Analysis On the Impact of Traffic Overload on Asphalt Concrete Pavement's Service Life in Jose Abad Santos Avenue (JASA) K0098 – K0099, Balsic, Hermosa, Bataan

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Abstract: - Trucks are primarily responsible for poor road conditions as they often overload more than the standard capacity of vehicles. It is significant to analyze the impact of traffic overloading on asphalt concrete pavement to attain its full-service life. The study area is the asphalt concrete pavement near kilometer post 0098 in Balsic, Hermosa, Bataan. All the data used in this study was collected from DPWH Regional Office III and axle load factor method was utilized to determine the overloaded vehicles. It showed that 19% of the trucks weighed from the North Bound and 70% from South Bound were overloaded. The equivalence factor vs. axle load and pavement life vs. axle load graph and graph have been superimposed to evaluate the effect of axle load on the pavement. The average axle weight of 20.857 tons contributed the greatest amount of load, which caused the highest amount of damage. Moreover, premature failure of asphalt concrete pavement occurs at the age of 3.2 years, which is only 32% of its assumed 10-year design service life. Thus, the heavier the axle load, the greater the damage imposed on the pavement. The assessment of the road condition is advisable at 3–3.4 years of pavement life as premature failure becomes evident. Therefore, it is recommended that regulations and guidelines must be strictly implemented to control the prevailing truck overloading.

Key Words: — *Traffic Overloading, Asphalt Concrete Pavement, Premature Failure.*

I. INTRODUCTION

Traffic volume and the resulting load that vehicles move onto roads are important factors to consider when designing roads. Heavy vehicles like trucks are the biggest consumers of roads and can cause the most damage to pavements. As a result, the road infrastructure cannot operate properly, which can cause inconvenience for a lot of people.

Manuscript revised June 18, 2023; accepted June 19, 2023. Date of publication June 22, 2023.

This paper available online at www.ijprse.com

ISSN (Online): 2582-7898; SJIF: 5.59

It may impede economic growth and bring about low living standards, which would be detrimental to the nation's development. On the other hand, Shahul and Prathap (2018) stated that an extremely excellent road network construction directly increases the economy of a nation. In line with this, a well-maintained and high-quality road network helps to decrease travel time, decrease vehicle running expenses, and increase commodities and people's mobility. For these reasons, having a properly maintained road network is an important public asset of a country that can improve the quality of life of its citizens.

The condition of many roads in the Philippines, including national, regional, and district roads, is damaged in the early stages of their service life. Looking at the Philippines' Road network in the year 2020, paved roads had a total length of about 32,500 kilometers, which is about 98.21% of the total road length in the country (Statista Research Department, 2022). In 2019, the Philippines' highway network had 10,440.98 kilometers of asphalt roads and 21,646.10 kilometers of concrete roads, according to the Department of Public Works and Highways (DPWH). Moreover, pavements are designed to last, but due to unsuitable design, faulty construction, and vehicle overloading, they do not serve their full-service life. These pavements already require repairs after a relatively short time. Due to rapid deterioration, it frequently requires reconstruction, which may cost a lot of money and cause inconvenience for motorists and commuters because of the traffic jams that it may cause. Consequently, many concerned individuals complain about why recently developed pavements are being excavated and reconstructed when they are still in good condition, and that is because these roads are not properly maintained and not supervised for overloading.

In the construction of road structures, it is important to consider the amount of traffic overload that will travel on the road to have a better design parameter, as the issue of transport vehicles has arisen due to the current logistics industry's rapid development. In the study of Swai (2015), he recommended that to prevent premature pavement damage, several efforts should be made, such as early prediction of pavement damage caused by overloaded trucks. Furthermore, due to the lack of law enforcement, there are a lot of people who most often violate the rules and regulations of truck overloading. Truck owners are ignoring the rules and keep overloading their payload capacity in order to get more profit in less time (Shahul and Prathap, 2018). In addition to that, overloading is getting progressively worse and has a great impact on the road pavement’s service life. Vehicles that are overloaded will severely damage the road, and it will be a great economic loss for the country. Furthermore, in the study by (Pais et al., 2013), it was found that overweight traffic is frequently one of the main causes of problems on road pavements. It shortens the pavement's lifespan while raising maintenance expenses.

