TO STUDY IMPACT OF ROAD ROUGHNESS ON FREE FLOW SPEED OF VEHICLE

Vrushali P. Mate[1] & Asst. Prof. Payal Hon[2]
[1]PG student in Transportation Engineering & Planning, Department of Civil Engineering, SOET, Sandip University, Nashik, Maharashtra, India.
[2]Assistant Professor in Transportation Engineering & Planning, Department of Civil Engineering, SOET, Sandip University, Nashik, Maharashtra, India.
Email-Id:vrushalimate201@gmail.com[1]
Payal.b.pawar@gmail.com[2]

Abstract: *In Road Roughness is a major problem in Indian cities and for rural area it is very big issues. Roughness of road is occur due to heavy traffic, high intensity of vehicles in rural area poor quality of road construction. Roughness is not just small undulation of road and pits on road surface. Roughness measurement can be recorded by various techniques. Such as Drum troop, trailer method, coast-down method, etc. But this method are so complicated and varies assumptions hence the World Bank in 1982 made the International Road Roughness Index method. In IRI method various values of road index to measure the roughness. But in this method highly interactive sensor vehicles are occur hence it is very costly method. That's why we have developed the new method for measurement of undulation of road surface.*

Keywords – Roughness, IRI, Free flow.

1. INTRODUCTION

Pavement roughness (sometimes termed smoothness from another perspective) is a function of the deviations of a pavement surface from a true planar surface for the wavelengths of deviations that range between 0.5 and 50 mm. The wavelengths in this range primarily dissipate energy in the vehicle suspension, which also includes deformation of the tire body, by converting mechanical energy into heat which is then dissipated into the atmosphere. Roughness is usually reported in terms of the IRI, a parameter developed by the World Bank to provide a stable and portable measurement standard for pavement roughness for worldwide use. Roughness is an important criterion for pavement quality control purposes and/or in terms of pavement maintenance strategies because it is the one pavement property most noticeable to the traveling public. As it has been stated above, pavement roughness is the result of surface deviations that produce a response in the suspension system of the vehicles traveling over the road. Since most vehicles travel in well-defined wheel paths roughness measurements are typically made in either or both of these wheel paths.

Roughness measurements can be recorded by running a sensor profiler over the test section. In this way the profile elevations can be defined and using standard mathematical techniques such as Fourier analysis, the wavelength of the profile can be determined. This wavelength is the input that the road provides to a vehicle traveling over it. Wavelengths responsible for influencing roughness lie between 0.5 and 50 meters. Vehicles have significant differences in wheel base suspension characteristics as well as different tire and wheel response characteristics. Additionally the way each of these vehicles responds to unit amplitude of road output varies with the frequency of the input.

The perception of the riding quality has long been considered important criteria for the acceptance of the service provided by the road. The road roughness affects the dynamics of a moving vehicle, increases the wear on the vehicle parts and, hence, has an appreciable impact on vehicle operating cost (VOC), safety, comfort, and speed of travel. Roughness can have an adverse effect on the surface drainage, causing water to accumulate on the surface with a consequent adverse impact on both the performance of the pavement and on vehicular safety. The economic impact of roughness is considerable, usually outweighing the considerations of riding comfort and thus providing the strongest objective basis for evaluating the road policies. The cost of operating the vehicles and

transporting the goods rises as road roughness increases. As the total operating costs of all vehicles on a road outweigh the agency cost of maintaining the road by typically 10–20 folds, small improvements in roughness can yield high economic returns. One of the major unknown aspects in capacity studies is the effect of the pavement condition or the surface unevenness on operating speed. The pavement condition that substantially affects the operating speeds can have substantial economic implications in terms of extra user time, discomfort, cost, and low capacity.

