A

Dissertation Report on

Economic Feasibility Analysis of Highway Projects Using Highway Development and Management (HDM-4) Model

Submitted

in partial fulfilment of the requirements for the degree of

Master of Technology

in

Civil-Construction Management

by

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Rajarambapu Institute of Technology, Rajaramnagar

(An Autonomous Institute, Affiliated to Shivaji University, Kolhapur)

2019-2020

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EIRR percentage for all case studies is ok but once compare all obtain results in HDM with our conventional method in excel. All other report is content wise ok.
Best luck!

With Regards,

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TO WHOMSOEVER IT MAY CONCERN

This is to certify that **Ms. Pratiksha Ramchandra Patil** a student from **Rajarambapu Institute of Technology, Rajaramnagar Islampur, Dist- Sangli** has successfully completed her project work on **"Economic Feasibility Analysis of Highway Project Using Highway Development and Management (HDM-4) Model"** under the guidance of **Mr. Vinod Yashwant Chougule** (General Manager- Planning & Design, Dhruv Consultancy Services Ltd., Navi Mumbai) for the period of 28th June 2019 to 28th June 2020 at the Head Office (Mumbai).

During the training period her conduct is found to be good and she has worked sincerely towards the tasks assigned to her.

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DECLARATION

I declare that this report reflects my thoughts about the subject in my own words. I have sufficiently cited and referenced the original sources, referred or considered in this work. I have not misrepresented or fabricated or falsified any idea/data/fact/source in this my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute.

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ACKNOWLEDGEMENTS

I would like to express a deep sense of gratitude towards my guide Prof. D. S. Patil, Department of Civil Engineering, RIT Islampur and my co-guide Mr. Vinod Chougule, General Manager, Dhruv Consultancy Services Ltd., Belapur, Navi Mumbai also my special thanks to Ms. Tanvi Dandawate, MD, Dhruv Consultancy Services Ltd. for providing this opportunity, valuable guidance and inspiration throughout the project work.

I would like to thank all my seniors at Dhruv Consultancy Services Ltd. for their co-operation and help in clarifying my doubts during my project work.

I am thankful to Civil engineering department and my parent institute RIT, Islampur for providing support. I am grateful towards all teaching and non-teaching staff of my college.

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ABSTRACT

A well-developed transportation system plays vital role in economic development of the country. The huge increase in vehicular population creates traffic congestions on city roads. Thus, to reduce traffic bottleneck, creation of new road infrastructure as well as improvement of existing one has long term economic and social benefits. The economic benefits are calibrated on the basis of Economic Internal Rate of Returns (EIRR). EIRR for the road project is calculated as the difference between the capital and road user costs with and without the project. The Mumbai and Pune are the major cities of Maharashtra state, due to economic and industrial development in those cities faces frequent and heavy traffic jam on highway connecting to both cities. In order to sort out the traffic problem, building up new alignment in ghat section and widening of existing roads is suggested. The HDM-4 is computer software used for checking the engineering and economic viability of the investment in this road project. This project work describes the adaptation of World Bank's highway development and management model HDM-4 at project level, this allows the users to assess the physical, functional and economic viability of specified project alternative by comparison against base case. It was observed that results obtained with improvement alternatives are economic viable but construction of new alignment shows significant socio economic benefits.

Keywords: Traffic congestions, Economic Internal Rate of Returns (EIRR), HDM-4 software, economic viability , Social benefits.

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Chapter 1

INTRODUCTION

1.1 General

This chapter presents an introduction of research to conduct on highway project economic analysis using HDM-4 software. In the first part brief introduction to need of infrastructure development also introduce best suitable economic eveluation tool that helps in decision making.

1.2 Relevance

Roads are the dominant mode of transportation in India. Roads carry almost 85 percent of the country's passenger traffic and more than 62 percent of its fright traffic. Due to improvement in transportation network, reduction in transportation costs can be realized in numerous ways, such as reduction in travel time, decrease in vehicle operating costs, increased safety and reduction in the level of air and noise pollution. In addition to reduction in transportation cost, it also increases comfort to passengers and also enhancing land value [1].

A well-connected transportation network ensures a faster and more reliable travel times. This is important as time spent in traffic jam resulted in wasteful expenditure on fuel, out of pocket expenses as well as time which could have been utilized in other productive activities. A high-quality road network is important for high level of economic performance. It helps in sustained economic growth, increases the productivity, helps in increment in regional development and increases competitiveness [2]. The infrastructure projects bring economic benefits in long-term by raising the productivity, innovation, lower prices, increases the income and overall creates more jobs thus bring more boom to the economy.

A well-plan transportation network helps the business to expand. It allows businesses to manage their inventories and transport goods more cheaply and efficiently as well as access a variety suppliers and markets for their products making it more cost-effective for manufacturers to keep productions in and out. Thus, the priority to reduce the infrastructure bottleneck is important for any government. This require creation of more and more road infrastructures and maintenance of the existing one.

The decision-making process for development of best suitable infrastructure strategy for highway section suffers from lack of customized economic evaluation tools. The Highway Development and Management (HDM–4) is one of the software, developed by the International Study of Highway Development and Management (ISOHDM) funded by World Bank, presents a good frame work for economic evaluation of road investments on improvements.

1.3 Outline of Project Report

The dissertation report is divided into following chapters. These chapter describes the different work conducted for study.

Chapter 1: This chapter is an introduction on transportation infrastructure development and general information about Highway Development and Management Tool (HDM–4) system.

Chapter 2: This chapter includes the review of all the previous literatures, the literature gap from each of the papers are also enlisted in the chapter. In this chapter motivation of study and objectives of project work is given.

Chapter 3: This chapter includes the methodology adopted and brief introduction to input parameters study which involved in process of economic analysis.

Chapter 4: This chapter includes overview of HDM-4 software along with their key areas of applications in highway sector. This chapter also include validation of HDM-4 software with RUCKS.

Chapter 5: This chapter includes details of each case study with input details of road network, vehicles characteristics, vehicles economic cost etc. also gives economic analysis results in tabulated form for all case studies.

Chapter 6: In this chapter discussion of results is carried out. Results shows economic performance of the proposed components by comparing the with-project and without project scenarios. Also, socio economic benefits of research work are explained through

socio economic cost comparison of all case studies.

Chapter 7: In this chapter conclusion of project work is given along with scope for further research.

1.4 Closure

This chapter describes the need of economic analysis for transportation projects and also give the brief information of Highway Development and Management (HDM-4) system followed by review of literatures on highway projects economic analysis in next chapter.

Chapter 2

LITERATURE SURVEY

2.1 General

The research mainly focuses on finding out best alternative strategies for road development projects. The proposed research includes the development of cost effective alternatives for project execution. Also Numerous research papers were selected to study the Highway Development and Maitenance Model (HDM-4) for economical analysis by researchers. From the research, objective function of model, input parameters used in research were studied. Some research was also performed on suggesting best economical alternative for stretch improvement using various maintenance strategies from EIRR obtain. Also, some researches consider social benefits from developments of road.

2.2 Review of Previous Studies

2.2.1 Pavan R. Vyas, et. al. (2016) "Project Level Analysis using Highway Development and Management Model (HDM-4): A Case Study"

The author states that HDM-4 is a support system for taking decision by highway administrators and engineers by predicting the economic, social and environmental impacts which might occur while making the investment decisions. This paper includes a case study of road section of a State Highway SH5 in Karnataka State.The decision-making process for selection of maintenance and rehabilitation strategy rehabilitation strategy for road section suffers from lack of customized economic evaluation tools. The Word Bank's Highway Development and Management Tool (HDM–4), developed by the International Study of Highway Development and Management (ISOHDM) funded by World

Bank, presents a good frame work for economic evaluation of road investments on maintenance.This study includes collection and analysis of functional condition and structural condition data of the road section under study. The previous maintenance and rehabilitation data, Traffic data, and other cost related data are obtained from secondary sources. Using the above data, a Project level analysis id carried out in HDM – 4 software form 10 years. The obtained results are analyzed and the final optimum strategy for each rad section is decided based on the economic indicators like IRR and Net Present Values/ Cost ratios.

2.2.2 Ing. Radan Tomek et al. (2016), "Improvement of Economic Effectiveness of road highway projects."

The author studied deficiencies in the current investment decision process to the highway network and with the major problems and in effectivities in the consecutive phase of realization. The approach of this research paper is to reveal the possibilities to improve effectivity of realization phase through proposal of the very concrete measures. This paper depicts the current road infrastructure situation in the Czech Republic, local state offices and agencies and uses local transport infrastructure data. The author analyses global experience and its findings aspire to be of general validity and applicability. The author concluded that evaluating competing bids on the basis of the investor's own flowless control budget and rejecting those bids of the abnormally low or high values by a pre-set strict rule. Also he concluded that the execution of own technical supervision i.e. none outsourcing being acceptable for this task.

2.2.3 B. Malsawmkima et al. (2015), "Impact of road construction on the socio- economic condition of the communities in the hilly terrain of Lunglei district, Mizoram, India."

Roads are the major means of transportation and communication. The author studied that the impact of roads and road construction on the socio-economic status of community directly within the project site. Author studied and analyzed pre- construction and post-construction conditions of the community through collection of various parameters. The study revealed that the construction of roads not only improves the livelihood community but also increases the number of educational institutions and health centers as well. Author concluded that the construction of proper road channels increases the efficiency of import and export of goods and services to a great extent. The increased in number of

educational institutions as a result of this project also improves the literacy of villagers [3].

2.2.4 Yi Jiang et al. (2015) " Economic Analysis of Highway Design Exception Project"

This paper describes the design exception projects to compare with the standard designed projects. An economic analysis method was developed to conduct benefit-cost evaluations for design exception highway projects. The method considers life-cycle-costs as well as life-cycle-benefits resulted from a proposed built project in terms of monetary values. In this paper, author estimated agency cost by engineers or designers based on past experience, bid prices, design specifications, materials costs, and other information. Travel time and delay costs are usually valued as a percentage of average personal wages. Accident or crash costs are the monetary values for fatalities and injuries associated with crashes. The vehicle operating costs are attributed to the changes in highway speeds, traffic congestion, pavement surface, and other conditions that affect vehicle fuel consumption and wear and tear. In this study, benefit-cost analysis method was used to evaluate the effectiveness of design exceptions [4].