1.1 Impacts of Overloaded Trucks

The roads must be strong enough to support the huge utility vehicles that will pass through them. In such a manner, load restrictions are being imposed on the roads when they are not designed to carry heavy loads. If vehicles exceed the payload limit, they can damage the road. In line with this, the effect of traffic overload on pavement analysis and design has been studied by several researchers. Almeida et al. (2019) assessed that overloading can remarkably increase pavement damage. As stated in the conclusion of the study by Almeida et al. (2019), there are significant reductions in the life span of road pavements due to these practices, which is approximately 7–8 years. Additionally, Hamim and Hoque (2019) stated that from the 20-year design service life of a flexible pavement, only 24.4% of the design service life is being used due to overloading, and this issue needs special attention to ensure the design life of flexible pavements.

The vehicles with higher payloads tend to have higher damage rates. This causes more damage to the pavement every time a heavy truck passes over it than a lower-capacity one (Wilches et al., 2018). Additionally, as stated by the DPWH, in 2013, overloaded vehicles that passed by on access roads caused serious damage to them. Furthermore, Rusbintardjo (2013) measured the influence of overload on the level of pavement damage by performing a sensitivity analysis. As stated in the study, traffic load, characteristics of pavement materials, stress on the surface layer of the pavement, thickness layer factor, subgrade, environment factor, and failure criterion are factors affecting the road. In 2022, the National Capital Region-West (NCR-West) and the DPWH conducted anti-truck overloading mobile enforcement activities and flagged 142 trucks for suspected overloading, with 54 out of 142 charged with overloading, as stated by the Land Transportation Office. In addition, LTO claimed that more than 120 out of the 180 trucks were reported to be overloaded in Central Luzon during the anti-truck overloading mobile enforcement operations.

1.2 Variations of Cost Due to Overloading

The cost of the road pavement is dependent on the degree of overloading. Ohja (2014) determined that heavy vehicles significantly increase the cost of pavement construction and rehabilitation by damaging the pavements in significant ways. Significantly greater than 100% is the increase in road construction costs when the overloaded vehicle is compared to the cost of an automobile with allowable loads. The Philippines has set aside $138 million for the upkeep and restoration of provincial roads in 73 of the 81 provinces in the nation, according to World Highways under Finance and Funding Year 2016. Furthermore, the funding for regular maintenance of the Philippines' national roads has increased significantly since 2010, according to a financial analysis by the Asian Development Bank. The funding for routine maintenance has greatly increased, with an average annual growth rate of 25 percent from 2010 to 2017. In the study conducted by Pais et al. (2013), it was revealed that overloaded cars increase road damage and life cycle costs by roughly 30% when compared to vehicles with permissible loads. However, in a study conducted by Sharma (2019), there is a significant improvement in service life when strict enforcement of legal axle limits is adopted. The study also revealed that various significant benefits from this include reduced maintenance and rehabilitation costs for roads, maintenance at the intended serviceability levels, and finance availability for maintaining road pavements.

1.3 Specific Objectives

Specifically, this study aimed to:

- Determine the Traffic Equivalence Factor by acquiring the axle load data;
- Evaluate the reduction of pavement service life due to overloading of Class 2 and Class 3 Vehicles;
- Propose a possible timeline for the assessment of the road condition in connection with the traffic overload being imposed on the asphalt concrete pavement.

II. METHODOLOGY

2.1 Site Selection

In this study, one site was chosen to achieve the stated objectives of this research work. The criteria for the site selection includes the following:

- Location of the area where trucks frequently pass through.
- Data accessibility concerning the axle load data of the particular road section.
- Reliability and accuracy of the axle load data

Several locations were found during the traffic survey conducted annually by DPWH Pampanga 1st District. However, DPWH does not include barangay roads in their traffic survey. Due to the observation of the researchers on the road conditions of the actual tentative study area in Balsic, Hermosa, Bataan, the asphalt concrete pavement in JASA Road Section ID S01254LZ in Balsic, Hermosa, Bataan was finalized as the study area.

2.2 Methods of Data Collection:

The Department of Public Works and Highways (DPWH) Regional Office III has the data that will be beneficial for the study. To formally ask for permission to gather the relevant data, a formal letter was given to the concerned personnel in charge in DPWH Regional Office III. The data that will be needed are the following:

- Axle load data for Class 2 and 3 vehicles
- Actual Service Life of the Pavement
- Visual Road Condition Assessment Manual (RoCond).
- Other available and suitable information which will be helpful in the study.

The weighing machines for conducting an axle load survey are for limited use only; hence, the axle load data is accumulated from the DPWH Regional Office III and used to determine the equivalence factor and the impact of the overloaded vehicles on the road pavement. Fortunately, the researchers were able to obtain the axle load data on JASA Road, Section ID S01254LZ in Balsic, Hermosa, Bataan.

