International Journal of Advanced Scientific Research
ISSN: 2456-0421
Impact Factor: RJIF 5.32
www.allscientificjournal.com
Volume 3; Issue 1; January 2018; Page No. 09-13

HDM-4: Application in highway engineering

[1] Ashlesh Jagtap, [2] Shrikant M Harle

[1] B.E. Final Year Student, Department of Civil Engineering, Prof. Ram Meghe College of Engineering and Management, Badnera, Maharashtra, India

[2] Assistant Professor, Department of Civil Engineering, Prof. Ram Meghe College of Engineering and Management, Badnera, Maharashtra, India

Abstract
The present paper represents HDM-4 is a computer software for Highway Development and Maintenance Management System. It is a decision making tool for checking the Engineering and Economic viability of the investments in road projects. The World Bank for the global use has developed it. HDM-4 is the new windows version after HDM-III with incorporation of many new features so that it can be used in any locality of the world with any environmental and engineering situation. HDM-4 is the new windows version after HDM-III with incorporation of many new features so that it can be used in any locality of the world with any environmental and engineering situation. This paper describes the adaptation of the World Bank's highway development and management model HDM-4 at the strategic level. Urban road network of 21 sections, consisting of total 60 km road length of Noida city, near New Delhi, capital of India, were analyzed. The HDM-4 strategic analysis can serve as a customized economic evaluation tool in forecasting budget requirements and network condition and can be used for managing urban roads on the basis of sound engineering principles.

Keywords: software, traffic, road data, life cycle cost and pavement evaluation

1. Introduction

The Highway Development and Management System is a decision tool to help you investigate your road investment choices. HDM-4 is a computer software for Highway Development and Maintenance Management System. It is a decision making tool for checking the Engineering and Economic viability of the investments in road projects. The World Bank for the global use has developed it.

1.1 General

Nowadays, with the rapid increasing travel demand and high economic pressure, more and more highways are built under a build-operate-transfer (BOT) scheme to raise direct private finance [2].

This deals with the major deficiencies in the current investment decision process to the highway network and with the major problems and ineffectivities in the consecutive phase of realization. Overall approach of this is to reveal the possibilities to improve effectivity of above mentioned investment decision process and realization phase through proposal of the very concrete measures [3].

Pavement Life-Cycle Cost Analysis (LCCA) is known as a technique helping pavement designers make better decisions that balance initial construction cost and projected future cost of a project [4].

As is well known, surface texture plays a key role in tyre-road interaction phenomena and greatly affects road safety. Surface texture, defined by the ISO Standards 13473-1 as "the deviation of a pavement surface from a true planar surface", can be seen as the superposition of many elementary harmonics, each one corresponding to a specific domain associated with a wavelength range: microtexture, macrotexture, megatextureand roughness [1].

During the construction of highway runway, the clearance condition is one of the key factors restricting highway runway site selection which must be considered, and also occupies considerable weight in the demand of technology in highway runway site selection [12].

Managing the impact of traffic growth under huge financial constraints with a clear message of ''more for less", and ''making the most of what you have" is causing extra pressure on the use of existing physical infrastructure assets [11].

The adhesion phenomenon takes effect at the smallest texture scales (microtexture); it is due to the molecular interaction forces which grow between the tyre and the surface [9].

Highway maintenance work is different from the ordinary highway maintenance operations. Compared with ordinary highway maintenance work, it has many unsafe factors: large traffic volume, high speed, pavement under heavy load and potential danger caused by bad weather on the maintenance personnel [10].

The World Bank has developed Highway Development and Management System
(HDM-4) which is an internationally recognized tool available for making timely and cost effective maintenance management decisions for urban road network [5].

Current importance of this topic is also given due to the currently increasing production of the construction segment and the present situation of financing the construction of roads and highways [3].

To achieve the goal of total cost comparison, LCCA requires extensive and project specific information in its inputs, such as material volumes, material unit costs, agency support costs, traffic volumes, and lane closure schedules. Due to the complexity and diversity of LCCA, practitioners are overloaded and often prone to miscalculated total costs from inadequate and/or deficient input data [4].