2.2.5 Shah Yogesh U. et. al. (2014) "Adaptation of HDM-4 Tool for Strategic Analysis of Urban Roads Network"

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 analysis was carried out to maximize the net present value (NPV) and minimize the costs to achieve a desirable target international roughness index (IRI). Min areas of analysis in HDM-4 include Project analysis, Program analysis and Strategy analysis. Data collection for all pavement sections was aimed to meet the requirements of HDM-4 input system. The process of data collection was classified as Road Network Data, Vehicle Fleet Data and Maintenance and Rehabilitation Works History. This analysis presented the need for the optimal capital and recurrent maintenance required to maintain the urban road network in serviceable condition. It was found that the urban roads can be managed and maintained effectively using the strategy application of HDM-4 [5].

2.2.6 Jana Korytárováa et. al. (2014). "The Economic Evaluation of Megaprojects-Social and Economic Impacts"

This paper describes the impact of transport infrastructure projects in the form of changes in the time consumption, changes in operation costs for vehicles, social costs connected with car accidents and newly impacts on environment. Project economic evaluation was done using HMD-4 Model by taking case study of Czech Republic, concerns about big city bypass including spinal road and several supplementary roads and economic analysis is carried out with the comparison of the base case (zero option) and project case (investment option) in the discounted total costs connected with the project. Results are given by comparing percentage output of base case and project case of costs of investor, vehicle operation costs, travel time costs, costs for car accidents, costs for pollution of environment and on results basis socio economic impacts are explained [6].

2.2.7 Ross B. Corotis (2007), "Highway User Travel Time Evaluation"

In this paper the improved highway network is how to benefit to society is studied of which the reduction of travel time is one of the most important. A full life cycle of cost assessment of project requires a future savings in travel time projected over a project's life time. The author has investigated an alternative approach to the very important valuation of user time which is beneficial for the new projects and cost items during construction and maintenance. Author hypothesized in this paper that the amount of work time remains relatively independent of commuting time and instead of amount of time left for other activities is directly affected. Author discussed some issues in this paper include regional differences and discounting. This paper suggests that the lifestyle actions taken by individuals differ greatly under those different circumstances. The value of user travel time is a very important aspect of transportation project and must be included [7].

2.2.8 Henry Kerali (2003), "Economic appraisal of road projects in countries with developing and transition economies"

This paper describes about economic appraisal model based on the concept of life-cycle cost analysis, in which the annual costs of construction and maintenance of one or more road investment alternatives are compared against a base case (without project) alternative in order to estimate the corresponding reduction in vehicle operation costs. This

paper uses HDM-4 tool for the purpose of analysis and outputs are shown in terms of net present value (NPV). The results from the economic appraisal of road projects in developing and transition economies often show that benefits to be derived from investments in improvement of existing roads far exceed those from construction of new roads. The models also show that where there is significant traffic congestion, investments in capacity expansion can produce high economic returns [8].

2.3 Gap Analysis

The present researches consider conventional method for project analysis of alternative project routes. But new special softwares are developed which specially made for economic analysis and can provide more accurate results. Also, by considering future traffic growth, there is need to develop highways for carrying traffic. Modification and implementation of alternative options can be useful for controlling the heavy traffic demand on major transportation routes. These proposed alternatives must be economically viable and also achieves social benefits.

2.4 Objectives

Following are the objectives of the proposed work,

1. To choose the economic parameters for economic analysis of highway projects.
2. To perform traffic analysis for application on Highway Development and Management (HDM-4) software.
3. To analyze economic viability of proposed alternatives in terms of economic internal rates of return by HDM-4 software.
4. To perform comparative analysis and show socio-economic benefits of proposed alternatives from results obtain.

2.5 Closure

In this chapter different researches on economic analysis of trasportation projects using HDM-4 software are studied. These research work gives the knowladge of calculation of EIRR, precise use of HDM-4 model, inputs needed to HDM tool and social implications

of highway projects. Also find out the gap and objective are derived from the perspective of comparing economic alternatives form suggested standards.

Chapter 3

PARAMETRIC STUDY

3.1 General

The chapter explain the problem statement and proposed methodology of research which depict the steps that were performed in this research. This chapter includes the defination of economic analysis perform in this research. Explains details about input parameters required for economic analysis. Also the chapter includes the study of model used for economic analysis of highway project.

3.2 Problem Statement

The most important aspect which effects on highway construction is economical returns of project. The project aims to study economic benefits from the investment. Also help in raising the welfare of society. So, this project aims to use suitable strategy for economic analysis using HDM-4 software and states the social benefits from project.

3.3 Proposed Methodology

The procedure used in the project is divided into four steps. First step is to identify problem and collect the data for research work. Problem identification and data collection is done and move to second step is to decide case study for project work and finding out alternatives. Third step is to find out input to economic analysis and run the all datasetup in HDM-4. IN forth step find out the results and draw the conclusion and diagramatic presentation of methodology adopted for research work is shown in Figure no. 3.1

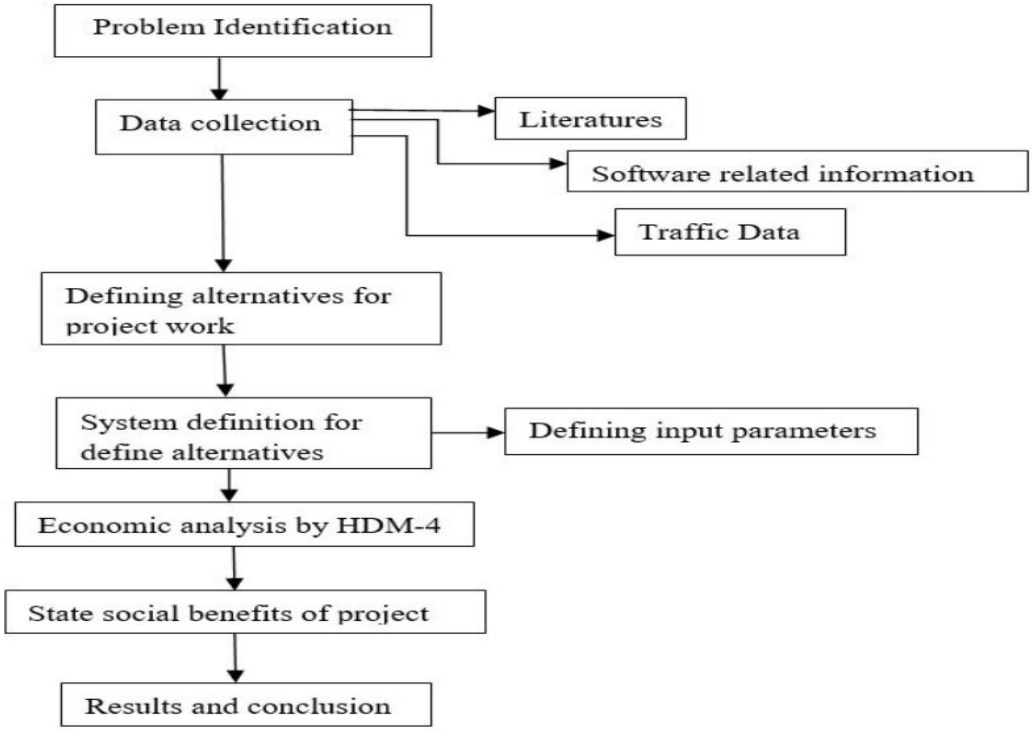


Figure 3.1: Methodology adopted in project work

3.4 HDM-IV Overview

HDM-IV 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 [12].

Areas of Application of HDM-IV Software

- **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 project analysis can done for maintenance of existing road, improvement of existing road, new construction, stage construction and project evaluation.

- **Program Analysis**

The program 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.

- **Strategic Analysis**

The strategic analysis is done on the entire road network for long term budget planning or for optimizing the maintenance strategies.

• **Research, Policy and Regulation Analysis**

HDM may also be used for research purposes such as Road User charges for setting up road funds, Impact of axle load limits, Pavement design evaluation, Pavement maintenance and rehabilitation standards.

3.5 Steps for Data Inputs for Economic Analysis in HDM-4

The steps for data inputs for Economic Analysis in HDM-4 are shown like as, HDM-4 workspace window in Figure no. 3.2, Road network data inputs in Figure no. 3.3, Vehicle fleet basic characteristics input in Figure no. 3.4, Vehicle fleet economic cost input in Figure no. 3.5, Maintenance work standard details in Figure no. 3.6, Improvement work standard details in Figure no. 3.7, General project description in Figure no. 3.8, Select road section in Figure no. 3.9, Select vehicles in Figure no. 3.10, Define traffic composition with annual increase in Figure no. 3.11, Define alternatives and assign work standards in Figure no. 3.12, Setup run inputs in Figure no. 3.13, Analyse the current project in Figure no. 3.14, Reports directory in Figure no. 3.15, Roughness output in Figure no. 3.16, Road work summary output in Figure no. 3.17.