2.3 Determination of Overloading

According to several studies, there are two techniques to determine whether the vehicle is overloaded. The truck factor method is one of the techniques, wherein the entire load carried by the vehicle is calculated as a whole. It is from the loaded vehicle's total Gross Vehicle Weight (GVW). With axle load factor techniques, for load analysis, only individual axles will be examined. The axle load factor is primarily used to express the effect of axles on pavement damage. Additionally, the allowable axle load based on the Implementing Rules and Regulations (IRR) of Motor Vehicle User's Charge or Republic Act 8794, set fines for overloaded trailers and trucks that violate the 3,500 kg allowable axle load on the highway. It was decided to generate the distributions for these axle loads to determine if the axle loads exceed the maximum allowable axle loads as well as for possible future purposes.

Evaluation of the Impact of Class 2 and 3 Vehicles on the Asphalt Concrete Pavement's Service Life

For the assessment of the effect of overloading on the life of a pavement, axle load data from the study area was collected from DPWH Regional Office III as stated in the data collection phase. The axle load data that has been gathered was concatenated into a significant form without distorting the efficiency of the data obtained. In line with this, the axle weight range depends on how vast the data is. The other data that was needed for the evaluation of the impacts are the average axle weight, frequency, cumulative frequency, equivalence factor, and pavement service life.

The average axle weight can be calculated by getting the average of the axle load data belonging to the range.

Frequency can be calculated by dividing the number of vehicles' axles spotted within the axle weight range by the total number of vehicles' axles.

The cumulative frequency can be calculated by adding each frequency in the table to the sum of the previous frequencies.

The Equivalent Single Axle Load method converts all loads, including multi-axial loads, into a single-axle load of 8.2 tons or 18,000 pounds and is used in the design. For a specific weight and axle combination, the Load Equivalency factor (LEF) indicates the equivalent number of ESALs. The Load Equivalency Factor can be calculated using the formula:

EF = ((Axle Load in tons)/8.2)4

Pavement life (PL) can be calculated using this formula:

PL = ((Life expectancy of the pavement)/(Equivalence Factor))

To examine the effect of overloading on the asphalt concrete pavement life. The Equivalence Factor vs. Axle Load graph and Pavement Life vs. Axle Load graph are the two graphs that have been superimposed.

Proposal of the Possible Timeline for the Assessment of the Road Condition

The current Visual Road Condition Manual Assessment (RoCond) was obtained from the DPWH Regional Office III and compared to the current conditions of the JASA Road in K0098 – K0099, Balsic, Hermosa, Bataan. Moreover, a possible timeline for the assessment of the road condition based on the analysis of the impact of traffic overload would be recommended.

III. Results And Discussion

Table.1. Weighed Trucks on North Bound (Olongapo-Gapan Road)

Truck / Trailer's Code	Number of Weighed Trucks	Number of Axles
11 (Truck with 2 Axles)	7	14
11-1 (Truck Semi-Trailer with 3 Axles)	4	12
11-2 (Truck Semi-Trailer with 4 Axles)	20	80
11-3 (Truck Semi-Trailer with 5 Axles)	8	40
12 (Truck with Tandem Axle)	33	99
12-2 (Truck Semi-Trailer with 5 Axles)	4	20
12-3 (Truck Semi-Trailer with 6 Axles)	30	180
13 (Truck with Tridem Axle, 4 Axles)	3	12
TOTAL	**109**	**457**

Table 1 shows the number of vehicles weighed on the North Bound (Olongapo-Gapan Road). There are a total of 109 trucks that have been weighed on the North Bound which has a total of 457 axles. From the table above, there are 33 trucks with tandem axles that have a trailer code of 12. Additionally, there are 3 trucks with tridem axles (4 axles), and it is the least weighed truck.

Table.2. Weighed Trucks on the South Bound (Gapan-Olongapo Road)

Truck / Trailer's Code	Number of Weighed Trucks	Number of Axles
11 (Truck with 2 Axles)	2	4
11-1 (Truck Semi-Trailer with 3Axles)	1	3
11-2 (Truck Semi-Trailer with 4 Axles)	19	76
11-3 (Truck Semi-Trailer with 5 Axles)	4	20
12 (Truck with Tandem Axle)	18	54
12-2 (Truck Semi-Trailer with 5 Axles)	3	15
12-3 (Truck Semi-Trailer with 6 Axles)	20	120
13 (Truck with Tridem Axle, 4 Axles)	11	44
Total	**78**	**336**

Table 2 features the number of vehicles that were weighed at km post post 0098 on the South Bound (Gapan-Olongapo Road). From the table presented, there were a total of 78 vehicles weighed which had a total of 336 axles. From a total of 78 trucks that have been weighed, there are 20 trucks with a classification of 12-3 (Truck Semi-Trailer with 6.

