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Comparative Study of Scheduled and Condition Responsive Maintenance Strategies for National Highways

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ABSTRACT

Economic losses due to poor roads in India amount to a huge sum. India, having one of the largest road networks, consists of national highways, expressways, state highways, major district roads, other district roads and rural roads. National Highways account for only about 2% of the total length of roads, but carry about 40% of the total traffic across the length and breadth of the country. It should be borne in mind that for achieving the desired economic growth, the foremost requirement is to ensure a good and effective road network. For this purpose a study has been done to compare the scheduled and condition responsive maintenance strategies for national highways by using HDM-4. It has been found that the condition responsive maintenance strategies in comparison with the scheduled type of maintenance strategies for a pavement section saves around 40% highway agency costs, over an analysis period of 25 years. It has been suggested that the condition responsive maintenance strategies, rather than scheduled maintenance strategies may be adopted for rational utilization of maintenance funds.

Keywords:Maintenance Strategies, Pavement Performance, Four Lane Highway, HDM-4

INTRODUCTION:

Pavement performance is a function of its relative ability to serve traffic over a period of time. Originally, a pavement's relative ability to serve traffic was determined quite subjectively by visual inspection and experience. However, experience is difficult to transfer from one person to another, and individual decisions made from similar data are often inconsistent. In the late 1950s, systems of objective measurement (such as roughness meters, deflection and skid test equipment) began to appear that could quantify a pavement's condition and performance. The pavement performance study helps in arriving at the most appropriate maintenance and rehabilitation activity or remedial measures, suitable for a particular section of the road. The various prediction models for deterioration of unpaved and paved roads in HDM III were further modified and new prediction models for deterioration of unpaved and paved roads were suggested in Highway Development and Management Tool HDM-4.

Due to the poor condition of roads, it is estimated that an annual loss of approximately over Rs. 6000 crores ($1.33 billion) is resulted in vehicle operating costs (VOC) alone. Any neglect in the maintenance is self-defeating as one rupee spent in maintenance saves 2 to 3 rupees in vehicle operating cost. It should be borne in mind that for achieving the desired economic growth, the foremost requirement is to ensure a good and effective road network. The pavement performance study will help in arriving at the most appropriate maintenance and rehabilitation activity or remedial measures, suitable for a particular section of the road.The objective of this study to develop a systematic procedure that would predict the most economical maintenance for a particular pavement section, and optimization of such maintenance activities in case of constrained budget.

LITERATURE REVIEW

Fwa and Sinha (1986) proposed a methodology for evaluating the effects of routine maintenance on pavement performance. An application of the concept is illustrated by means of a case study based upon the data of the state highway system of Indiana. Sharma (1986) carried out a study on pavement performance evaluation of

some typical road sections. Pavement Serviceability Index (PSI) models were developed based on structural and functional aspects of pavement such as cracking, patching, surface distress area, roughness, rut depth, deflection etc. From this study it was concluded that Pavement Serviceability Index can be helpful in maintenance program of pavements. Study shows that roughness depends upon the deflection. Roughness models were also developed using different parameters. Dhir et al. (1987) proposed terminal thresholds values for riding quality and skid resistance. Bhatia (1990) developed the linear regression equations between characteristic deflection and rut depth for the various categories of roads. It has concluded that as the thickness of the overlay increases, both deflection as well as rut depth decrease. For hilly terrain, the rut depths were found to be much higher as compared to the plains.Chakrabarti et al (1995) calibrated HDM-III for Indian conditions, to predict total life cycle costs i.e. construction, maintenance and road user costs as a function of design and maintenance standards and other policy options. To perform the calibration of the HDM-4 model, it is necessary to have history and survey data of pavement condition. Dadang et al. (2005) developed a simple practicable pavement performance model for network of the Malaysian Federal Road where rutting was the focus of the measurement. Gedafa (2006) carried out the pavement performance study for Indian highways using HDM-4.Gedafa et al. (2010) developed a relationship between remaining service life (RSL) and Center deflection. The relationship between RSL and center deflection has been investigated by keeping other variables constant. The results show a decrease in RSL after a certain threshold value of the center deflection.Rokade et al. (2010) carried out the various studies to evaluate the performance of flexible National Highways and State Highway near Bhopal. A detailed pavement condition survey is done on 4 National Highways (NH 3, NH 12, NH 69, and NH 86) and 1 State Highway (SH 23) and the road condition is evaluated both functionally and structurally. The Benkelman beam study was conducted on all the five stretches and structural inadequacy was found in the sections of all the five stretches.Ferreira et al. (2011) compared different pavement performance models (PPMs) from around the world and recommends one for use in the Portuguese pavement management systems (PMS).