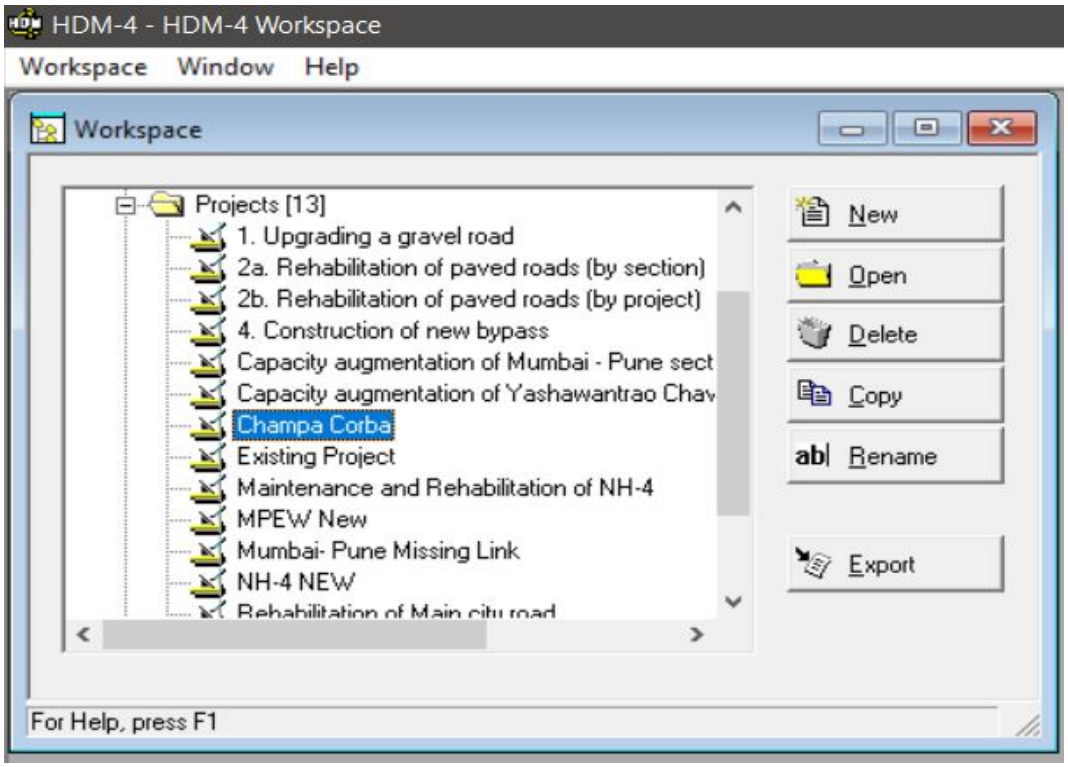


Figure 3.2: HDM-4 workspace window

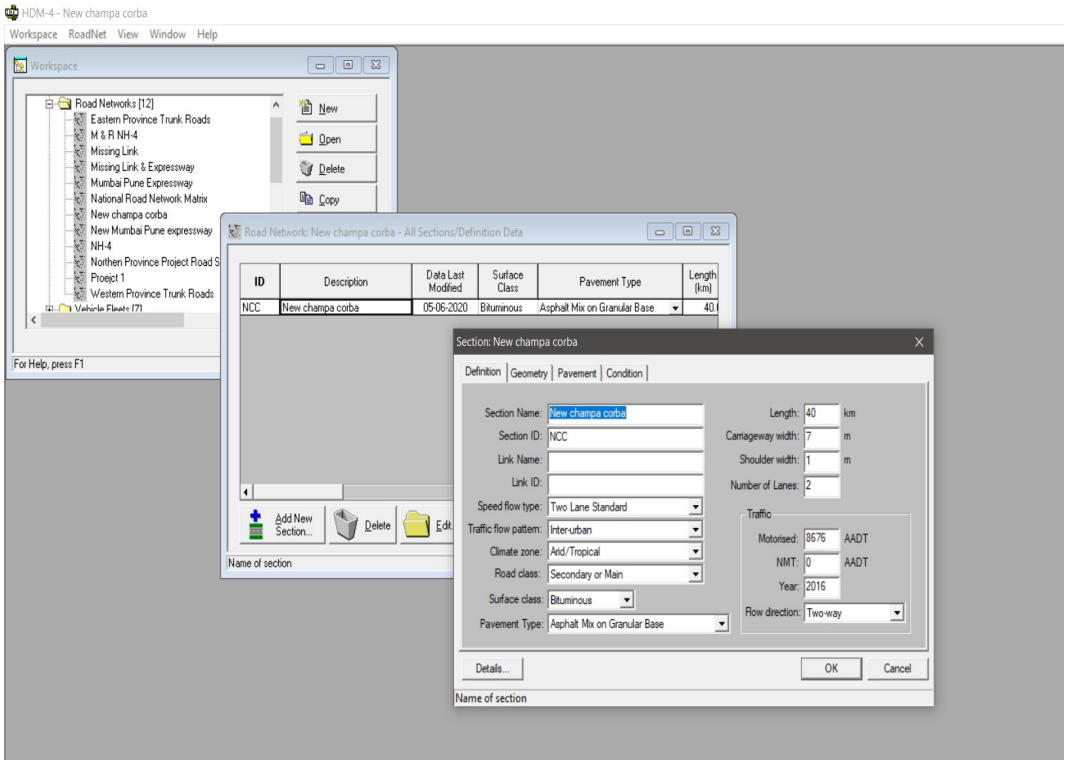


Figure 3.3: Road network data inputs

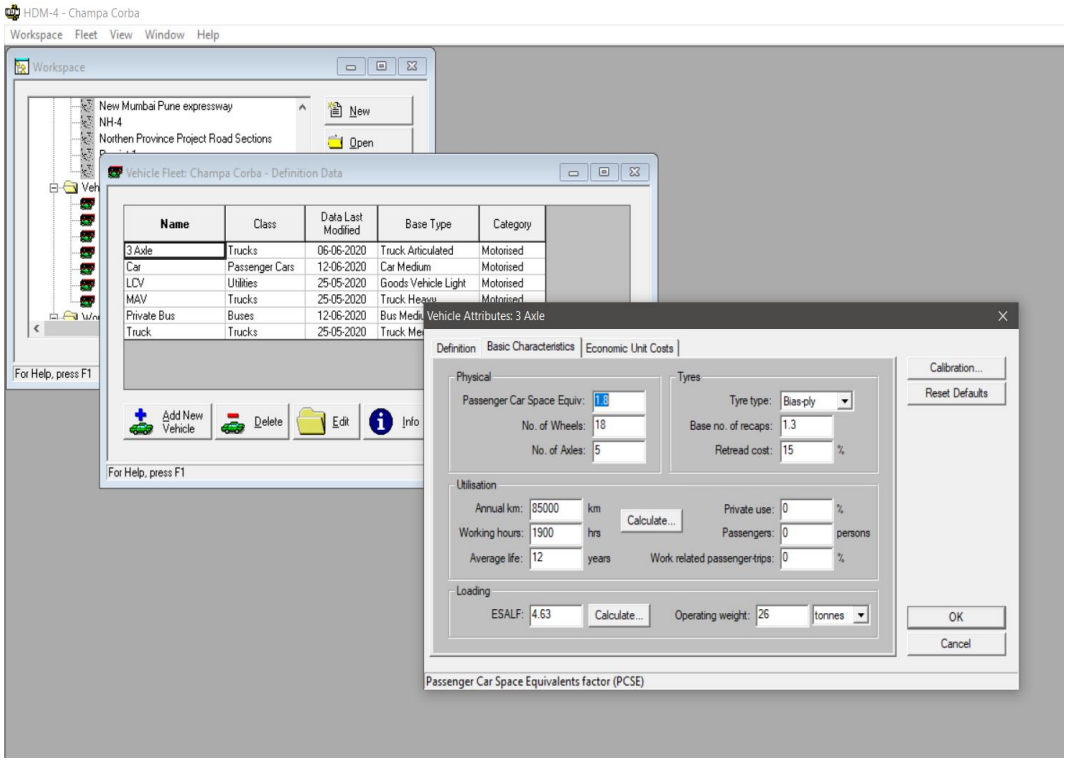


Figure 3.4: Vehicle fleet basic characteristics input

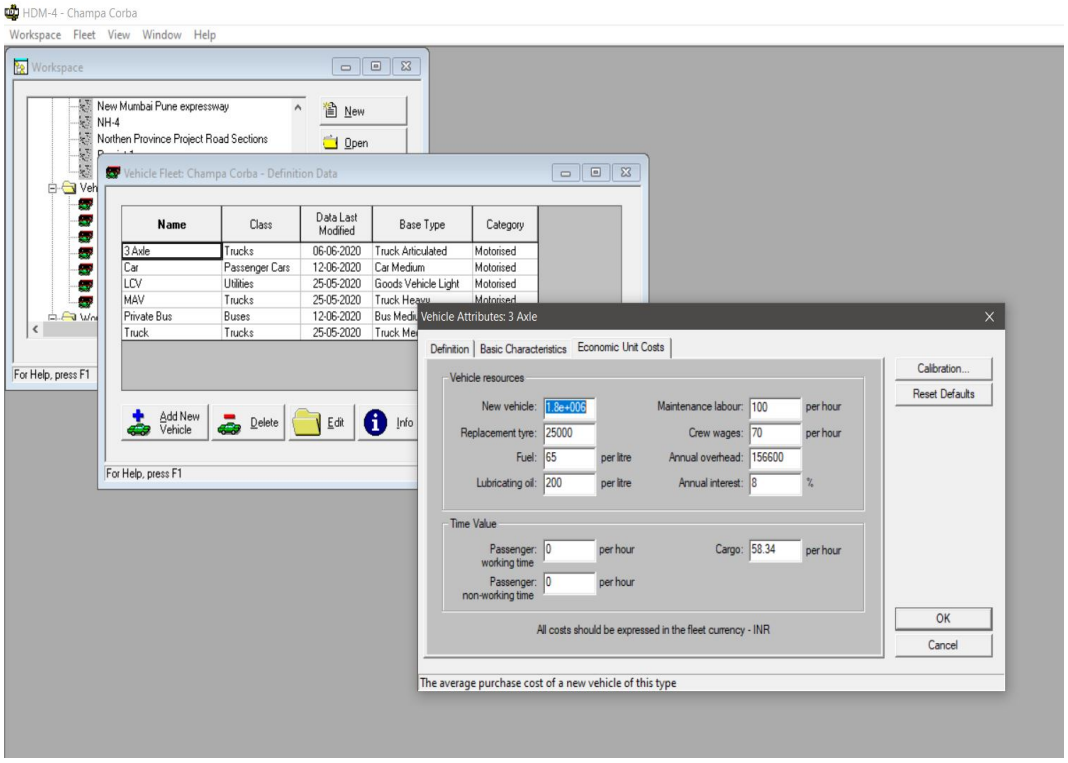


Figure 3.5: Vehicle fleet economic cost input

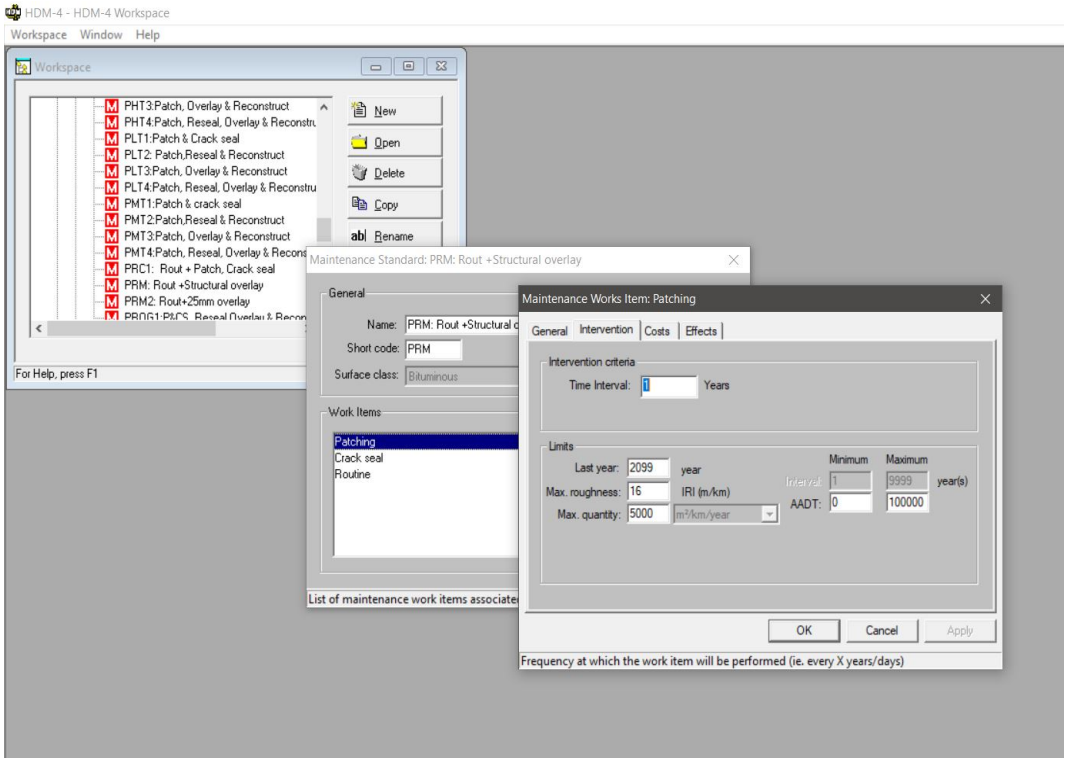


Figure 3.6: Maintenance work standard details

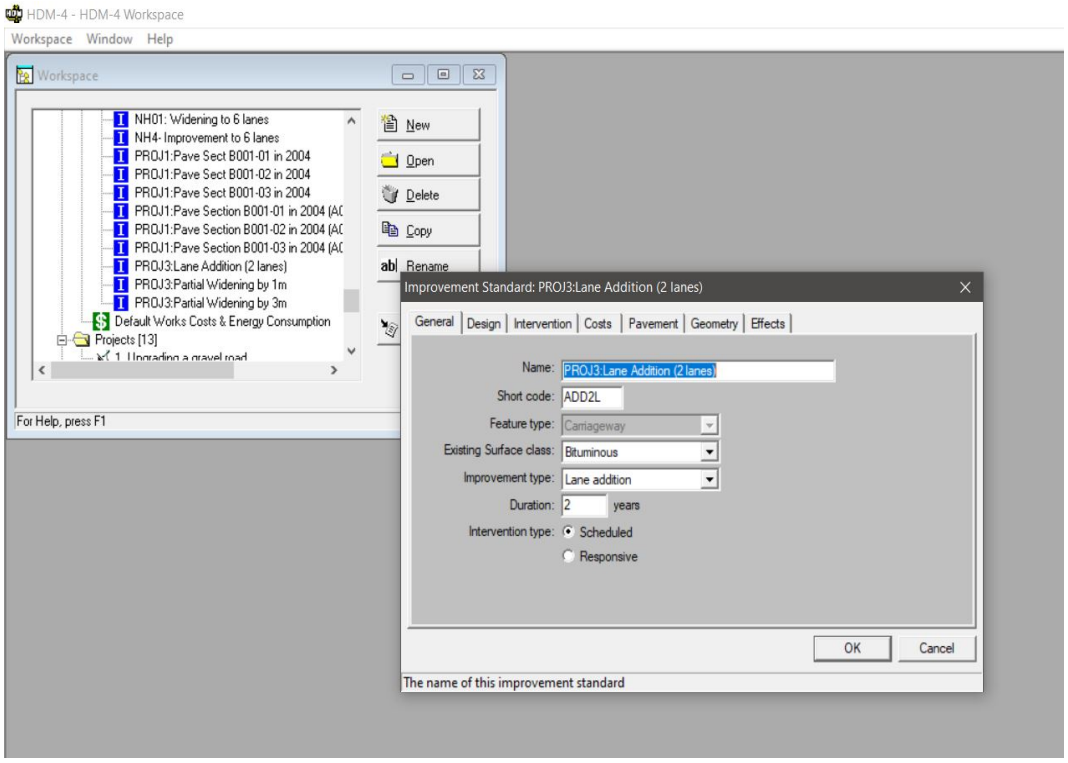


Figure 3.7: Improvement work standard details

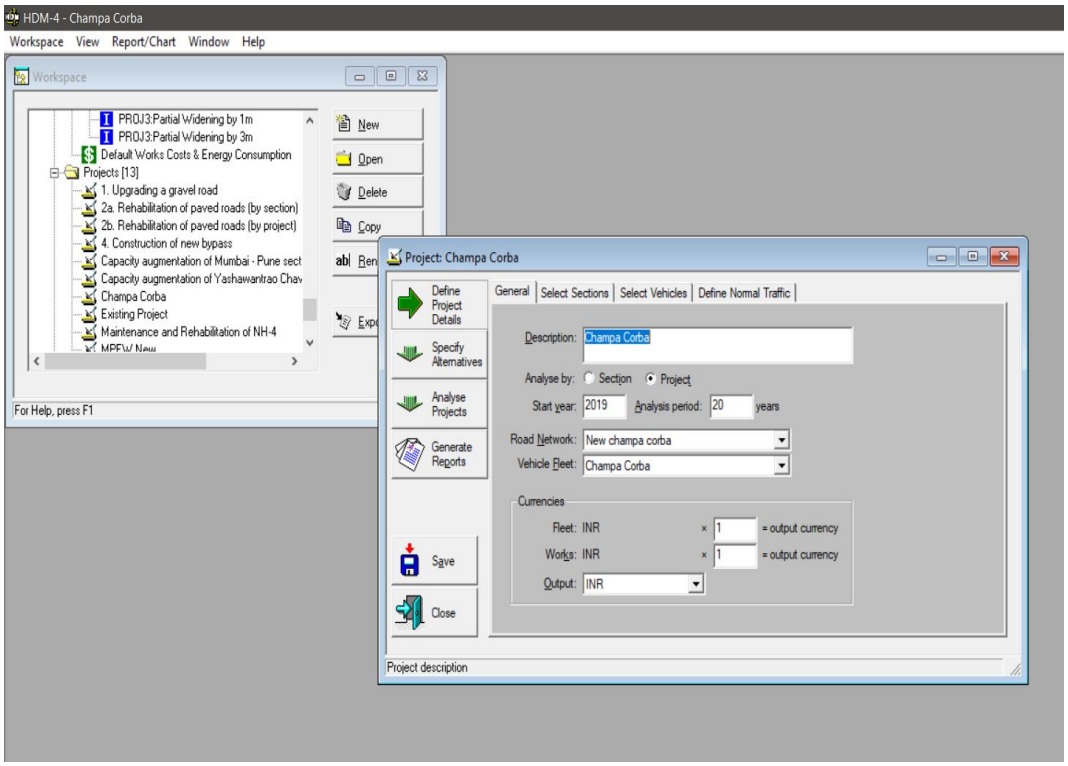


Figure 3.8: General project description

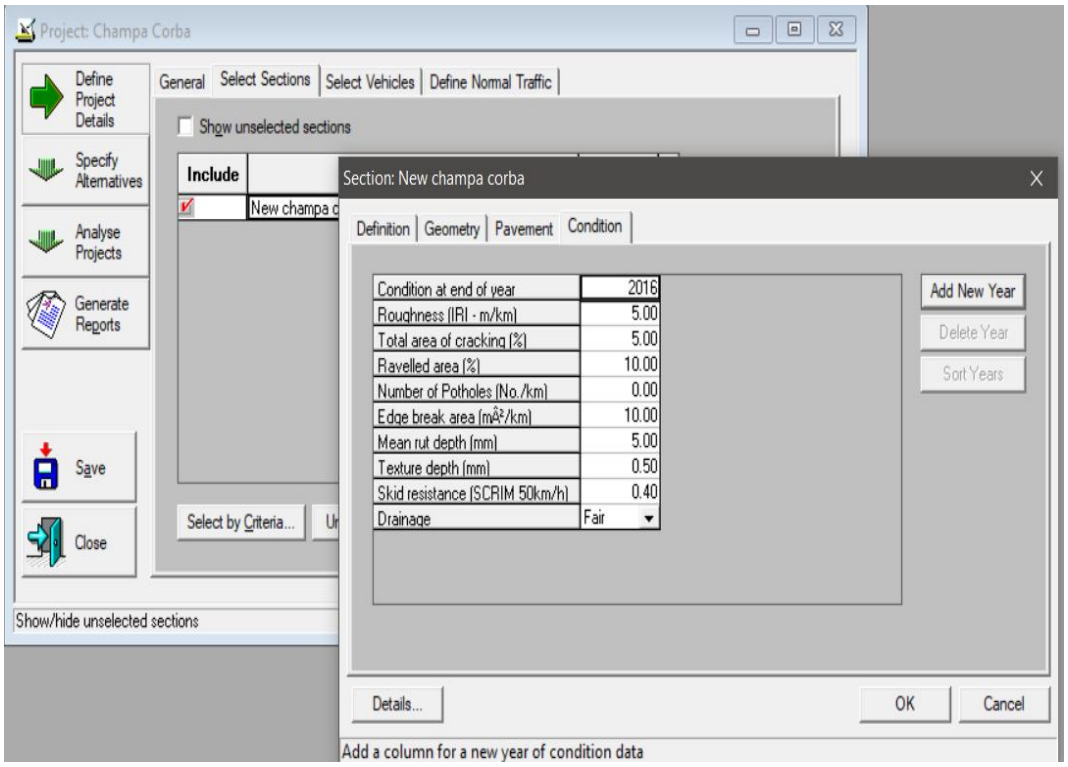


Figure 3.9: Select road section

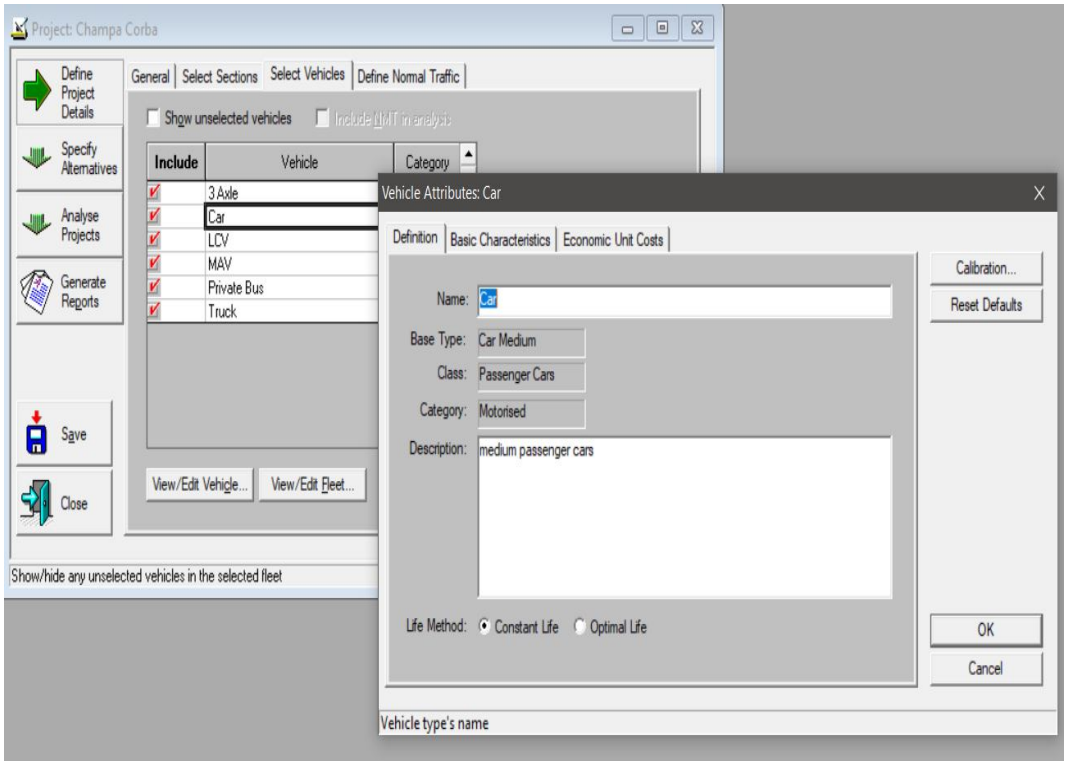


Figure 3.10: Select vehicles

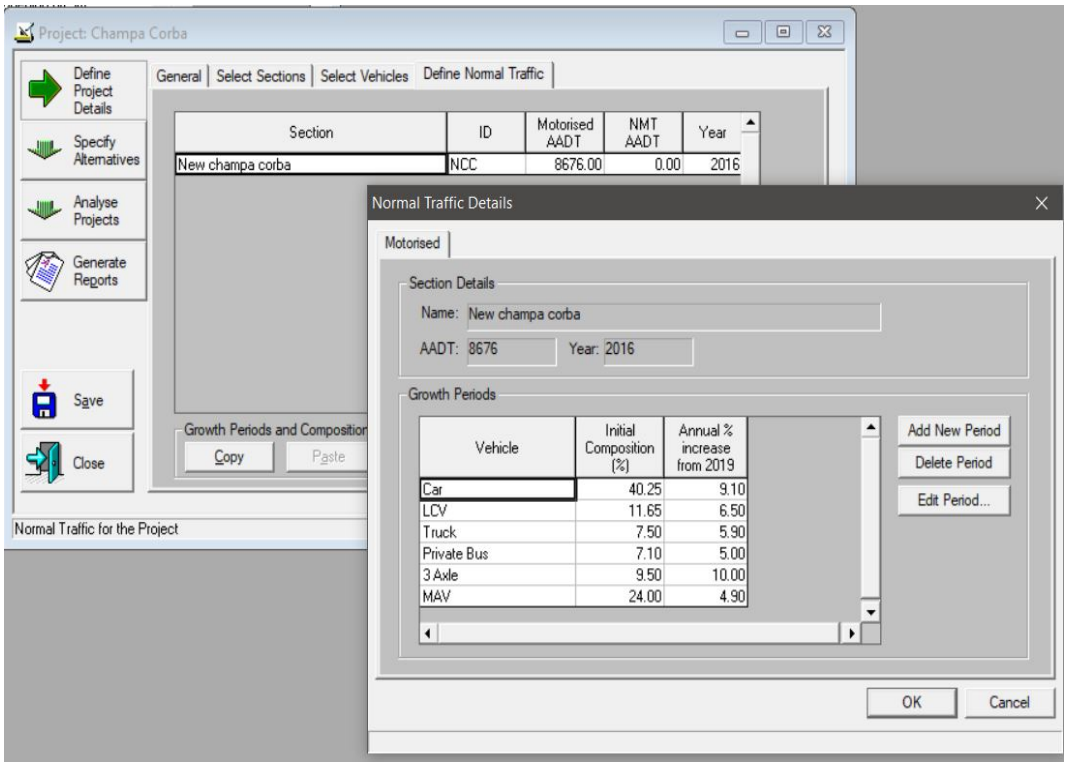


Figure 3.11: Define traffic composition with annual increase

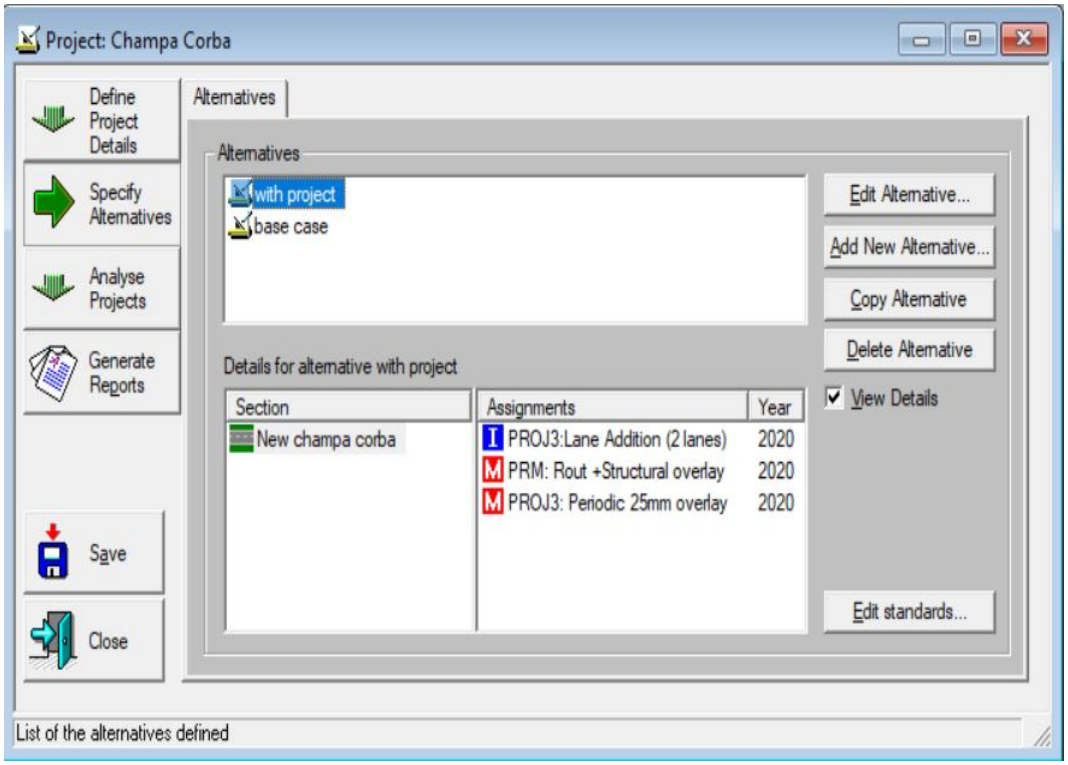


Figure 3.12: Define alternatives and assign work standards

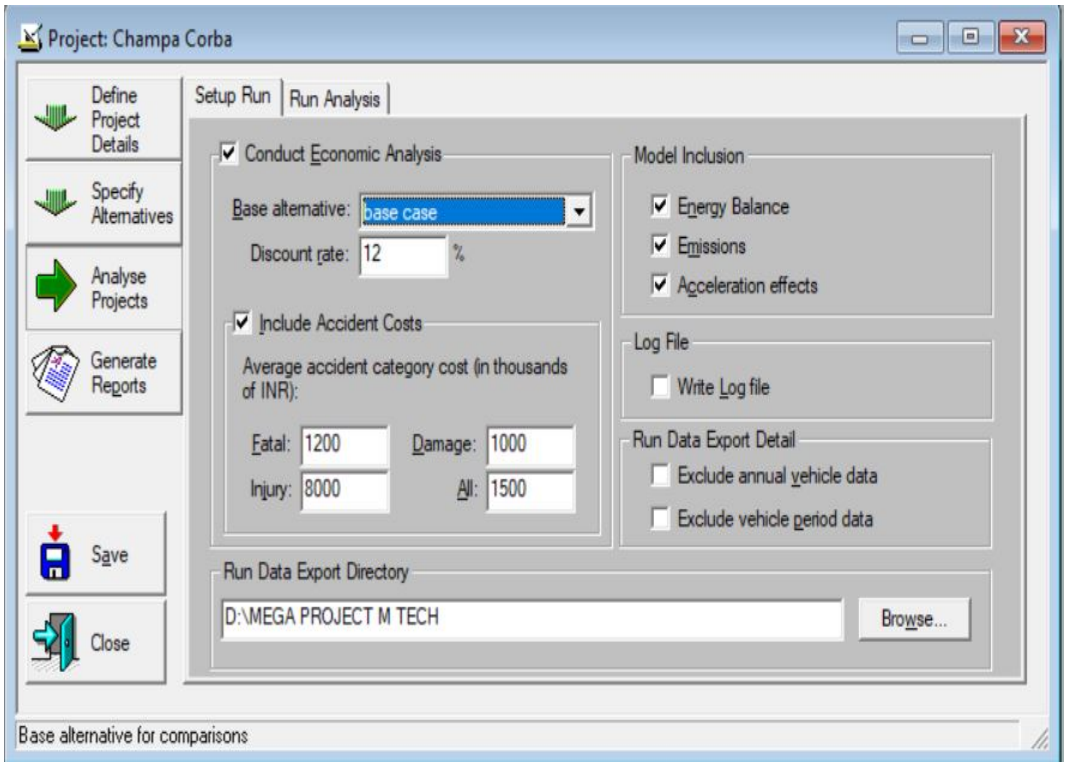


