OVERLAY DESIGN BY MECHANISTIC EMPIRICAL METHOD

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Abstract

Introduction

In mechanistic-empirical (M-E) method, overlay design is done by considering individual modes of structural failures. Alligator cracking (fatigue) and rutting along the wheel path are common failures of flexible pavements. The lane marking is provided to guide the vehicles to follow designated path. The position of the lane marking generally remains same through out the design period of the pavement. However, if the lane marking is shifted by a distance during the design period, the position of lateral distribution of traffic (i.e. lateral wander) would also change. This small change in position of lane marking can be made effective during routine activity of application of renewal painting to the pavement markings and signs. The present work develops an asphalt overlay design process by M-E approach for a given reliability level and attempts to study the effect on estimation of overlay design thickness when shift of lane marking is planned during the design period. A conceptual scheme for overlay design of flexible pavement, to seek the best design option by considering overall cost has been developed.

Objectives

The objectives of this study are as follows

- Estimation of lateral distribution factor
- Numerical study on the effect of lane marking shift on the lateral distribution factor
- Study on economy of pavement design considering with and without lane marking shifting
- Estimation of reliability shift factor
- Study on economy of pavement design at different reliability levels with lane marking shifting.

Effect of lane marking shifting on pavement design

As per M-E method the field performance equation of fatigue and rutting is obtained by multiplying a shift factor to the obtained laboratory performance equations. This shift factor adjusts the differences in the boundary condition, loading pattern (magnitude of load, rest period, lateral wandering etc.) between the laboratory and field conditions. lateral distribution factor (LtDF) is proposed as a shift factor which is to be multiplied to the laboratory performance equations to take care the lateral wandering in the field load repetitions.

Damage of a pavement section is caused by load applications. Total equivalent damage at various points due to all the load repetitions has been calculated with the results of multi layer analysis of the pavement. LtDF is defined as the ratio of design total equivalent damage when all the wheels are passing at a single point to the design total equivalent damage due to all the wandered wheel passes. It is observed that the total damage is not same along the cross-section of the pavement. Since the design is done based on maximum total equivalent damage, the entire width of the pavement is not effectively used over the design period. It is proposed that lane marking may be shifted during the design period to shift the wheel passes considering that driver follows the lane marking. LtDf for various values of lane marking shifting has been calculated. The modified fatigue and rutting performance equations for the equations given in IRC is derived considering the standard deviation of the lateral wandering as 250 mm and lane marking is shifted by an amount of 550 mm after application of half of the load repetitions during the design period. An optimal pavement design chart has been developed for 10 msa and 100 msa. Thickness of a pavement with and with out lane marking has been compared. On multi lane road, an operational policy to decrease the design traffic is recommended, by distributing traffic equally among the lanes.

Study on overlay design

A pavement design is safe when the allowable number of standard axle repetitions (the fatigue and rutting life) is greater than applied standard axle repetitions (Expected traffic) during the design period. In general, these values exhibit significant variability due uncertainties of input parameters. Therefore pavement can be designed for a given safety, known as reliability. Thus for a given reliability, mean allowable standard axle repetitions can be found for an expected future traffic. A factor named as reliability shift factor (RSF) is proposed which is to be multiplied to the fatigue and rutting performance equations to incorporate the design reliability. RSF for fatigue and rutting is estimated by considering the traffic and fatigue and rutting life follows normal distribution. RSF for fatigue and rutting has been found out by considering coefficient of variation for fatigue life as 35%, for rutting life as 60% and for estimated traffic as 30%. Overlay design charts for an existing pavement made up of 140mm of AC layer and 240mm of granular layer has been developed.

The optimal designed asphalt layer thickness and granular layer thicknesses for 100 million ESALs are found to be 176 and 215mm respectively, for 40 million ESALs they are 140 and 250mm, for 60 million ESALs they are found to be 160 and 230mm and so on. If second stage is planned after 40 million ESALs, the thickness required for the rest of 60 million ESALs is 147mm. Similarly, if the stage construction is planned after

60 million ESALs, the thickness required for the rest of 40 million ESALs is 125mm. Like this way many alternatives can be designed for a given reliability level. Out of various possible alternatives suggested the best option has been found by performing cost analysis with a discount rate of 2.5

Conclusions

- Lane marking shifting is proposed as an efficient approach to improve the performance of the pavement, which results in decrease in the design thickness of asphalt pavements.
- It is also observed that shift of lane marking will not be effective when the standard deviation of wheels (σ) is more.
- On multi lane roads, an operational policy which distribute the traffic equally on the lanes is recommended to decrease the design traffic.
- It is more economical to design a pavement pavement with longer life rather than designing it in stages.

Future scope

- Past studies found that the distribution of fatigue and rutting life matches with lognormal distribution but in the present case it is considered as normal distribution. One can estimate the reliability shift factor for fatigue and rutting with log normal distribution.
- For the second stage overlay design, it is assumed that the modulus of elasticity of the asphalt layer becomes equal to that of granular layer after the expiry of the first stage. One can do a better review on AC modulus and plan for suitable stage construction.