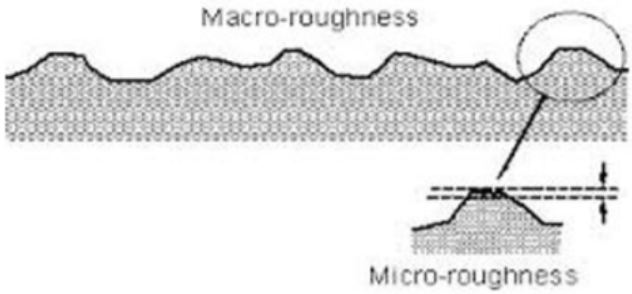

Figure 1. Surface undulations on the pavement (Source: www.tut.fi.com)

2. LITERATURE SURVEY

Molenaar and Sweere (1980) Found the impact of road roughness on riding comfort and pavement deterioration. Distinction is made between an inventory and a diagnostic survey. The equipment used for both surveys is described. They are a ride meter for the inventory survey and a high-speed profilometer for the diagnostic survey. Since the ride index, which is given by the ride meter, is dependent on the measuring vehicle, relations are established between the ride index and fundamental indicators of road roughness as determined with the high-speed profilometer. Based on measurements with the high-speed profilometer, the impact of road roughness on the structural deterioration of the pavement and on the riding comfort is calculated. Also, the impact of road roughness on the safety of the road user is described.

Chattiet al. (2017) Roughness of up to 3m/km had no impact on maintenance cost, but the cost would increase beyond that limit, according to the calibrated HDM-4 model. The increase would vary with the exact roughness. IRI decrease by 1m/km resulted in savings up to 24 to 73 billion dollars per year in repair and maintenance cost alone, as 3m/km to 4m/km change would result in 10% increase of operating cost. The variation is not linear either. In this study, various values of roughness need to be calculated. Applied HDM-4 model for U.S. conditions, and they found that for every 1m/km increase of IRI, there is an increase of 1% in tire wear, at 88km/h. The results were obtained for heavy trucks and passenger cars.

Surns (1980) Found that the roughness plays a significant role in roadway accidents and should be considered when evaluating pavement safety as well as when planning and designing safety improvements.

Sulaymon Eshkabilov (2018) Presented experimental studies from the road profile measurements by employing accelerometers and international roughness index - IRI assessment tools and practical guidelines with respect to measured acceleration data

processing in terms of digital filter design and conversion of vertical acceleration data into displacement data.

Nair and Hudson (1985) developed the predictive pavement serviceability equations based on the serviceability– performance concept. One of the primary objectives of highway agencies in Canada is providing a safe and reliable road network with a good level of service. In the Province of Alberta specific International Roughness Index (IRI) threshold values classify pavements into good, fair, and poor condition categories to manage and schedule rehabilitation and maintenance programs. This research investigated the significant factors that affect the perception of road roughness and established IRI threshold values for good, fair, andpoor road condition based on public perception. A questionnaire was designed to investigate the road users' perception and included questions covering gender, age, familiarity with the road, type and model of car, and perception of road roughness. In addition, psychometric scaling analysis was used to develop a set of IRI threshold values for classifying road condition based on public perception in the Province of Alberta. According to the results of the survey, Alberta Transportation threshold values of IRI do not agree with the road users' opinion and an alternate set of threshold values was developed.

Karan et al. (1978) Developed relationship between average speed and pavement conditions for two-lane highways. Pavement surface conditions have an influence on traffic safety, operating speed, maneuverability, and driver comfort and service volume. Although many researchers have studied the influence of different roadway characteristics on traffic stream characteristics and performance, little research has been conducted to investigate the impact of pavement conditions on traffic stream characteristics. This research therefore investigates the impact of pavement conditions on traffic speed, the most important traffic stream characteristic. Field data were collected across 13 sites from two-lane, two-way roads in Menoufia and Gharbya governorates, Egypt. Each site included two sections, distressed and un-distressed. Road geometry and pavement condition characteristics were collected manually while traffic surveys were carried out using automatic traffic recorders. The data analysis revealed that poor pavement conditions caused a large variation in vehicle speeds and consequently made the speed distribution deviate from the normal distribution. There was a significant difference between the mean speeds for different classes of vehicles.

3. RESEARCH GAP

There is need to evolve a strategy towards the reduction of urban road roughness as it's reducing overall road performance as well vehicles too. In previous studies of the impact of pavement roughness on life cycle greenhouse gas emissions, it was assumed that pavement roughness has no impact on vehicle speed, which implies that travel behaviour does not change before and after the performance of pavement preservation and rehabilitation processes that reduce pavement roughness for some particular vehicles only. Estimate free-flow speed, this study attempts to verify this assumption using IRI as an indicator of pavement roughness on free-flow speed. Only few studies have provided permanent solution to find road roughness. It is costlier to find road roughness using different machines as well GPS. So this study implies suitable method to find road roughness as well its effect on all kind of vehicles.

