Study On the Effect of Axle Overloading on the Road (In Front Of SNIT) And Proposal of New Design Using Waste Materials

Athira Surendran[1], Devika Dev S[2], Pranav S Prasad[3], Sneha J[4]

[1,2,3,4]Final Year UG. Students, Dept. of Civil Engineering, SNIT, Adoor, Kerala, India

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Abstract – *The condition of the road in front of SNIT college, Adoor is very pathetic. Even though the area has a smaller number of vehicles, the road undergoes heavy damages very often. The objectives of the project were to ascertain the contribution of overloaded vehicles to pavement failure, determination of subgrade soil strength to check whether the soil is capable of carrying the traffic and design a better pavement. The effect of axle overloading was studied by comparing the Vehicle Damage factor of the vehicles with their standard values. And it was found that the Medium Commercial Vehicles and Heavy Commercial Vehicles contribute to the damages on the road. The strength of the soil subgrade was studied based on the California Bearing Ratio test carried out. CBR value of the existing soil was obtained as 7.5%. This was improved by locally available waste materials like Waste Ceramic Dust and Waste Plastic Strips. Use of these materials make the waste management easy. Based on this study, a new pavement was designed as per IRC: SP-72-2015.*

Key Words: *Axle overloading, Subgrade, Vehicle Damage Factor, California Bearing Ratio, Waste Ceramic Dust, Waste Plastic Strips, Pavement, Design*.

1. INTRODUCTION

1.1 GENERAL

Roads are fundamental in transportation and help in catering all human comforts. Sometimes, road transport is the only way of carrying goods and people to and from rural areas. The roads are vital for the economic development of an area. So, these roads need to be in good condition and should have long life. Here, in case of the road in front SNIT college, Adoor in Pathanamthitta district of Kerala, the road has been used by two wheelers, cars, college buses and even trucks from the nearest quarry. This has caused serious damages on the road. The heavy-duty vehicles constitute more in the damaging influence on the pavement. This damage increases as the axle load increases. The over loading has reduced the life of the road.

In addition to this, the type of subgrade soil also contributes to the damages. In sight of the vehicle growth rate, the subgrade strength needs to be increased as it is necessary. The subgrade strength can be increased by adding waste materials to the subgrade. Using the waste materials (Waste Ceramic Dust and Waste Plastic Strips) not only increases the strength of subgrade, but also helps in the easy management of those waste materials. The strength of the road can be measured using CBR test.

1.2 OBJECTIVES OF THE PROJECT

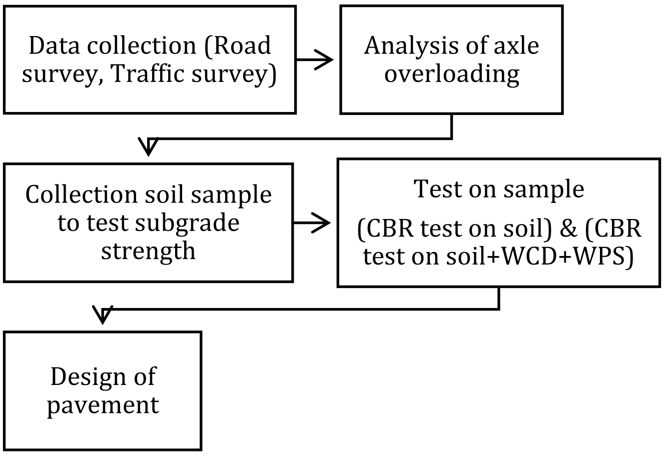
- To study the effect of axle overloads on road pavement
- To determine the strength of the existing road by California Bearing Ratio (CBR) test method
- To improve the strength of subgrade soil by adding Waste Ceramic Dust (WCD) and Waste Plastic Strips (WPS)
- To design a better pavement based on the study carried out

2. STUDY AREA

The study area is located between Puthumala village and Theppupara village of Ezhamkulam Panchayat in Pathanamthitta district of Kerala state. The road is important as it gives accession to the college as well as the quarry. The distance of study area is about 2.0km, with a width of 7m including shoulders.

Fig. 1: Existing road

3. METHODOLOGY



4. DATA COLLECTION

Road survey and traffic survey were carried as the first phase of the project. Map study was conducted to get an idea about the area. The basic details about the road were collected from the respective panchayat, who owns the road. Reconnaissance survey was conducted to get the idea of the main features of the road, such as drainage conditions, alignment, points of serious damages, etc. Traffic survey was conducted on a working day to obtain the peak hour, count and type of vehicles which uses the road. From this data, average Daily Traffic (ADT) for 24 hours was computed for each vehicle type.

5. ANALYSIS OF AXLE OVERLOADING

The effective way to compare the damaging effect of the axle loads is to measure the axle loads and calculate the vehicle damage factor, since the Vehicle Damage Factor varies with the vehicle axle configuration. The axle load was conducted during traffic survey to collect preliminary information regarding the heavy axle loads. The axle load survey was conducted on the basis of two assumptions: -

- The load on the wheels of an axle remains constant at all times
- The load exerted on the road by any wheel of a vehicle, whether at rest or in motion, is constant

The portable wheel weight measuring equipment was used for the measurement of wheel loads. Each vehicle to be weighed is to be aligned on to the unit and stopped with the wheel being weighed at the center of the top plate. The vehicle needs to be stopped just long enough for the reading on the display unit to get stabilized. Assuming the load on each axle as evenly distributed, the axle load was be taken in proportion to the wheel load.

Since only vehicles with a weight more than 1.5 tonnes only causes serious damages on the road, vehicles like buses, Medium Commercial Vehicles (MCV) and Heavy Commercial Vehicles (HCCV) were considered in the analysis.