STUDY AREA

In the present study, the identified National Highway network consists of total road length of 40 km from Muzaffarnagar bypass to Daurala (KM-130 to KM-90). The inventory and pavement condition data in respect of all pavement sections have been collected using equipment, such as, Portable Falling Weight Deflectometer-LOADMAN, ROMDAS, and Portable Skid Resistance Tester etc.

ANALYSIS AND RESULTS

The pavement condition data on all sections of the highway network was collected by the end of year 2010 (Kumar, D., 2011) using various types of equipment and methods. The pavement condition data on these pavement sections was collected once again by the end of year 2011, using the same types of equipment and methods, so as to ascertain the annual progression of distresses during the year 2010-2011. The four types of distresses were measured, which have been compared with predicted by HDM-4 Model. Calibration factors obtained by Jain *et al.* (2005) are used for prediction of distresses and to develop the maintenance management strategies for the selected sections of National Highway.

This study presents the comparison of adopting a scheduled type of M&R strategy against a condition responsive M&R strategy for a pavement section, over a fixed time period. The scheduled M&R strategy has been selected as per the current maintenance norms for roads, provided in [MORT&H 2001], whereas the condition responsive M&R strategy has been selected as per the ‘Maintenance Serviceability Level’ up to which, the selected pavement section is to be maintained. The pavement section NH-58[KM120-KM110 UP] (Section ID NH-5802UP), of the identified National Highway has been selected for this study. General details and condition characteristics of this pavement section are given in Table 1.Two types of M&R strategies are defined for this case study. One is ‘Scheduled Overlay’, and the other one is ‘Condition Responsive Overlay’. The details of these alternative strategies are given in Table 2.

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Table 1 General details and condition characteristics of selected section

General Details		Pavement Characteristics	
Section Name	NH-58[KM120-KM110 UP]	Material Type	Asphaltic Concrete
Section ID	NH-5802UP	Surface Thickness	50 mm
Section Length	10.00 m	Roughness	3.60 m/km IRI
Carriageway Width	7.00 m	Cracked Area	2.9%
Number of Lanes	2	Ravelled Area	0%
Flow Direction	Two-way	No. of Potholes	0
Motorized AADT	14528	Mean Rut Depth	1.9 mm
Climate Zone	North India – Plains	Skid Resistance	0.69 SFC

Table 2 Details of defined M&R strategies

M&R Strategy	M&R Work	Intervention Criteria
Scheduled Overlay	Bituminous Concrete (BC 25 mm)	Scheduled every Five years
Condition Responsive Overlay	Bituminous Concrete (BC 25 mm)	Roughness > 4.0 mm/km IRI

Project analysis

The 'Project Analysis' application module of HDM-4 is used for simulating the pavement condition of the selected pavement section under two defined M&R strategies, over an analysis period of 25 years (i.e., 2012 – 2036).

