

Pavement Maintenance Management System for Indian Roads Using HDM-4

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Abstract – In latest years, a major significance has been put on the upkeep of existing road network of India in a suitable and orderly route through different vital undertakings, for example, the Expressway Management Capacity Improvement (HMCP, 2002), the Road Network Improvement Project (RNIP, 2003), and the Third Road development project - Implementation of Sector Development Policy (ISDP, 2005). Highway Development and Management Framework HDM-4 (PIARC, 2001) has been utilized for the procedure and program examinations of the road network under not limited and limited spending plans and in addition for streamlining of footpath upkeep options at project level for a particular road area. Hence, in this project we are presenting the pavement maintenance management system and its analysis using the HDM-4 software tool by using the Indian roads datasets. The main goal of this research is to present the Pavement Management System (PMS) for a recognized National Highway Network keeping in mind the end goal to help the highway engineers in charge of keeping up the highway network and additionally the experts in charge of distributing funds, in making steady and price efficient choices, identified with upkeep and restoration of footpaths. This necessitates advancement of a precise methodology that would foresee the most economical maintenance procedure for a specific footpath segment and prioritization of such upkeep exercises in case of an obliged spending plan. The HDM-4 is another global standard helping pavement managers to anticipate future financial, specialized, social and environmental result of conceivable investment choices concerning upkeep administration of pavement. The pavement weakening models joined in HDM-4 have been adjusted to adjust to local conditions and reasonable calibration factors have been resolved.

Keywords— Pavement Maintenance, HDM-4, Indian Roads, Highway Management, Road Network.

1. INTRODUCTION

Road Transportation it inhabit a very governing location inside the complete transportation method of India. Enlarge of road traffic within the region liberty space has been absolutely unmatched both in Intellection of products and traveler traffic. In the year from 1951 to 2001, the vehicular traffic has rising from 3,00,0000 to 4, 300, 0000. But unfortunately, the according to enlarge inside road system have not been matching with the massive enlarging in vehicle driver population; these are the rising from 4,00,0000 km to 33,00,0000 km between the equal duration (Odoki, 2014) without enough and well-timed support, road degenerates enormously, required to bigger vehicle working price, expanding number of accidents and reduces dependability of transport facilities and consequently there's necessitates of producing a scientific model to finding the care and renewal demands of pavements. Efforts also are necessary to manufacture road controlling and planning machines to

add the present highway network. Those machines are obligatory for estimates the economical requirements, analysis other maintenance scheme and prioritizing the work programs. In hence conditions, implements and application of a well-organized Pavement Management System would allocate compulsory data and purposeful analysis to securely constant and price efficient choice associated to maintenance of the highway networks (Odoki, 2014) (Chan and Lane, 2014)

In present years, a large significance has been position on the upkeep of exist road pavement framework in both created and creating the country to keeping the huge investments in pavements. If the efficient that the successful and research scheme for safeguarding are employed, for a larger period of time the pavement system can supplies larger level of service and what's more, accordingly results in saving with regarding the whole transport expenses to the community.

In the year of 2003, HDM-4 (Management & Highway Development) are antecedent HDM-III (Maintenance Standards Model & Highway Design) (Watanatada *et al.*, 1987), which were performed through the World Bank and another world wide firms, have been gathered as state-of-the art frameworks for the looks at of road administration and investment conspire through numerous genuine and development project in excess of 100 country over the most recent 3 decades, due to the underneath benefits: (1) the disguise of both road client expenses and association cost in an life-cycle cost compute, (2) the utilization of normalized parameters for types-based relevance in different atmosphere and appropriate, and (3) the utilization as a reasonable scheme device for pavements, if accurately graduated, especially to develop countries, while reception scheme levels specifically from the scheme portrayal of industry countries (Tsunokawa and UI-Islam, 2003).

Destruction and decay of pavements are developed detected as outcomes of traffic, pavement and climatic or natural aspects. These aspects cause surface fatigue, integration or shear, implementing in the sub-grade, sub base, or surface.

Traffic factors include heavy axle-load repetitions, accelerating and decelerating traffic while pavement factors may include excess asphalt, poorly graded, inadequate particle interlock and poor sub grade drainage. Temperature variations and rainfall are examples of climatic factors that may cause damage to pavements. The impairment of a pavement is also evident by different outer signs and denoted is known as distresses. Normally, pavements distressing are descends into one of the following types: distortion, faults, decomposition and exists of sideslips resistance.