Figure 3.13: Setup run inputs

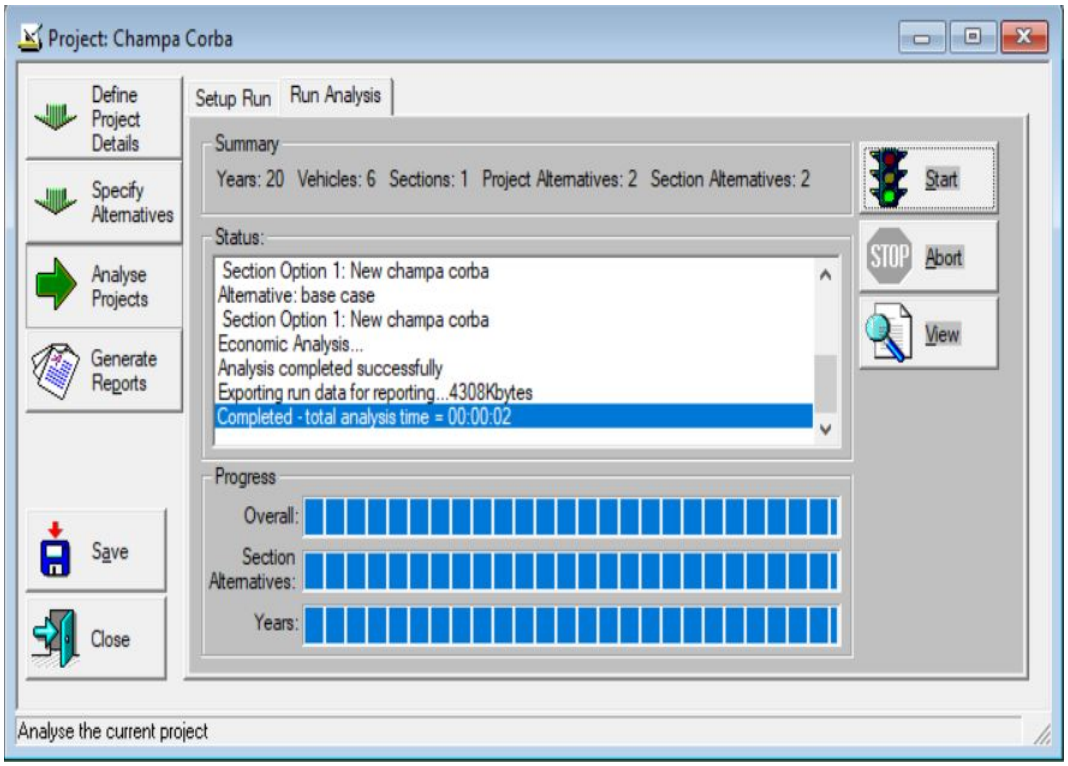


Figure 3.14: Analyse the current project

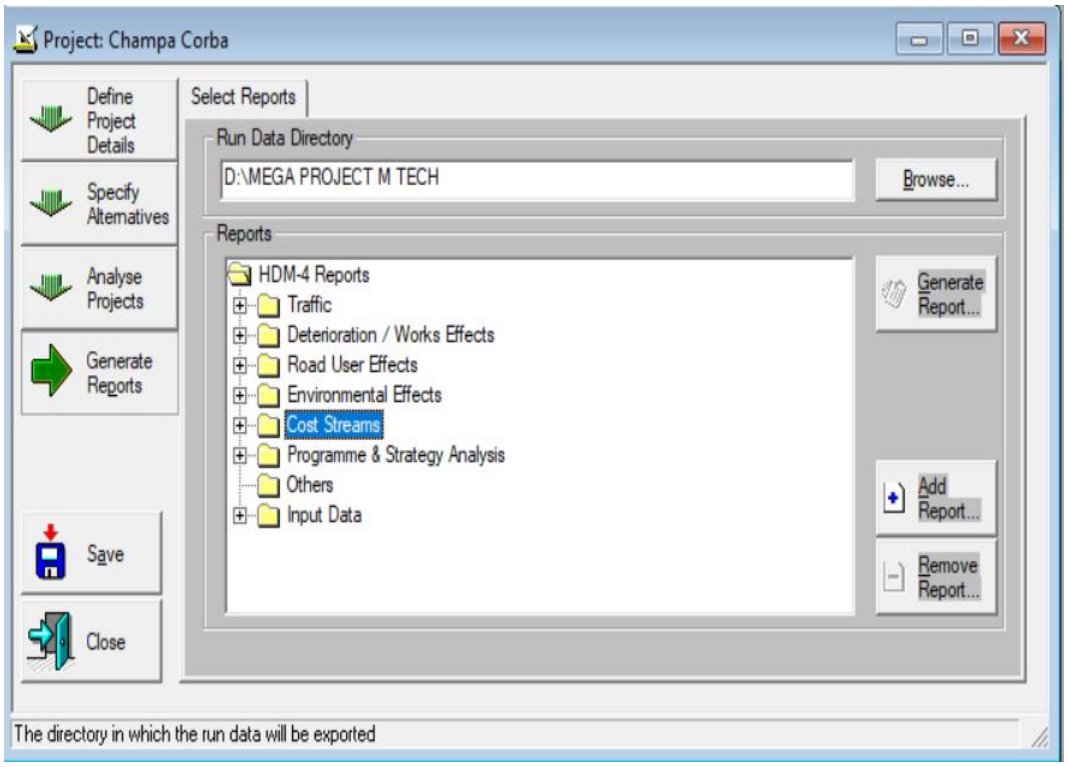


Figure 3.15: Reports directory

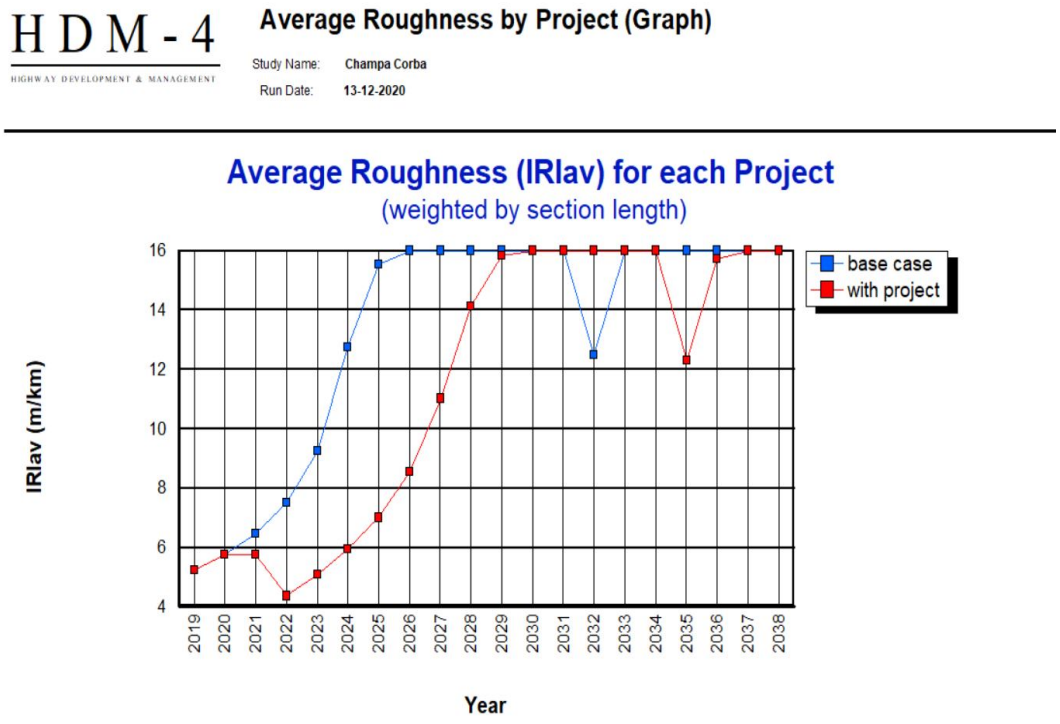


Figure 3.16: Roughness output

HDM - 4
HIGHWAY DEVELOPMENT & MANAGEMENT

Road Works Summary (by Year)

Study Name: Champa Corba
Run Date: 13-12-2020

All costs are expressed in the following currency: INR.

base case

Year	Section	Works Description	Code	Economic Cost	Financial Cost	Work Quantity
2031	New champa corba	25mm overlay	TV25	166,600,000.0	196,000,000.0	280,000.00 sq. m
		Prep. Patching		20,092.7	23,638.5	47.28 sq. m
		Prep. Edge Repair		630,000.0	737,100.0	1,260.00 sq. m
Total Annual Cost:				167,250,092.7	196,760,738.5	
Total Costs for Alternative:				167,250,092.7	196,760,738.5	

with project

Year	Section	Works Description	Code	Economic Cost	Financial Cost	Work Quantity
2020	New champa corba	PROJ3:Lane Addition (2 lanes)	ADD2L	4,524,000,256.0	4,934,000,128.0	280,000.00 sq. m