Roughness progression

The progression of roughness over the analysis period of 25 years, under two defined M&R strategies is shown in Figure 1. In case of 'Condition Responsive Overlay' strategy, overlay is required to be provided as soon as the roughness value progresses to 4 m/km IRI. This will happen in the years 2015, 2024 and 2033 (3 times in 25 years), as indicated by the sudden drop in the roughness value. But in case of 'Scheduled Overlay' strategy, the overlay is to be provided at a fixed interval of five years. This will happen in the years 2014, 2019, 2024, 2029 and 2034 (5 times in 25 years). But in this case, overlay is provided when the roughness value progresses to only 3 m/km IRI. This roughness value is well below the limiting roughness value 4 m/km IRI, as per the requirements of 'Medium Serviceability Level'. Thus, it clearly shows that under scheduled maintenance strategy, overlay is being provided at an early stage, in comparison to condition responsive maintenance.

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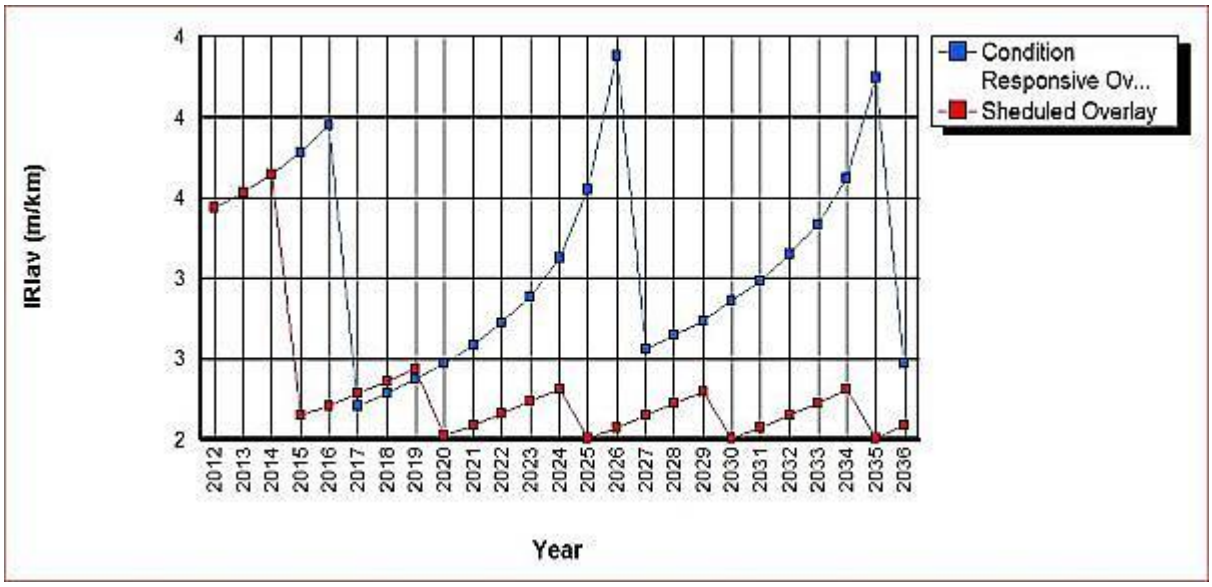

Fig. 1 Progression of roughness under two M&R strategies

Description of works

The various work items resulting from the two specified M&R strategies, as triggered by the respective intervention parameters, and timings of their application are given in Table 3. The total cost to be incurred by the highway agency on maintenance management of the pavement section under two M&R strategies, over the whole analysis period of 25 years is also given in Table 3.

Comparison of M&R strategies

The cost comparison of the two M&R strategies, as given in Table 3, indicate that the highway agency shall have to dispense with Rs. 68.683 million over a period of 25 years, on providing overlay to the pavement section five times in the case of 'Scheduled' maintenance strategy. However, in the case of 'Condition Responsive' maintenance strategy is adopted, the highway agency shall have to spend Rs. 41.371 million on providing overlay to the pavement section only three times.