Cracks in flexible footpaths are produced through the shuffling of the surface, thermal extension enlargement of the surface, and diversion of the surface across an unsafe foundation and badly created lane joints or reflection cracking. The below are the instances of cracks that may run in pliable pavements:

Longitudinal and transverse cracking: A longitudinal crack below a training equivalent to the axis line. On the other hand, a transverse crack runs roughly perpendicular to the roadway centreline. By contraction of the pavement surface both are caused. Implementation of longitudinal splits may be expediting due to badly foundation lane joints.

Alligator Cracking: Alligator faults are interrelated faults that form an order of small blocks approval an alligator surface. They might be begun by over the top avoidance of the black-top surface crosswise over feeble establishment or by fumes of the asphalt surface under frequent loading o.

Block Cracking: Shrinkage of the black-top and day by day temperature is cycling cause piece splitting. These are correspondence splits that parcel the asphalt into equivalents to rectangular portion. The episode of this torment for the most part signified that the black-top has acclimated vitally. It is usually occurs across a huge region of the pavement area and may sometimes happens in non-traffic region.

Slippage Cracking: Slippage splits are begun by interrupt or turn wheels on the grounds that the asphalt surface to crawl and harm. These splits has been half - moon formed breaks which is having two finishes pointed a long way from the method for the motion.

Reflection Cracking: Using perpendicular or flat activity into the pavement underneath a surface, Reflection cracks are started. These faults revolve the crack scheme in the repressed pavement.

2. RELATED WORK

This section presents the study of recent works reported on research title.

Jennaro B. Odoki *et.al* (2016) [22], the creator's disclose a contextual analysis to adjust the thruway advancement and administration instrument (HDM-4) for exploring street venture decisions in Kenya. Streets constitute the most essential method of transport in Kenya since more than 93% of all cargo and traveller movement is transported by street. Kenya's open street arrange involves about 161,451km of which 14,561km is cleared while 146,890 km is unpaved. The evaluated estimation of the street resource 2.5 trillion and this speaks to a huge part of the nation's open speculations. Given its commitment to the nation's financial advancement and the general population speculation it speaks to, the streets arrange must be ceaselessly created, overseen and kept up in a reasonable and compelling way.

Susanne Chan *et.al* (2016) [23], this first unending asphalt trial achieved its 9-year benefit life. Yearly asphalt condition information, for example, asphalt unpleasantness, rutting and breaking were gathered and dissected. The creator's demonstrates the asphalt execution and looks at the consequences of the ceaseless asphalt with regular profound quality asphalt.

Yung-Lin Chen *et.al* (2013) [24], they utilized balanced mode with genuine roadway spending plan to decide the limit of routine and period support. Assuming support cost, customer cost and interstate economy to choose appropriate limit. At last, in view of the best upkeep methodologies clarify the connection between support spending plan and execution. Base on this outcome, they can decide the

monetary allowance allocating criteria to achieve the greatest economy advantage of the asset.

Ho-Szu Lin et.al (2013) In [25], the creator's predominantly centres around district, country and fractional urban streets in the Hsin Chu County, demonstrates the pertinent enactment and frameworks drawn up by the legislature that have a positive effect for administrative usage to the general population.

Jan Mikolaj et.al (2013) [26], the provincial street executives battle with the volume of streets in their circle of expert and restricted spending plan to secure a working country street organize. Without an advantage administration framework a loads of assets stream in wrong resources while on the opposite side bunches of financial advantages are lost because of poor state of different resources. That joined with the demand that their upkeep designs need to meet the necessities of manageability standards prompted a plan of a working ad lobbied resource administration framework to satisfy the part of an appropriate resource administration framework.

Trisha Senet.al (2013) [27], the creator's clarify the utilization is higher at top hours because of diminished movement speeds. Client cost is higher on the state course than the interstate because of unpredictable movement. Street office price for the state course is four times greater than the interstate. Scaled scale surfacing treatment may cost less, yet does not improve groove significance, while an overlay upgrades the roadway including assistant breaking and trench intelligence. In Tennessee, HPMA practical improvement investigation is accessible to enough disseminate the accessible assets.