Table.3. Overloaded Axles per Classification of Truck (Olongapo-Gapan Road)

Truck / Trailer's Code	Axle 1	Axle 2	Axle 3	Axle 4	Axle 5	Axle 6
11 (Truck with 2 Axles)	3	0	-	-	-	-
11-1 (Truck Semi-Trailer with 3 Axles)	3	0	0	-	-	-
11-2 (Truck Semi-Trailer with 4 Axles)	3	2	0	2	-	-
11-3 (Truck Semi-Trailer with 5 Axles)	5	4	4	4	3	-
12 (Truck with Tandem Axle)	8	2	1	-	-	-
12-2 (Truck Semi-Trailer with 5 Axles)	2	0	0	0	0	-
12-3 (Truck Semi-Trailer with 6 Axles)	29	2	2	2	2	2
13 (Truck with Tridem Axle with 4 Axles)	0	0	0	0	-	-
Total	**53**	**10**	**7**	**8**	**5**	**2**
	85					

A total of 457 axles were surveyed on the North Bound and 85 axles of which or approximately 19% were found to be overloaded.

It can be observed from Table 3 that Truck Semi-Trailers with 6 axles contribute the largest share of overloaded trucks on the 1st axle, followed by the Truck with Tandem Axle and only 2 trucks were considered to be overloaded on the 6th axle.

Table.4. Overloaded Axles per Classification of Truck (Gapan-Olongapo Road)

Truck / Trailer's Code	Axle 1	Axle 2	Axle 3	Axle 4	Axle 5	Axle 6
11 (Truck with 2 Axles)	1	0	-	-	-	-
11-1 (Truck Semi-Trailer with 3 Axles)	1	0	0	-	-	-
11-2 (Truck Semi-Trailer with 4 Axles)	15	9	10	11	-	-
11-3 (Truck Semi-Trailer with 5 Axles)	3	4	4	3	3	-
12 (Truck with Tandem Axle)	14	11	9	-	-	-
12-2 (Truck Semi-Trailer with 5 Axles)	3	0	0	0	0	-
12-3 (Truck Semi-Trailer with 6 Axles)	20	14	15	15	15	15
13 (Truck with Tridem Axle with 4 Axles)	11	11	11	7	-	-
Total	**68**	**49**	**49**	**36**	**18**	**15**
	235					

Table 4. shows the number of axles of the trucks that are considered to be overloaded on Gapan-Olongapo Road (South Bound). It can be noticed that 235 axles, which was approximately 70% of the 336 axles of the trucks that were surveyed, were found to be overloaded. The truck semi-trailer with 6 axles contributes the greatest number of overloaded trucks and 15 trucks were considered overloaded on the 6th axle.

Table.5. Frequency Distribution of Axle Load Dat

Axle Weight Range (tons)	Number of Vehicle Axle Load Spotted	Average Axle Weight (tons)	Frequency	Cumulative Frequency	Damaging Factor	Pavement Life (years)
0-2	32	1.735	4.035	4.035	0.002	4989.505
2-4	250	3.141	31.526	35.561	0.022	464.498
4-6	216	4.988	27.238	62.799	0.137	73.038
6-8	67	6.907	8.449	71.248	0.503	19.865
8-10	53	8.934	6.683	77.932	1.409	7.097
10-12	87	10.897	10.971	88.903	3.119	3.206
12-14	42	12.868	5.296	94.199	6.064	1.649
14-16	28	14.575	3.531	97.730	9.981	1.002
16-18	6	17.148	0.757	98.487	19.125	0.523
18-20	9	18.572	1.135	99.622	26.314	0.380
20-22	3	20.857	0.378	100	41.855	0.239
TOTAL	**793**		**100**			

On the table 5, 10 years was the assumed design service life of the asphalt concrete pavement. It can be observed that the range of 20-22 tons has contributed the greatest amount of load to the pavement with an average axle weight of 20.857 tons, encompassing approximately 18% of the total average axle weight. It also produced the greatest number of damaging factors. Thus, it can be concluded that the heavier the axle load weight is, the greater the damage imposed to the pavement life.