From the literature survey it is observed that the road roughness can be reduces by varies different methods and can be calculate using different methods. Only few studies have provided permanent solution to reduce the traffic congestion. Therefore, present study is important and its finding will be useful in road roughness measurement and preventive measures. From the total literature review, no one author have stated economical solution to find road roughness and about its reduction. Therefore, there is scope for proper strategy planning to detect and reduce road roughness.

4. METHODOLOGY

As per above mention we are created the new method by using leveling staff and auto level we have measured the road roughness in context of centerline. The method we adopted is basically called the centerline method. (C.L.A)

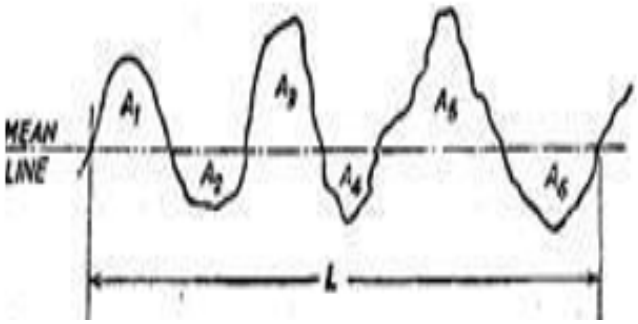

Figure 2. Road Profile

By using planimeter calculate the area of curve and the use the following formula to calculate the roughness of road.

$$= \frac{A_1 + A_2 + A_3 + \ldots\ldots}{L} = \frac{\Sigma A}{L}$$

Figure 3. Statistical Formulation

To calculate the road roughness it is necessary to fulfill all the criteria of roughness like heavy traffic, high intensity, etc. The service road of NH-3 in Nasik is selected with the two landmark “Meenatai Thakare Stadium” and “Amrutdham” having distance about 1000 M. In this patch of road we have surveyed very bad condition of road pavement which was most likely suitable for our area of practice. “Road Bounce Application” is used for measuring the actual road condition for selection of road / area of practice.

Figure 4. Road condition of study area by using "Road Bounce Application"

5. RESULT AND DISCUSSION

As mention the above we have created the road profile by using Auto level and measure the area of survey and calculated the roughness value by using formula. Our calculation the roughness value is 0.9.

For experiment purpose we have compared the roughness value by some other parameters like speed of vehicles, fuel, economy, comfort of passenger, etc.

1) Impact on speed: We have compared the roughness value (like = 0.9) on the vehicle speed level and plotted the graph as follows

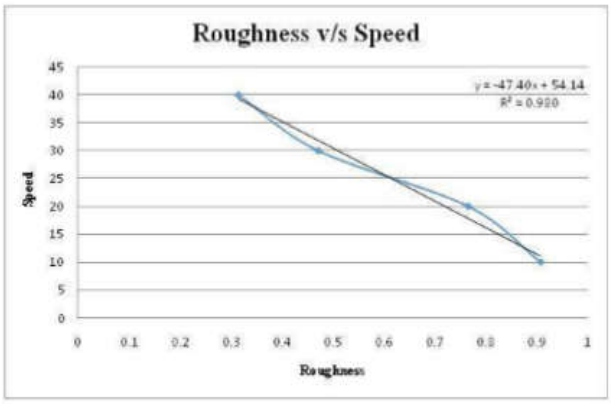

Figure 5. Roughness Vs Speed

With the base of above graph we have studied and calculated that as the roughness increases the vehicle speed decreases.

Now-a- days high speed transportation is so important to reduce the transportation time of good and passenger. Hence high road roughness is affecting the transportation facility.

2) Impact on Fuel economy: The main expectation of vehicle owner is that the vehicle acquires the low fuel. The fuel economy is not 100 % based on road roughness but some percentage of roughness is considered.