Po-Hsun Sung et.al (2013) [28], the primary the objective is that to figure the approximation of central points and evaluate the advantage of the meander. Exactly when utilized the favourable position organization system on road black-top organization, it must be developed on resources stock and important upkeep. To figure all the cost of inclinations could list the approximation of the significant number of advantages. The most basic work of advantage organization was looking over the focal points. Each one of the advantages were analyzed the survival life of the impressive number of focal points and find time of the cheapening in the examination. It is 8.9 years that the period between as of late advancement also, first upkeep. It is 4.5 years that the time among structures for upkeeps. The survey demonstrates was set by the two time periods. The outcomes cross the investigation demonstrate were that the great conditions benefit level was brilliant.

Ying Xu et.al (2009) [29], the creator's bankrupt down the life cycle costs of three dark best black-top

structures: versatile base wearisome dark best black-top, semi-rigid base unending dark best black-top and semi-unbendable base dark best black-top which was a kind of wide-used dark best black-top structure in China. The association costs and the client's expenses among the three black-top frameworks were figured exclusively.

YU Lehua et.al (2010) [30], the creator's clarify a movement of change of improvement frames have been given in the area with the more noteworthy post-progression settlement of delicate ground. Remembering the true objective to diminish post-progression settlement, outline clears among filling-sand wells should reduce, and time of stacking and pre-press ought to be drawn out, and furthermore finished weight pre-press connected on fragile ground. Additionally, ephemeral black-top structure ought to be worked in areas of more prominent post progression settlement of touchy ground to substitute unending black-top structure. Research happens as intended for other roadway progress, from the specific and monetary related perspective for the delicate ground the most ideal approach to manage direct and give data.

Zarabizan Zakaria et.al (2013) [31], the creator's recognized the work history not refreshed and the examination isn't utilizing the present information as components adding to the framework exactness. The outcome is discovered that HDM-4's system precision used by PWD Malaysia achieves ordinary 65 for each penny just and had not the proficient level that had been set by PWD Malaysia particularly 80 for each penny.

The creator's has uncovered the reasons for the events in the asphalt administration framework in development venture in Malaysia and examined the results of the late instalments and last record issues faced by contractual workers in Malaysia, which in the long run proposed vital moves that could be made by the temporary workers in securing their instalments.

Nasir et.al., (2010) [32] thought about six asphalt condition records from five DOT's in the United States, utilizing the trouble and ride quality information acquired from the Pavement Management Information System of the Texas Department of Transportation. The figured scores were looked at outwardly utilizing scramble plots and factually utilizing combined t – test. The outcomes demonstrated noteworthy contrasts among apparently comparative asphalt condition lists.

3. RESEARCH METHODOLOGY

Keeping in mind the end goal to accomplish the general target of building up a pavement administration framework for road arrange upkeep to fill in as a choice help device to help to enhance the proficiency of deciding; the accompanying technique was taken after:

The information acquire by the record and efficiency of current PMS that are controlled by different road upkeep administration in the country. The feature and exact model of the PMS are innovated. In PMS, historical information are innovated that the exposure of PMS, past and current from and possible attributes based on its current place and the available methods that are exploits to raising it. Information regarding the international PMS position was obtained via the innovation of PMS in all disciplined via study organized in various nations in the world. These nations are China, Germany, New Zealand, Australia, Italy, Canada, UK, France and Spain. The PMS of various South African (SA) administrations was also obtained. Obtained of this information was fully via the discussion with the applicable operators from the South African National Roads Agency Limited, Local Municipalities, Provincial Road Departments, SARB (South African Roads Board), Consulting Engineers and Contractors, CSIR (Council for Scientific and Industrial Research),

A. Problem Definition

In the problem statement, in India, expand of road guests in the produce autonomy innovation has been very unprecedented, both as far as items and additionally traveller activity. The vehicular activity has expanded manifolds from zero.3 million to forty five million at some stage in the duration 1951-2001. Be that as it may, appallingly, develop in the street arrange has never again been equivalent with the extensive development in vehicular populace, which has extends from 0.4 million km to only three million km, all through the equivalent length. Across the Nationwide Highways (NH) constitutes the require device of road transportation inside the United States. These expressways represent to significantly less than 2 percent of the entire road time frame, yet convey around forty rates of aggregate street site guests.

However the renovation and what's more, restoration calculates of pavements are constructed absolutely on subjective management and past delight in of the toll street engineers only. National High Networks Identification

The first step in PMS is recognizing that the highway network for the pavement management model required to be expands. In this research survey, a sub- network of the 65,000 km assembling the 'National Highway Network' of India has been recognized for extends of the build of Pavement Management are equal.