Total Annual Cost:				4,524,000,256.0	4,934,000,128.0	
2021	New champa corba	Prep. Edge Repair		1,280,794.8	1,498,529.9	2,561.59 sq. m
		Prep. Patching		59,600,016.0	70,117,664.0	140,235.33 sq. m
		PROJ3:Lane Addition (2 lanes)	ADD2L	4,524,000,256.0	4,934,000,128.0	280,000.00 sq. m
Total Annual Cost:				4,584,881,066.8	5,005,616,321.9	
2034	New champa corba	25mm overlay	TV25	333,200,000.0	392,000,000.0	560,000.00 sq. m
Total Annual Cost:				333,200,000.0	392,000,000.0	
Total Costs for Alternative:				9,442,081,322.8	10,331,616,449.9	

Summary of Total Annual Costs

	base case	with project
2020	0.00	4,524,000,256.00
2021	0.00	4,584,881,066.75
2031	167,250,092.72	0.00
2034	0.00	333,200,000.00
Total	167,250,092.72	9,442,081,322.75

Figure 3.17: Road work summary output

3.6 Economic Analysis

3.6.1 Intrduction

Economic analysis aims to ensure that scarce resources are allocated efficiently, and investment brings benefits to a country and raises the welfare of its citizens. The essential objective of public expenditure is to maximize the returns on investment in economic terms. This objective is accomplished by determining the appropriate improvement proposal that leads to the minimum total transport costs in the case of road upgradation projects.

The economic analysis is based on incremental costs and incremental benefits, i.e. comparing the total transport cost "with the project" and "without the project" which is the base case or the do minimum case. Economic analysis is not concerned with the sources of financing, the availability of funds and the collection of funds. Economic analysis is not concerned about should estimate future traffic, costs and benefits.

The benefits obtain from highway projects are depends on i) reduction in Vehicle Oper-

ating Cost (VOC) ii) reduction in travel time cost iii) reduction in accident cost. The results are expressed in terms of Economic Internal Rate of Return (EIRR) and Net Present Value (NPV).