HDM-4 system could be implemented to assist the highway agencies for establishing realistic levels of funding, and to set levels and priorities to maximize the effectiveness of expenditure on pavement maintenance activities [5].

The purpose of the research is not only to provide results of the analysis of calibration and the calibration coefficient, but also to propose a strategy for the needs of calibration in the future as well as comparing the results of the measurements between cracking initiation on urban roads and highways [8].

1.2 Need of Study

Pavement surface performances have a great influence on road functionality and can affect user's safety, vehicle operational costs, environmental sustainability [1].

Private provision of the public highways through the build-operate-transfer (BOT) scheme has become popular worldwide. Studies published in dozens of academic journals have investigated various kinds of cases of BOT highway projects [2].

With regards to the strategic role of transport in a country's economic development and the large investments that are required, a thorough economic appraisal of these investments is of high importance. Therefore, it is appropriate to analyze and possibly modify existing methods for evaluating the economic efficiency of road construction at the scientific level [3].

The HDM Circle is carrying out the large-scale surveys like Road Condition Survey, Roughness Survey and Traffic Survey for the whole Road network every year since 1995. So RHD is rich in database. A central databank has been established in the Head Quarter. The data is stored in the local server and is accessible to the users through Local Area Network (LAN). The LAN will be converted to Wide Area Network (WAN) in near future so that the user from the local districts can have access to the database [4].

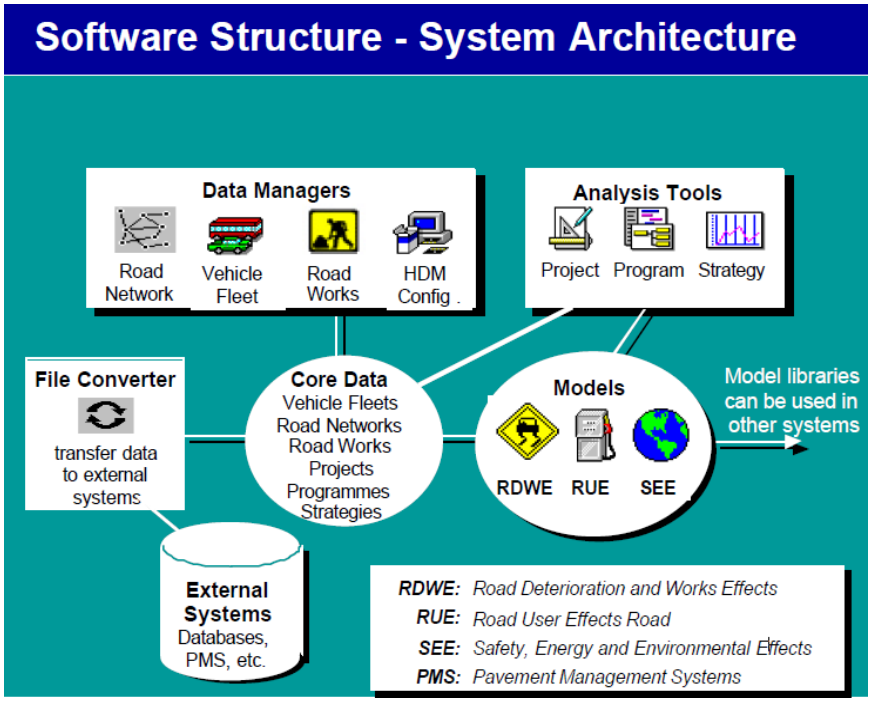

Fig 1: HDM-4 software System Architecture

1.3 Objective

By verifying the evaluating cases, this method can effectively improve the effectiveness and accuracy of the highway safety production. It has great significance for accelerating highway maintenance safety management system [10].

An exploratory research method was used through an extensive review of literature and an industry survey. The findings from the literature and case study review were used to design a questionnaire and conduct the survey [11].

All these have provided a theoretical basis for exactly determining the position, altitude and the superelevation value of the obstacle in the highway runway clearance zone [11].