Table 3 Description of M&R works and associated costs

M&R Strategy	M&R Work	Applicable Years	Frequency of Application	Total Agency Costs in Million Rupees
Scheduled Overlay	Bituminous Concrete(BC 25 mm)	2014, 2019, 2024, 2029, 2034	5	68.683
Condition Responsive Overlay	Bituminous Concrete (BC 25 mm)	2015, 2024, 2033	3	41.371

Selection of optimum strategy

It has been found on the basis of cost comparison of two M&R strategies that there will be a net saving in cost of about 40% (Rs. 27.31 million) over the analysis period of 25 years, if the 'Condition Responsive' M&R strategy is adopted by the highway agency, for the maintenance management of the pavement section. Therefore, It is recommended on the basis of above case study that condition responsive M&R strategies, rather than scheduled maintenance strategies should be adopted for maintenance management of pavement sections, for rational utilization of the limited maintenance funds.

CONCLUSIONS

In this study, internationally recognized Highway Development and Management system (HDM-4) has been selected for development of pavement management system for the Indian National Highway network. This model has been selected because of its wider acceptance and applicability in a large number of developing countries. The application of the developed maintenance management system methodology has been made, using various application modules of HDM-4. The adoption of condition responsive maintenance strategies in comparison with the scheduled type of maintenance strategies for a pavement section indicate 40% (Rs. 27.31 million) savings in highway agency costs, over an analysis period of 25 years. Therefore, it is recommended that the condition responsive M&R strategies, rather than scheduled maintenance strategies may be adopted for rational utilization of maintenance funds.

REFERENCES

1. Bhatia, S.K., (l990), "Development of Relationship between Rut depth and Deflection for Flexible Pavements", M.E. Thesis, COTE, Department of Civil Engineering, University of Roorkee, Roorkee.
2. Chakrabarti, S., Rawat, M.S., and Mondal, B., (1995), "Highway Design and Maintenance Standards Model (HDM): Calibration and Adaptation to Indian Conditions" Indian Roads Congress Journal, Vol. 56, No. 1, pp 75-101.
3. Dadang, M., Hamid, A., (2005), "Pavement performance model for federal roads", Proceedings of Eastern Asia Society for Transport Studies, Vol. 5, pp. 428-440.
4. Dhir, M.P., Phull, Y.R., Sood, V.K., (1987), "Studies Towards Development Of Pavement Management Systen in India",2nd North American Pavement Management Conference.
5. Ferreira, A., Picado-Santos, L., Wu, Z., and Flintsch, G., (2011), "Selection of pavement performance models for use in the Portuguese PMS",International Journal of Pavement Engineering Vol. 12, No.1, pp 87–97.
6. Fwa, T.F., and Sinha, K.C., (1986), "Routine Maintenance and Pavement Performance", Journal of Transportation Engineering, ASCE, Vol. 112, No. 4, pp 329-344.
7. Gedafa D.S., (2006), "Present Pavement Maintenance Practice: A Case Study for Indian Conditions using HDM-4" Fall Student Conference, Midwest Transportation Consortium. Ames, lowa,pp.1-16.
8. Gedafa, D.S., Hossain, M.,Miller,R., Van, T., (2010), "Estimation of Remaining Service Life of Flexible Pavements from Surface Deflections", Journal of Transportation Engineering, ASCE, Vol. 136, No.4, pp 342–352.
9. Kumar, D., (2011), "Pavement Deterioration Modelling for Four Lane National Highway", Unpublished M. Tech. Thesis, Department of Civil Engineering, Indian Institute of Technology Roorkee, Roorkee.
10. MORT&H (2001). "Report of the Committee on Norms for Maintenance of Roads in India", Ministry of Road Transport & Highways, Government of India, New Delhi.
11. Rokade, S., Agarwal, P. K., and Shrivastava, R., (2010), "Study on Performance of Flexible Highway Pavements",International Journal of Advanced Engineering Technology Vol. 1, No.3, pp 312–338.
12. Sharma, B.M., (1986), "Pavement Performance Evaluation of typical Road Sections", M.E. Thesis, COTE, Department of Civil Engineering, University of Roorkee, Roorkee.