• **Socio Economic Benefits**

(i) Vehicle Operating Cost (VOC) – VOC depends on the fuel consumption cost, wear and tear of tyres and other maintenance costs.

(ii) Travel Time Cost - It is depend on the occupants travel time.

(iii) Accident Cost – The component of accident cost may include cost of damages to vehicle and other properties, injuries and loss of human life, delays to vehicle and passengers, cost of investigation, legal proceedings etc.

3.7 Basis of Economic Analysis

The most commonly used indicators to determine economic viability are economic net present value (ENPV) and economic internal rate of return (EIRR).

1) Economic Net Present Value (ENPV)

The ENPV is the sum of the differences between the discounted benefit and cost flows, and can be estimated as

$$\text{ENPV} = \sum_{t=1}^{n} \frac{(B_t - C_t)}{(1+r)^t}$$

Where, Bt - the gross economic benefit in year t,

Ct - the sum of economic costs (including capital costs, operating maintenance costs, and negative terminal values) in year t

r - the required economic discount rate

n - the project life

2) Economic Internal Rate Of Return (EIRR)

The EIRR is the discount rate at which the ENPV becomes zero, and it can be estimated from the following:

$$\sum_{t=1}^{n} \frac{B_t}{(1+r)^t} - \sum_{t=1}^{n} \frac{C_t}{(1+r)^t} = 0$$

Where, r is the EIRR, at which, the sum of the discounted stream of economic benefits equals that of the economic costs of a project.
The economic analysis carried out using HDM-IV software. The HDM-IV system helps pavement managers in making effective investment choice at all management level i.e. at project level management and network level management.

3.8 Input Parameters for Economic Analysis

The following are the parameters required for the economic analysis of highway project.

3.8.1 Analysis Period

Analysis period includes construction period as well as benefit period.

3.8.2 Project Cost

Construction cost for economic analysis includes Land Acquisition, Resettlement & Rehabilitation, environment and utility shifting cost along with civil construction cost.

3.8.3 Road and Pavement Characteristics

Road and pavement characteristics that are used for economic analysis include road length, carriageway width, width of paved shoulders, existing pavement composition, sub-grade CBR, roughness of the existing road (IRI), structural number and cracking, raveling and other pavement distress parameters.

3.8.4 Routine and Periodic Maintenance Cost

Maintenance cost rates considered in Per Sq.m, which includes patching, crack sealing, edge repair, overlay, drainage clearance and markings and installation of damage traffic sign boards etc.

3.8.5 Traffic Volume Data

AADT (No. of Vehicles) on the project road includes motorized and non-motorized vehicles [9].
The vehicles are grouped under following heads are shown in Table no.3.1

Table 3.1: Vehicle Types

Details		**Vehicle Category**
Motorized Vehicles	Passenger Vehicles	Car, Jeep & Van
		2- Wheelers
		3- Wheelers
		Minibus
		Standard Bus
	Freight Vehicles	LCV
		2-Axle Truck
		3-Axle Truck
		4-6 Axle
		Tractor
		Tractor Trailer
Non-Motorized Vehicles	Slow Moving Vehicles	By-Cycle
		Cycle Rickshaw
		Animal / Hand Cart

3.8.6 Secondary Data

- Vehicles & Tyre prices
- Current Fuel price in the Project Corridor
  - o Petrol (Rs/Ltr)
  - o Diesel (Rs/Ltr)
  - o Lubricants (Rs/Ltr)

3.9 Closure

The chapter explains about input parameters used for any economic analysis of highway projects, same parameters being to use as input data for software. Also this chapter explains the key areas for application of HDM-4 system.

Chapter 4

VALIDATION OF HIGHWAY DEVELOPMENT AND MANAGEMENT MODEL (HDM-4)

4.1 General

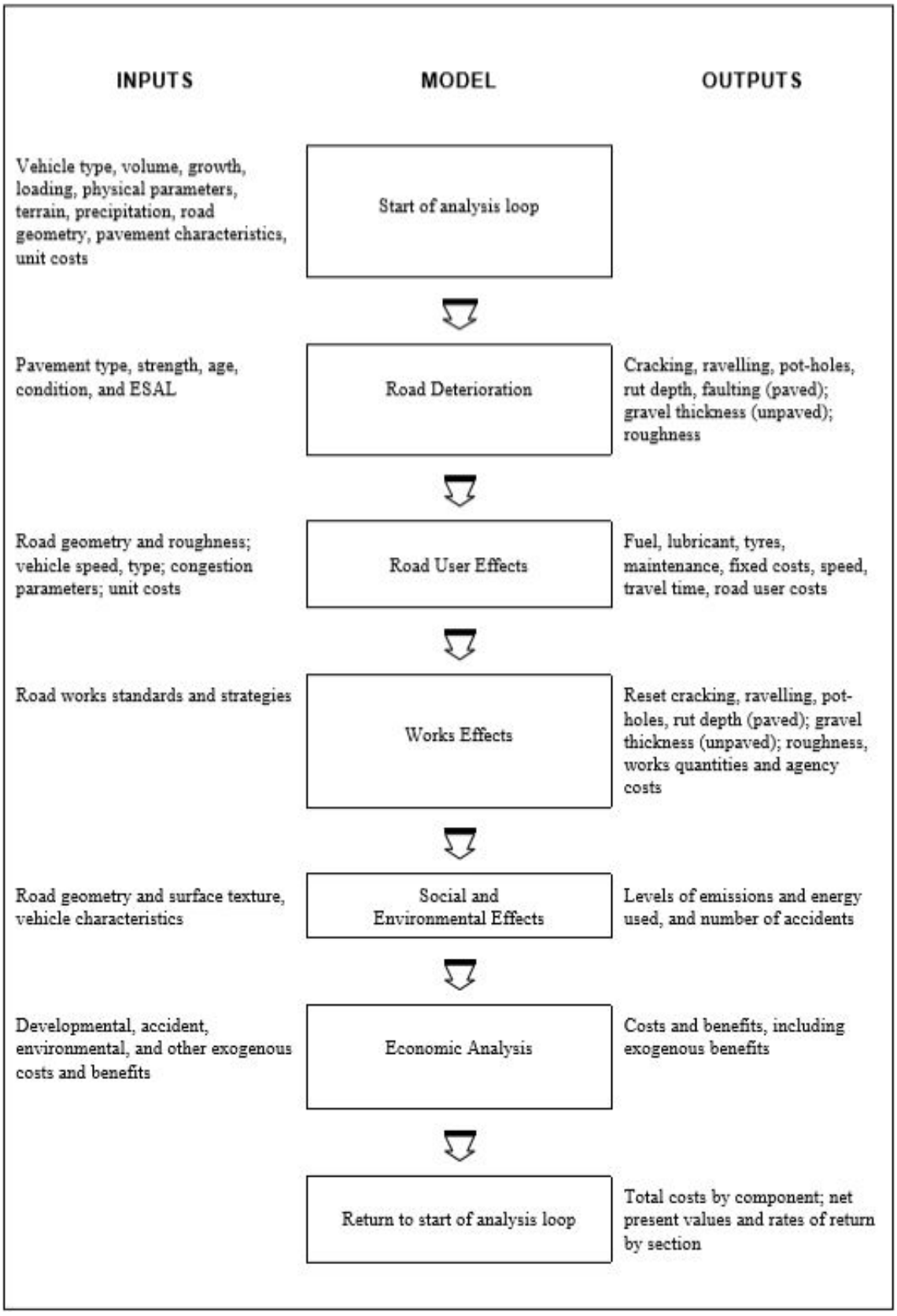
This chapter reports the importance and applications of HDM-4 and also explains the results of study done on validation of HDM-4 for conducting economic analysis.

4.2 Economic Analysis using Software

There are a number of software's available for the economic analysis of road projects including MicroBENCOST, Cal B/C, Redbook, RED, HDM-III, HDM-4, RUCKS etc [10].

The HDM-4 now provides a set of tools which can be integrated either individually or as a set within road management systems used by road agencies [11]. The modular system design adopted for HDM-4 should facilitate the adoption of HDM-4 as the standard tool for project analysis, work programming and long-term strategic analysis of road network requirements which is shortly presented in Figure 4.1 below.

The Highway Development and Management Model (HDM-4) Version 1.3 was released in January 2002 which is the recommended software for evaluating highway investment options.



1.jpg

Figure 4.1: Structure of HDM model

4.3 Validation of HDM-4

For the validation, Road User Cost (RUC) model being calibrate in HDM-4 and excel based data sheet i.e. Road User Cost Knowledge System (RUCKS) is used. RUCKS is an excel format system available which uses the "Macros" application in Microsoft Excel.

4.3.1 Inputs to RUCKS

The inputs needed for RUCKS are the same as HDM-4, but much lesser. In RUCKS, there are 12 vehicle types already assigned with default values. This does not include the non-motorized vehicle types and so the non-motorized traffic interaction effects are not included in RUCKS. Hence there is much lesser accuracy for the values obtained from RUCKS than HDM-4. However, a comparison can be done for the purpose of validation.

4.3.2 Case Study

A real case study has been considered. The project road comprises Widening and Rehabilitation of existing four lane to six lane road Champa-Korba-Katghora Section of NH-149B is although homogeneous and thus the project analysis is treated as a single section and average classified traffic is taken into consideration.

4.3.3 Data Collection

The project stretch being selected for the present study is a part of an important section of National Highway of Chhattisgarh. The project stretch has a length of about 40km and average carriage way width of 7 m.

A huge number of inputs are needed for analysis in software. Data collection includes primary data and secondary data.

1. Primary data

Primary data includes the classified volume count survey and pavement condition survey was collected for the project stretch.

• Traffic Data

Table no. 4.1 represents base year AADT count data.

2. Secondary data

The inputs needed in HDM-4 are enormous and for each representative vehicle the basic data like the following were collected from secondary sources:

Table 4.1: AADT count data

Vehicle Category	**AADT Count**
Car/ Jeep	21002
LCV	4428
Truck	3147
Private Bus	1780
3-Axle	2137
MAV	1481

1. Analysis period

   The analysis period starts from 2019. A discount rate of 12% is considered.

2. Routine Maintenance strategy is Considered that 100% patching, crack sealing edge repair, drainage clearance and markings, traffic signs gets complete.

3. Existing pavement condition data

   Existing Road Condition is fair, but 100% reconstruction is proposed on along the existing road.