Four different dense graded wearing courses were designed with different aggregates: limestone, basalt and expanded clay. Several surface performances were measured by different devices (Skid Tester, Sand Patch Test, Laser Profilometer) [1].

The theme of this research is essential for the development of urban areas. This paper presents the results of the researches in view of the definition of the calibration coefficient of the crack formation model in HDM4 [8].

2. Literature Survey

Vaiana R. *et al*. studied traditional tests to measure in-situ micro and macrotexture were carried out; overall 4 monitoring campaigns were done. It is noted that this project was run in

partnership with the Road Network Division of Provincial Administration of Cosenza.

Radan Tomek and Stanislav Vitásek studied there are significant inefficiencies in the current decision process regarding investments to the road network. There are different methodologies on investment decision process (based on a location) but for the actual economic assessment of the project, it is the software tool HDM-4, which is most widely used.

U. Shah Yogesh *et al*. studied the HDM-4 strategic analysis can serve as a customized economic evaluation tool in forecasting budget requirements and network condition and can be used for managing urban roads on the basis of sound engineering principles.

U. HANEBUTTE *et al*. studied computer model has been developed to simulate highway traffic for various degrees of automation with a high level of fidelity in regard to driver control and vehicle characteristics. The model simulates vehicle maneuvering in a multilane highway traffic system and allows the use of an Automated Intelligent Cruise Control. An Expert Driver Model of instrumented vehicles with an in-vehicle navigation unit has also been incorporated.

G. Riente de Andrade *et al*. concludes model for free-flow speed (*FFS*) estimation on Brazilian expressways. Using this model, *FFS* estimates are obtained from segment characteristics that can be easily and directly observed in the field: posted speed limit, bendiness, abutting land use, type of highway, number of lanes and access point density.

Slobodan Ognjenovic *et al*. obtained calibration coefficient yields satisfactory results in comparison with the non-calibrated model, with certain reserve regarding the scope of dissipation of the data on the predicted and measured time of crack initiation.

Vaiana R. *et al*. studied field measurements showed that there was no difference in crack initiation between the state highways and selected major urban streets. Thus, the obtained calibration coefficient can be used for the primary city network of Skopje as well as for the state highways.

Jianyou Zhao *et al*. The objectivity and accuracy of weight coefficient is ensured preferably by adopting analytic hierarchy process to select the evaluation indicators and establishing the comprehensive evaluation form of highway maintenance safety protection with AHP.

R. Shah *et al*. concluded from the literature that a reduction in highway maintenance budgets has led to a reduction in the outputs of the structural maintenance that is being carried out in the UK. Hence, highway departments have been forced to carry out more reactive maintenance rather than planned, preventative maintenance. This approach is not providing required benefits to the taxpayer with the best value for money.

3. Theoretical Aspect

This section presents the theoretical concept related to the subject of Paper as follows.

3.1 Application of HDM-4

There are four main characteristics for a HDM-4 including Project Analysis, Program Analysis, Strategic Analysis, and Research, Policy and Regulation Analysis.

Project Analysis

Project analysis allows the users to assess the physical, functional and economic feasibility of specified project alternatives by comparison against a base case (do nothing). The key issues are:

- **Pavement structural performance**: Pavement is generally designed to carry the load of traffic that runs over it. If the structure of the road is not strong enough to withstand the traffic loading then the road structure will fail. HDM has the analytical model that can calculate the structural strength of the pavement for the traffic running over it.
- **Life cycle prediction of deterioration, maintenance effects & costs:** For the particular traffic loading, HDM-4 is able to calculate the deterioration of the road structure and the surface for each year of the analysis period. If the user provides the maintenance option then HDM-4 can apply the maintenance, calculates the cost of maintenance and the effects thereof. For example, if the user gives the option that whenever the roughness will reach 6 IRI, an overlay has to be applied. In this case the HDM-4 will calculate the roughness increase every year due to traffic loading and whenever the roughness will reach 6 IRI, HDM-4 will apply an overlay. As an effect of this maintenance the roughness will be decreased to an extent as will be specified in the overlay option. HDM-4 will also calculate the cost of the overlay with the help of the rate supplied by the user.
- **Road user costs and benefits:** The road user costs consists of the Vehicle Operating Costs (VOC), the Travel Time Cost (TTC) and the Accident Cost (AC). If no maintenance is done (do nothing option) the road user costs will be high but if any maintenance is applied such as overlay (do something option), the road user costs will be reduced to a great extent. If the Road user costs of the above two options are compared then it will be seen that a benefit will be obtained by doing the maintenance.
- **Economic comparison of project alternatives:** For the maintenance of the road, the user might have various maintenance strategies. HDM can calculate the economic indicators like NPV, IRR etc for every option of the maintenance strategies for the projected analysis period. The most beneficial maintenance option will be one that gives the maximum economic return.