Vehicle category	No. of vehicles
Buses	20
Medium Commercial Vehicle (MCV)	18
Heavy Commercial Vehicle (HCV)	24

Table 1: Vehicle count for each category of vehicles

For each vehicle of each category, based on the measured axle load, the Vehicle Damage Factor (VDF) was calculated using the equation:

$$\text{Vehicle Damage Factor, VDF} = k \times (Qj/Qs)^{4}$$

Where,

Qj = Actual load
Qs = Standard single axle load 80kN
k = 1 (2 axles- 1 wheel)/ 0.086 (2 axles- 2 wheels)/ 0.053 (3 axles)

The average of this VDF value obtained for each vehicle was then compared with the standard VDF value for the analysis of the effect of axle overloading (Table 2).

Category of vehicle	Standard VDF value	Obtained VDF value
Buses	3.898	3.427
Medium Commercial Vehicle	3.898	4.682
Heavy Commercial Vehicle	3.679	3.742

Table 2: Comparison of standard and obtained VDF values

Based on the comparison, it was inferred that the medium goods vehicles and heavy goods vehicles have a VDF higher than the respective standard values. This indicates the axle overloading has vital influence in causing damage to the road.

6. TESTS AND RESULTS ON SOIL

6.1 CALIFORNIA BAERING RATIO OF EXISTING ROAD

California Bearing Ratio (CBR) test was carried out to study about the strength of the soil subgrade. By

conducting CBR test on the soil, the value was obtained as follows:
CBR value of the soil = 7.5%

6.2 ADDITION OF WASTE CERAMIC DUST AND WASTE PLASTIC STRIPS TO INCERASE SUBGRADE STRENGTH

Waste Ceramic Dust- Waste ceramic tiles, that were collected from building debris, were first broken into small pieces, using hammer. Then it was inserted into Los Angeles abrasion testing machine to get smooth powder. The Waste Ceramic Dust (WCD) was added to the soil at different percentages of 10%, 20% and 30% by weight.

Waste Plastic Strips- Waste plastic bottles were cut by using scissors into small pieces of 12mm x 8mm to obtain the Waste Plastic Strips (WPS). These WPS were added into the soil at 0.5% and 1% proportions by weight.

Addition of 30% WCD and 1% WPS showed the maximum increase in the CBR value of the soil.

The CBR value obtained for the same percentage of WCD and WPS = 10.49%.

7. DESIGN OF PAVEMENT

Composition of traffic- Traffic census was conducted over a period of 3 days. Number of each type of vehicles were recorded.

Growth rate- An average annual growth rate of 15% over the design was assumed.

Design life- A design life period of 10 years was selected.

Average Daily Traffic- Average Daily Traffic (ADT) for each type of vehicles were computed. And ADT of vehicle type including buses, MCV and HCV was obtained as 59.

Vehicle Damage Factor (VDF)- The average of the three VDF of buses, MCVs and HCVs obtained was taken. Therefore, VDF = 3.59

Equivalent Standard Axle Load (ESAL)- For the purpose of pavement design, only buses, MCVs and HCVs were considered. For 15% traffic growth rate (r), 10 years of design life (n), the cumulative ESAL applications (N) was computed using

$$N = T_o \times 365 \times [(1+r)^{\wedge}10)/r] \times L;$$

Where,

T_o = ESAL per day = Number of commercial vehicles per day x VDF,

L = Lane Distribution Factor

$T_o = 59 \times 3.95 = 233.05$

L = 1, for single lane

Therefore,

Cumulative ESAL applications, N

= 233.05x 365 x [(1+0.15)^10 -1)/0.15] x 1

= 17,27,100

Therefore,

ESAL for a year = 17,27,100/10 = 1,72,710

The cumulative ESAL applications (17,27,100) comes between 15,00,000 – 20,00,000. Therefore, this can be categorized under the category T_9 as per IRC: SP-72-2015 "Guidelines for the Design of flexible Pavements for Low Volume Rural Roads".

CBR value of subgrade- The CBR value obtained from the test after adding WCD and WPS to subgrade soil, CBR = 10.49% was used for the design.

Design thickness- The design thickness for the category 'T_9' and CBR value 10.49%, based on pavement design catalogues for gravel/ gravel bases and sub-bases as per IRC: SP-72-2015 "Guidelines for the Design of Flexible Pavements for Low Volume Rural Roads" was taken and is as in Table 3

Pavement layers	Designed thickness (mm)
Bituminous Macadam	50
Base Course	225
Subbase Course	125
Total thickness	400

8. CONCLUSIONS

- The axle overloading has a vital role in causing damage to the road.
- Among the vehicles plying on the road, MCVs and HCVs contribute more to the damaging effects.
- Also, the CBR value of the subgrade soil is less. This also causes damage to the road.
- The subgrade CBR value was increased by the addition of WCD and WPS. 30% WCD and 1% WPS gave a good increase in the subgrade CBR value.
- The addition of WCD and WPS not only increases the strength, but also reduces the cost of construction.

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BIOGRAPHIES

Athira Surendran pursuing B. Tech in Civil Engineering from Sree Narayana Institute of Technology, Adoor, Pathanamthitta, Kerala

Devika Dev S. pursuing B. Tech in Civil Engineering from Sree Narayana Institute of Technology, Adoor, Pathanamthitta, Kerala

Pranav S. Prasad pursuing B. Tech in Civil Engineering from Sree Narayana Institute of Technology, Adoor, Pathanamthitta, Kerala

Sneha J pursuing B. Tech in Civil Engineering from Sree Narayana Institute of Technology, Adoor, Pathanamthitta, Kerala