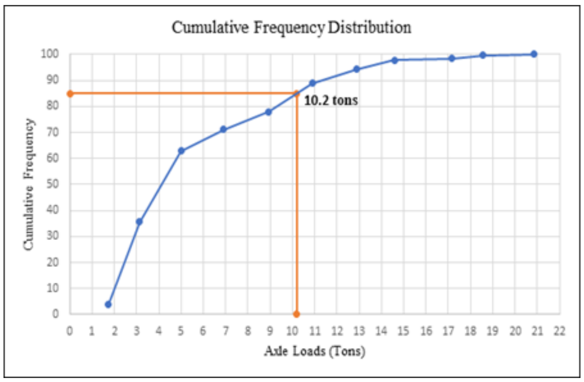

Fig.1. Cumulative frequency distribution of axle loads

From figure 1, The design truck load equivalent to the 85th percentile is 10.2 tons, exceeding the permissible axle load of 3.5 tons. From the results of the investigation, it can be concluded that overloading occurs frequently in the study area.

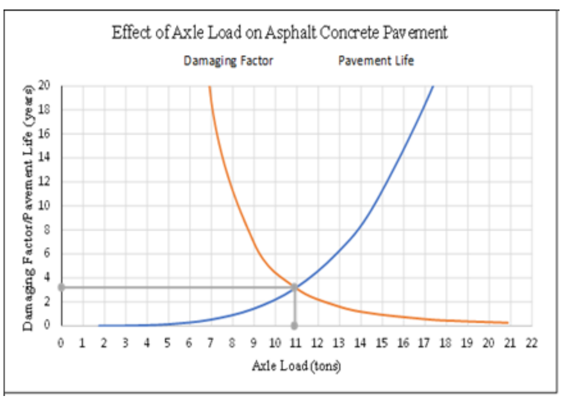

Fig.2. Effect of Axle Load on Asphalt Concrete Pavement Service Life

Figure 2 is a superimposed graph that shows the impact of the axle load on the asphalt concrete pavement. The diagram clearly shows that the asphalt concrete pavement has clearly achieved its terminal serviceability condition, as shown in Figure 2. It also shows that with a 10.9 tons of axle load, the damaging factor is equivalent to pavement life. Thus, premature failure of asphalt concrete pavement already arises at the age of 3.2 years, which is only 32% of the 10 years design life of the asphalt concrete pavement. Therefore, it can be noted that one of the main reasons behind the early failure is the frequent overloading.

Table.6. Timeline for the Assessment of the Road Condition of the Asphalt Concrete Pavement on JASA at K0098 – K0099

Time	Project Task
1st - 3rd year of the pavement	Assessment Not Necessary
3.2 years	Premature Failure on the Pavement is being evident
3 years – 3.4 years	RoCond Assessment is Necessary
3.4 years – 10 years	Rectification measures and annual assessment are needed

Table 6. presents the proposed timeline for the assessment of the road condition of asphalt concrete pavement on JASA at K0098 – K0099. Based on the results of this study, it was found that the premature failures in the asphalt concrete pavement will be evident after 3.2 years, so there is no need for an assessment of the road conditions for the first to third year of the newly constructed pavement. According to DPWH D.O 120, series of 2019, the duration of the assessment of a certain road is 2–3 months. During this phase, DPWH will assess if the specific road conditions need rehabilitation or preventive measures to attain full-service life. On that note, after 3 to 3.4 years, an assessment of the road condition is necessary as premature failure becomes evident. Finally, regular annual assessments and corrective measures are needed after 3.4 years and up to its assumed 10-year life span. From the research undertaken, it is concluded that it is highly advisable to maintain and forward the necessary timely intervention or maintenance before severe damage occurs to the infrastructure, which could be costly.

IV. Conclusion

The traffic equivalence factor is inversely proportional to the pavement's service life, so as the traffic equivalence factor increases, the pavement's service life decreases. Additionally, based on the axle load data, most of the weighted trucks are overloaded on the front axle. Consequently, based on the given data, the range of 20–22 tons have contributed the greatest amount of load to the pavement, with an average axle weight of 20.857 tons encompassing approximately 18% of the total average axle weight. It also has the most damaging factors. Therefore, it can be concluded that the heavier the axle load weight, the greater the damage imposed on the pavement. The study revealed that premature failure of asphalt concrete pavement already occurs at the age of 3.2 years, which is only 32% of its assumed 10-year design service life. It can be concluded that asphalt concrete pavement cannot achieve its design when overloaded truck traffic loads are applied. Designing pavements for vehicles reaching their maximum allowable weight reduces the impact of overloaded vehicles on pavement life. Therefore, asphalt concrete designs should be performed under actual loads rather than standard loads to prevent early-stage deterioration. For the proposed timeline for road condition assessment, assessment for the first to third years of the newly constructed asphalt concrete is not necessary. Furthermore, assessment of the road condition is highly encouraged at 3–3.4 years of pavement life as premature failure becomes evident.

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