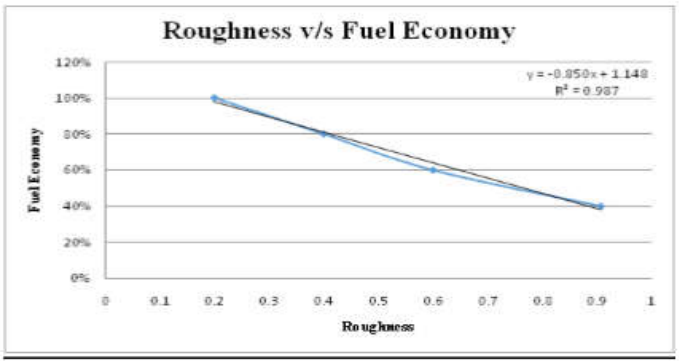

Figure 6. Roughness Vs Fuel Economy

From above graph shows that roughness affects the fuel economy, because vehicle engine is acquires extra fuel in undulated road condition. In small or large pits, low roughness increases the fuel economy

3) Impact on comfort: Passenger comfort is totally based on road condition in rural area its comfort is important issues on travelling. The driver's response to the high levels of road roughness is to reduce the vehicle speed to keep the vehicle ride within the tolerable limits for comfort, safety and protection of vehicle. The free flow vehicle speed are thus constrained by the ride response, among other factors.

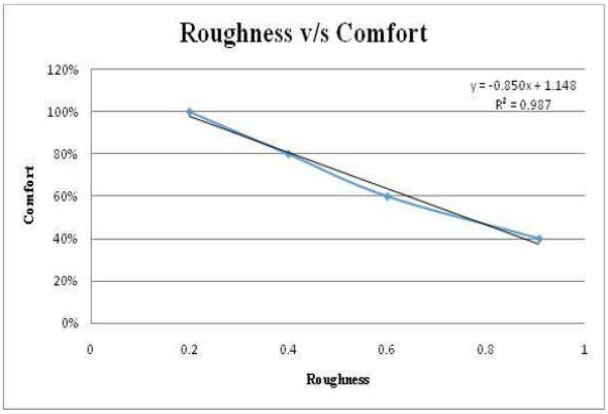

Figure 7. Roughness Vs Comfort

From the above graph show that the roughness increases the comfort level of passenger is reduced.

4) Impact on Vehicle damage factor: As importance of the road roughness being an important aspect as discussed above, involving the response of vehicle itself to the forces coming in through the wheels will affect the stresses in the vehicle structure differently for different vehicles. Relating the roughness values if we gently apply brake it don't even feel the stopping in actual wear, but due to worst conditions this causes wear and tear in vehicle structure.

There by driving over the bad category condition often recommended not to stop fully and brake to desired speed and continue moving slowly or at decreased speed to prevent additional heat build-up in braking as well the vehicle wear.

6. CONCLUSION

Result showed that the impact of pavement roughness on free flow speed, the effect of roughness is more apparent on speed, comfort, fuel economy. As per the study the capacity decreases with increase in road/ pavement roughness when the surface unevenness increases the speed/velocity of vehicle is affected. Also the fuel economy of vehicle descends due to low and unmaintained speed in bad quality road. On basis of studied factors/ parameters pavement/ road roughness had a bad impact on various interdependent conditions that are comfort and vehicle damage factor which are more predominant due to unevenness increases and bad conditioned road in area of practice. But also some percentage of roughness is allowed as per IRI and IRC standards.

7. REFERENCES

[1] T.D. Gillespie and M.W. Sayers, "Measuring Road Roughness and its Effects on User Cost and Comfort", ASTM Special Technical Publication 884, 1983.

[2] AUSTROADS, "Guidelines for Road Condition Monitoring, Part I – Pavement Roughness", Sydney, Australia 2001.

[3] R.W. Perrera and S.D. Kohn, "Issues in Pavement Smoothness", NCHRP Web Document 42, 2002.

[4] L. Sun, "Developing Spectrum-Based Models for International Roughness Index and Present Serviceability Index", Journal of Transportation Engineering (ASCE), 127(6), 2001, pp. 463-470.

[5] A. Loizos and C. Plati, "An Alternative Approach to Pavement Roughness Evaluation", International Journal of Pavement Engineering, Volume 9, Issue 1, 2008, pp. 69 – 78.

[6] PIARC, "International Experiment to Harmonize Longitudinal and Transverse Profile Measurement Report Procedure", Technical Report, PIARC Technical Committee on Surface Characteristics (C1), 2002.

[7] M.W. Sayers, "On the Calculation of International Roughness Index from Longitudinal Road Profile", Transportation Research Record: Journal of the Transportation Research Board 1501, 1995, pp. 1-12.

[8] T. D. Gillespie, "Everything You Always Wanted to Know about IRI, But You Afraid to Ask!", Road Profile Users Group Meeting, Lincoln, Nebraska, September 22-24, 1992.