Program Analysis

The Programme analysis as it is termed, is the analysis for doing the yearly maintenance programme or for the multi-year rolling programme. The programme analysis tool has been incorporated in HDM-4 for easy analysis of the whole road network for identifying the candidate road sections for the maintenance for a particular budget period. For the constraint budget, the economic criteria for selecting the candidate road is the maxisation of NPV/Cost.

By doing the programme analysis one can get the following:

- Identify the candidate road sections for maintenance,
- Determine the alternative improvements,
- Optimisation of the programme in case of budget constraints,

- Obtain the optimised list of projects for the budget period.

Strategic Analysis

The strategic analysis has been carried out for the selected urban road network. The analysis is carried out to maximize the NPV or minimize the costs to achieve a desirable target IRI, which means the maximum IRI at or below which the network is to be kept. The project period has been considered to commence from the year 2014. The economic analysis has been carried out for a design period of 10 years considering a discount rate of 12%. The analysis has been done using the M&R standards same as that used for LCCA.

On analyzing the sections under strategy analysis to maximize the NPV, an unconstrained work program has been generated through HDM-4. Average IRI for urban road network under strategy analysis [5].

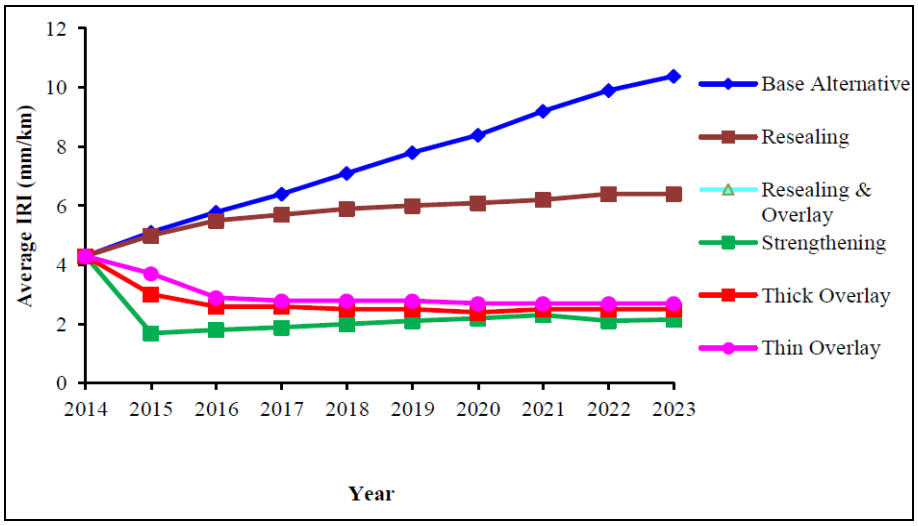

Fig 2: Average IRI for urban road network under strategy analysis [5].

Research, Policy and Regulation Analysis:

- Funding policies for competing needs; for example, Feeder roads versus main roads
- Road User charges for setting up road funds
- Impact of axle load limits
- Pavement design evaluation
- Pavement maintenance and rehabilitation standards

3.2 Priority of HDM-4 Software

The selection of the best maintenance alternative and forecasting the maintenance budget requirement for a selected road network depend on the criteria that a planner adopts. The planning criteria may be maximizing the NPV or keeping the average road network in an acceptable condition [5].