In Table 4.1 display that, the selected highway network that consists of the overall distance is 310 km, these highways combined of the five National Highway. These selected highway boundaries of Muzaffarnagar and Saharanpur in UP state and Haridwar and Dehradun in Uttaranchal state. In fig 3.1 display that, the boundaries of the national highway.

Table I: Selected National Highways

S. No	National Highway No.	Description
1.	NH-58	Delhi-Meerut-Roorkee-Haridwar-Badrinath Marg
2.	NH-72	Ambala-Paonta Sahib-Dehradun-Rishikesh Marg
3.	NH-72A	Chutmalpur-Biharigarh-Mohand-Dehradun Marg
4.	NH-73	Roorkee-Saharanpur-Yamunanagar-Panchkula Marg
5.	NH-74	Haridwar-Najbabad-Bareilly Marg

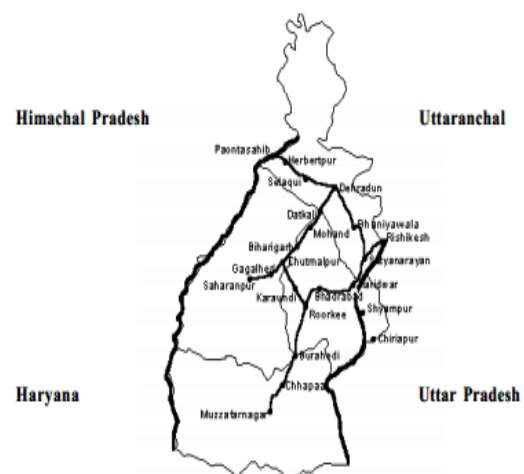


Fig.1. Layout of the Selected National Highway Network

B. Division of Highway Network into Pavement Sections

The above highway network has been separated in to twenty two administer pavement segments on the foundation of diverse attributes associated with them. The divisions of highway network divide in to the section for the basis of similarity with regarding to: pavement type and extent, traffic volume and pavement states attributes. The selected pavement division is completely homogenous inside themselves

but changing from the traffic, climatic attributes, and pavement and geometric. All pavement division changing in concepts of the traffic and pavement attributes. However the geometric attributes are mostly same for the pavement division but these divisions changing for several divisions located in the uneven region. The climatic circumstance is updating in worried of the pavement district arranged in the fields and hilly region. Whole they picked pavement division has been distributing an exceptional 'Section Name' and 'Section ID'.

These unique divisions are used to easy recognition on the highway network.

4. RESULTS

In this section we present the current results on this research work. The venture level asphalt administration examinations might be done by means of the "Task Analysis" utilization of the HDM-4. Task explores it is worried about the assessment of at least one street activities or venture choices. In the present investigation, for the venture level asphalt administration the underneath four unique sorts of contextual analyses have been attempted.

