2012 and 2011 as shown in Figure 1(a) and Figure 1(b). The data showed the same trend for both year where overloaded vehicles with 2 axles contributed highest percentage of overloading. It can be seen clearly the percentage of vehicles overloaded with 2 axles was increasing from year 2011 to 2012 with 17 %. The increasing of overloaded vehicles percentage with 2 axles in line with the decreasing percentage of overloaded vehicles with 3 axles and above. However, percentage of overloaded vehicles with 4 axles showed the higher decrement percentage from year 2011 to 2012 with 11.1 % compared to decrement of overloaded vehicles with 3 axles and 6 axles which was 2.6 % and 3.2 % respectively. Both year also showed the same pattern with having the least percentage of overloaded vehicles with 6 axles.

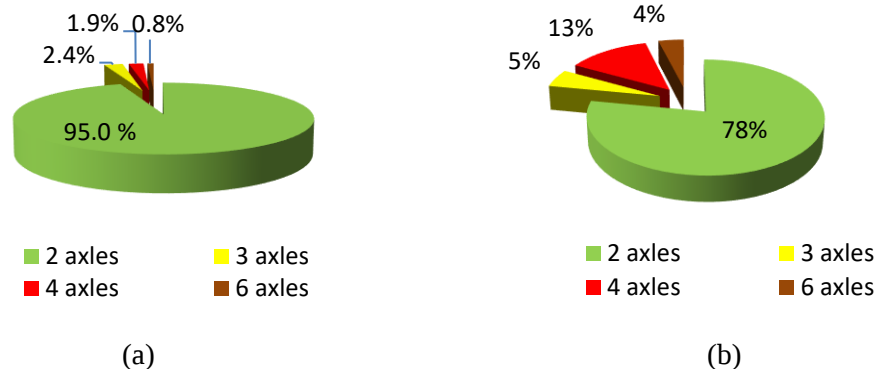


Figure 1. Overloading by types of vehicles (a) Distribution by types of vehicles in the year of 2012(b) Distribution by types of vehicles in the year of 2011.

3.2 Percentage of overloaded vehicles

Table 1 reveals the percentage of overloaded vehicles for year 2012 and 2011. For the year 2012, the data showed that more than 80% vehicles passed the weighting station and was classified as an overloaded vehicles. Both years gave category 1% - 25% overloaded vehicles were the major contribution. However, category 76% - 100% for 2011 and category non-overloaded for year 2012 were the least percentage of overloaded vehicles which were 9.0% and 8.3% respectively.

By comparing between these two years, the data obviously showed the increasing of percentage overloaded vehicles from year 2011 to 2012 from category 26% - 50% and above with 0.3%, 6%, 4.4% and 3% respectively. Clearly, category 51% - 75% overloaded vehicles was the highest increment percentage from year 2011 and 2012. Concurrently, category non-overloaded and 1% - 25% gave decrement percentage of overloaded vehicles from year 2011 to 2012 with 7.3% and 4.7% respectively.

Table 1. Percentage of overloaded vehicles.

Category percentage of overloaded vehicles	Average percentage of overloaded vehicles per year (%)	
	2012	2011
Non-Overloaded	8.3	15.6
1% – 25%	28.3	33.0
26% - 50%	17.5	17.2
51% - 75%	21.6	15.6
76% - 100%	13.4	9.0
Above 100%	12.7	9.7

3.3 Determination of Equivalence Factor (EF)

The data from weighbridge station was analysed by sorting the vehicles data by axle number and gross vehicles weight. The damaging factor or Equivalence factor (EF) for each weighed axle was calculated by using equation (1). Table 2 shows the calculated EF for all vehicles. The result clearly showed that calculated EF based on current traffic volume was 3.14. By comparing the EF from this study and EF

from manual specification [12], calculated EF had higher than EF standard which was 3.0. It showed that Muar-Malacca road was under designed.

$$\text{Equivalence Factor (EF)} = (N/8.16)^{4.5} \quad (1)$$

Where:

EF = Equivalence factor of the damaging effect

N = Axle load (tonnes)

4.5 = The load equivalency exponent

8.16 = The standard axle load (tonnes)

Table 2. Calculated Equivalence Factor (EF) for all vehicles.

Type of Heavy Vehicles	Sample Volume (Veh)	Average Equivalent Factor (EF) by axle						Total Average EF	Total EF	EF for all vehicles
		1	2	3	4	5	6			
2 axles	393	0.14	2.08					2.22	871.41	3.14
3 axles	11	0.37	16.74	5.19				22.30	245.35	
4 axles	9	0.26	11.15	2.45	2.52			16.38	147.45	
6 axles	4	0.57	1.39	2.69	3.35	2.16	1.29	11.44	45.77	
TOTAL	417								1309.98	

4. Conclusions

Based on the results, it can be concluded that:

- Overloaded vehicles with 2 axles showed highest percentage of overloaded vehicles in year 2011 and 2012. By the year 2012, overloaded vehicles with 2 axles was increased with 17%. Different with overloaded vehicles with 3 axles and above, by the year 2012, the percentage were decreased with 2.6%, 11.1% and 3.2% respectively. Overloaded vehicles with 4 axles gave the highest decrement compared to others. Both year gave the same trend where percentage of overloaded vehicles with 6 axles was the least. It showed that vehicles with 2 axles gave major contribution in overloaded vehicles compared to other vehicles.
- Both years showed category 1% - 25% overloaded vehicles had the highest percentage. Category 76% - 100% for 2011 and category non-overloaded for year 2012 gave the least percentage of overloaded vehicles which were 9.0% and 8.3% respectively. By comparing between these two years, category 26% - 50% and above had increment percentage from year 2011 to 2012 with 0.3%, 6%, 4.4% and 3% respectively. Concurrently, percentage of overloaded vehicles for category non-overloaded and 1% - 25% were decreased from year 2011 to 2012 with 7.3% and 4.7% respectively. It can be concluded that percentage of overloaded vehicles on road was increasing more than 26% of their maximum allowable load.
- Calculated EF for current traffic volume was higher than standard EF which was 3.14 and 3.0 respectively. It can be concluded, Muar-Malacca road was under designed since the percentage of overloaded vehicles was higher than before.

In nut shell, in order to prevent the damage of road pavement due to the increasing of overloaded vehicles, Muar-Malacca road needs to be redesigned and resurfaced to resist the current and future load.

5. References

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