Nevertheless, more comprehensive analyses are necessary, within the period of at least 10 years as well as possible development of another model, which in fact is calibration of level 3 according to HDM [8].

4. Discussion and Conclusion

- The assessment of pavement surface performance evolution plays a key role in road pavement management and maintenance operations. Based on the abovementioned facts, this study focused on the analysis of the most important factors that affect texture deterioration such as aggregate and binder properties, road geometry and traffic [1].
- There are significant inefficiencies in the current decision process regarding investments to the road network. There are different methodologies on investment decision process (based on a location) but for the actual economic assessment of the project, it is the software tool HDM-4, which is most widely used. Thanks to its complexity and flexibility to include high number of factors and inputs we have found this tool as suitable and verified that in a case study [3].
- This software has integrated the essential information (traffic data, pavement unit costs, and pavement structures) from related database sources. The automated pavement structure selection and M&R sequence selection allow users to compare realistic pavement design alternatives [4].
- The selection of the best maintenance alternative and forecasting the maintenance budget requirement for a selected road network depend on the criteria that a planner adopts. The planning criteria may be maximizing the NPV or keeping the average road network in an acceptable condition [5].
- Field measurements showed that there was no difference in crack initiation between the state highways and selected major urban streets. Thus, the obtained calibration coefficient cia can be used for the primary city network of Skopje as well as for the state highways [8].

5. References

1. Vaiana R, Capiluppi GF, Gallelli V, Iuele T, Minani V, Pavement Surface Performances Evolution: an Experimental Application. http://www.sciencedirect.com/science/article/pii/S1877042812044266
2. Qiang Meng, Zhaoyang Lu. Quantitative analyses of highway franchising Under build-operate-transport scheme: Critical review and future research directions.

http://www.sciencedirect.com/science/article/pii/S0191261516302077
3. Radan Tomek Ing. MSc., Ing. Stanislav Vitásek, Improvement of economic effectiveness road highway projects. http://www.sciencedirect.com/science/article/pii/S1877705816339777
4. Changmo Kim, Eul-Bum Lee, John Harvey T, Amy Fong, Ray Lott. Automated Sequence Selection and Cost Calculation for Maintenance and Rehabilitation in Highway Life-Cycle Cost Analysis. http://www.sciencedirect.com/science/article/pii/S2046043016300594
5. Shah Yogesh U, Jain SS, Tiwari Devesh. Adaptation of HDM-4 Tool for Strategic Analysis of Urban Roads Network. http://www.sciencedirect.com/science/article/pii/S2352146516306767
6. Hanebutte U, Doss E, Ewing T, Tentner A. Simulation of Vehicle Traffic on an Automated Highway System. http://www.sciencedirect.com/science/article/pii/S0895717798000557
7. Gustavo Riente de Andrade, Cira Souza Pitombo, André Luiz Cunha, José Reynaldo Setti. A Model for Estimating Free-Flow Speed on Brazilian Expressways. http://www.sciencedirect.com/science/article/pii/S2352146516305610
8. Slobodan Ognjenovic, Zoran Krakutovski, Nikolai Vatin. Calibration of the Crack Initiation Model in HDM 4 on the Highways and Primary Urban Streets Network in Macedonia. http://www.sciencedirect.com/science/article/pii/S1877705815018688
9. Vaiana R, Capiluppi GF, Gallelli V, Iuele T, Minani V. Pavement Surface Performances Evolution: an Experimental Application. http://www.sciencedirect.com/science/article/pii/S1877042812044266
10. Jianyou Zhao, Xiaoyu Fu, Yunjiao Zhang. Research on Risk Assessment and Safety Management of Highway Maintenance Project. http://www.sciencedirect.com/science/article/pii/S1877705816003052
11. Raj Shah, Oliver McMann, Fiona Borthwick. Challenges and prospects of applying asset management principles to highway maintenance: A case study of the UK. http://www.sciencedirect.com/science/article/pii/S0965856641730023X
12. Hao Geng, LiangCai Cai, XiaoLei Chong, Bin Shao, HaiFu Wang. Research of highway runway clearance rules. http://www.sciencedirect.com/science/article/pii/S0965856416000513