Following are results those we got for above four projects at network layer

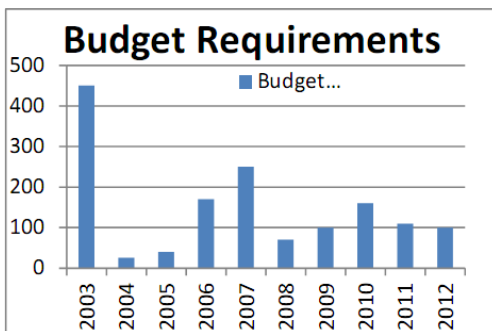


Fig.2. Year wise budget requirements

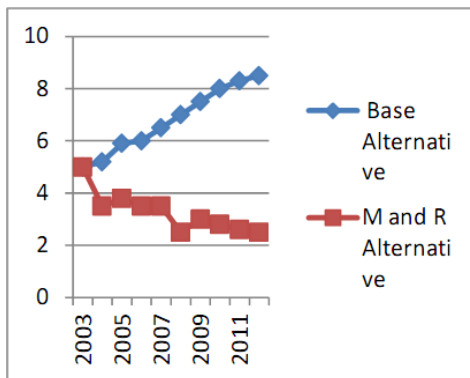


Fig.3. Average roughness value for the highway network

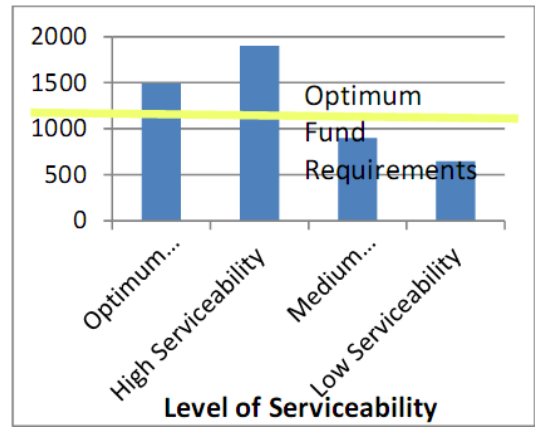


Fig.4. Fund requirements for each serviceability level

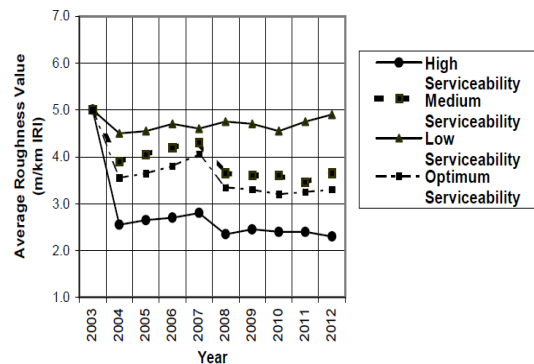


Fig.5. Highway network condition under each M&R serviceability level

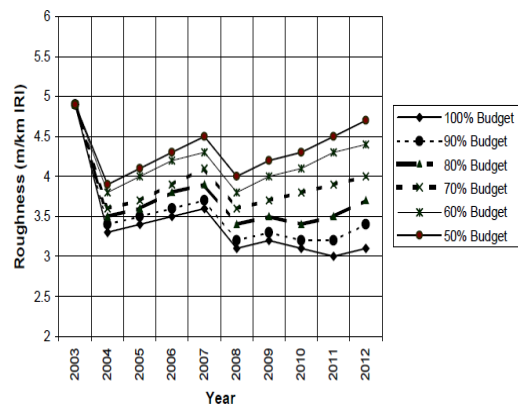


Fig.6. Average Roughness Value under Varying Levels of Budget Allocations

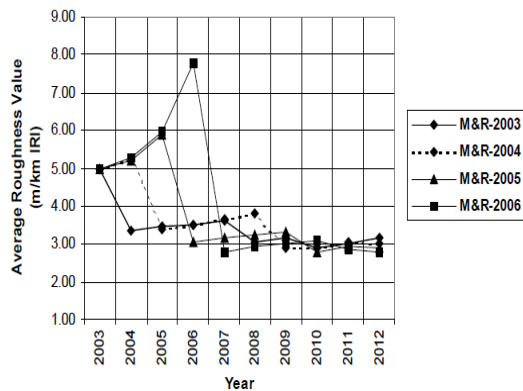


Fig.7. Highway network condition under each M&R strategy

5. CONCLUSION AND FUTURE WORK

Under task level PMS examination, the perfect M&R system for an asphalt district has been settled on the in light of most noteworthy NPV/Cost proportion, among a couple of pre-characterized M&R techniques. Basically, a flawless change framework for another asphalt segment has been settled. Whatever is left of administration life for several of asphalt zone has been figured which changes from 1 to 3 years, showing that amusement on most of the asphalt areas would be unavoidable sooner rather than later, with no solid support administration arrangement. Under system level PMS examination, an unconstrained works program has been set up for a period of 10 years and the total spending necessities for enabling organization of the whole expressway to arrange at a pre-described accurate serviceability level have been settled, which ends up being 1475.87 million Indian Rupees. The aggregate total required for supporting the road arrange at a perfect serviceability level are basically in excess of 40 times more than those necessitate for keeping it with essentially routine help sort of kind of exercises. Since the serviceability level of store assignments for the assistance association of National Highways in India is of the demand of 60% of the necessities just, thusly a formed and redesigned works program has been set up for 60 spending openness. The advantages necessities for keeping up of the total thruway arrange at the largest amount of serviceability (Rs. 1871.8 million) is around 27 % higher than those required for keeping up it at accurate level of serviceability.

Regardless, to keep the comparative expressway organizes at a medium level of serviceability at around 74% of assets (Rs. 1089.1 million) it is possible. To keep this parkway arranges in any event level of serviceability if the 60% spending plan is accessibility frequently then it would basically be conceivable. The similitude is also obvious when the support movement is logically conceded past the year in which they wind up due. Both these conditions have a to a great degree negative effect on the general strength of the thruway arrange.

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