   - RG in IRI (M/Km)
   - Total area of cracking (%)
   - Ravelled area (%)
   - No.of potholes / km (0.1 sqm area of pot holes)
   - Edge break area (sqm/km)
   - Mean rut depth

4. Other road details

   - RF – 10.00m/km
   - Altitude (m) 252 to 296
   - Average Horizontal Curvature – 3.00deg./km
   - Structural Number/CBR/Deflection : 50 nos of Structure/15% CBR

5. Pavement Design

   - Most recent surface thickness (mm): varies from 365mm to 480mm
   - Previous surface thickness (mm): varies from 365mm to 480mm
   - Proposed thickness (mm): 500mm

6. Economic prices

   Economic prices includes fuel, lubricant, tyre, maintenance cost, passenger time cost, crew cost, cargo time costs etc.

4.3.4 Comparison of Results

Road User Costs is an important consideration in the justification of highway investments, comparison of alternative designs, projects and programs ordering within limited budget and analysis of policy and regulation. The determination of road user cost is a key element in evaluating the highway projects [13]. For the purpose of validation, the road user costs obtained from both RUCKS and HDM-4 can be compared. Road User Cost is the combined value of Vehicle Operating Costs (VOC) and Travel Time Costs (TTC). So, comparing RUC is similar to comparing VOC or TTC. However, for decreasing the chances of error in prediction, Vehicle Operating Costs can be compared as it includes much more variables than Travel Time Cost. Thus, for the present study VOC of both the systems are compared.

Vehicle Operating Cost Values from HDM-4 and RUCKS are shown in Table 4.2 and Figure 4.2 below.

Table 4.2: VOC values for HDM-4 and RUCKS with variation

Vehicle Type	**HDM-4**	**RUCKS**	**Variation in values**
Passenger Car	4.4	4.48	-2%
LCV	11.01	11.65	-5%
Truck	25.9	27.35	-5%
3-axle	52.8	49.59	6%
Private Bus	18.06	30.29	-40%
MAV	42.59	45.58	-7%

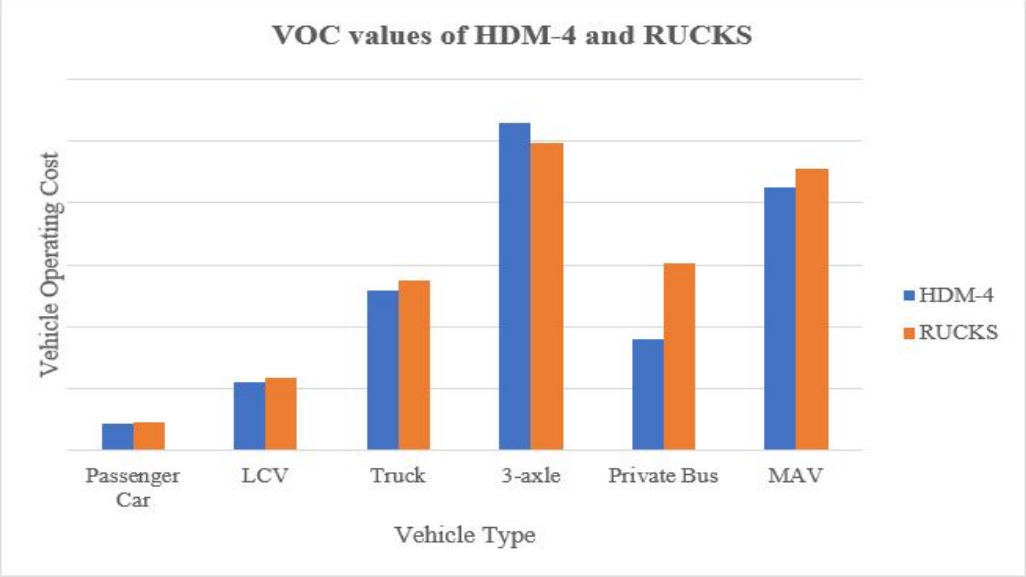


Figure 4.2: VOC values from HDM-4 and RUCKS

The percentage variation in VOC value up to 25% is considered acceptable. However, the variation in value of bus was found to be on a higher scale. Thus, it was necessary to check which component shows the variation. For this purpose, the percentage of VOC and TTC which comprises RUC was found as per shown in Table 4.3

Table 4.3: Component percentage of Road User Cost

Vehicle Type	**HDM-4**		**RUCKS**	
	VOC	**TTC**	**VOC**	**TTC**
Passenger Car	28%	72%	28.50%	71.50%
LCV	99%	1%	77.60%	17.90%
Truck	99%	1%	90.40%	3.40%
3-axle	99%	1%	91.20%	1.60%
Private Bus	**30%**	**70%**	**46.10%**	**50.00%**
MAV	98%	2%	89.70%	2.50%

As a thumb rule the percentage of TTC should be more for passenger vehicles i.e., in the range of 70% or more and VOC around 30% or below. While for commercial vehicles this TTC component should be below 5% and VOC should be above 95%. But from the table above its clear that the percentage of VOC and TTC for bus is not matching with the thumb rule in case of values form RUCKS. But the percentage matches in case of HDM-4 therefore, showing a correction needed only for RUCKS. As this project uses HDM4 there is no need for correction. Thus, the software is being validated and can be used for economic analysis.

4.4 Reliability Concept

The objective of an HDM analysis is to model roads. So, it is necessary to check how well the model predictions reflect reality. For that purpose, accuracy of obtain values is analysed using Chi-square Test. Table 4.4 explains the calculations for mean of observed and expected values.

Table 4.4: Chi square test

Sr. No.	Observed (Oi)	Expected (Ei)	$\left(\frac{(Oi-Ei)^2}{Ei}\right)$
1	4.4	4.48	0.0016
2	11.01	11.65	0.035
3	25.9	27.35	0.08
4	52.8	49.59	0.21
5	18.06	30.29	4.94
6	42.59	45.58	1.96E-01

$$x^2_{observed} = \sum \frac{(Oi - Ei)^2}{Ei} = 5.456 \tag{4.1}$$

Degree of freedom=6

$$x^2_{critical} = 18.548 for 6 d.o.f at \alpha = 0.005 \tag{4.2}$$

$$Since, x^2_{observed} < x^2_{critical} \tag{4.3}$$

Therefore, observation is statically proved to be acceptable

4.5 Concluding Remarks

The software validation study is ended up in identification of a tool for conducting economic analysis of road improvement schemes. While validating the values obtained in HDM-4 using RUCKS, 5 vehicle types were found to have only very minor variation in values while 1 vehicle types especially Bus, was found to have remarkable variation. However, the percentage of RUC that goes into VOC for bus is acceptable in case of HDM-4.

4.6 Closure

The chapter explains the input to HDM-4 and RUCKS software's that are used for economic analysis and validate those models. Finally, HDM-4 gives more accurate results and proves versatile than RUCKS.

Chapter 5

ECONOMIC ANALYSIS OF PROJECT CASE STUDIES

5.1 General

This chapter shortly introduced about three case studies analysed for this project with their existing situation and then one by one explains each case study with inputs used and obtained outputs.

5.2 Details of Study Area

The Mumbai and Pune are major cities of Maharashtra state, Mumbai is second largest city of India having a population of 12 million and is considered as the commercial capital as well as economic centre of the country. Today Mumbai accounts for 20% of India's total employment. Pune is one of the historical cities of India with a glorious past, an innovative present and a promising future. It has a population of close to 4 million. Thus, Pune city has been developed into a Pune metropolitan area, just equal in area to that of Greater Mumbai.

As both cities are growing in vehicular population, so most of time the corridor which connects those cities faces problem of traffic congestion and heavy landslide mainly in hilly section of this corridor as shown in Figure 5.1 and Figure 5.2. There is a strong demand from localities and the public representatives to remove all bottlenecks and improve the road. Therefore, it is proposed to widen the existing four lane Mumbai Pune section of NH-4 to six lanes, Widening of existing six lane Mumbai Pune Expressway to eight lanes and Construction of new alignment for missing link between Khopoli to Lonawala

in Mountain and Hilly section of Mumbai Pune corridor, which consists of Tunnels, Over Bridge, Viaducts, Elevated roads.

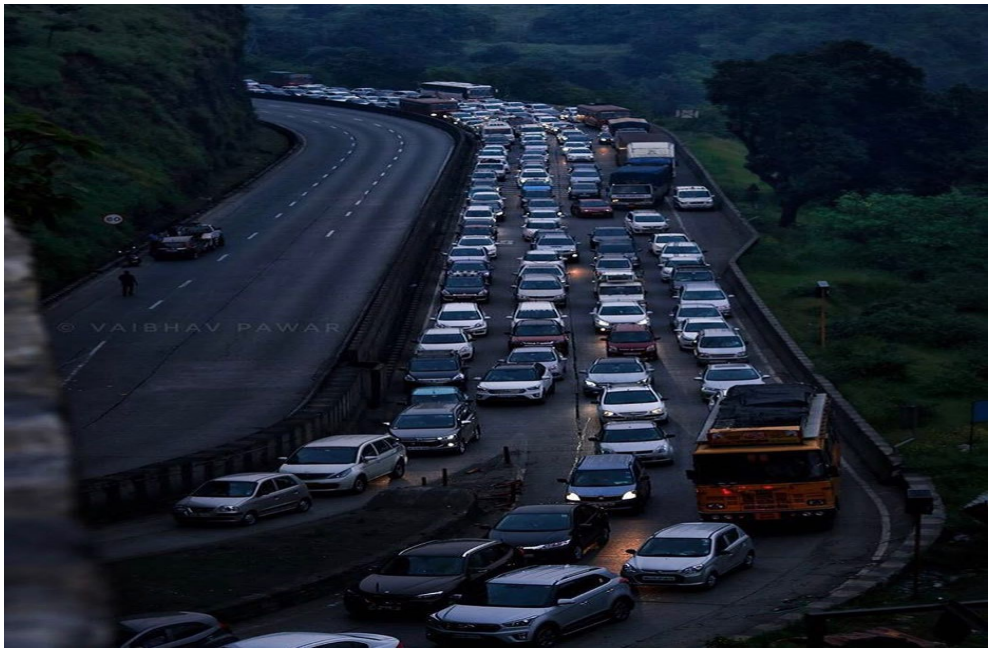


Figure 5.1: Traffic congestion on existing corridor of Mumbai Pune

Figure 5.2: Landslide in hilly section

5.3 Case Study-1) Widening of existing Mumbai Pune section of NH-4 to six lanes from existing four lanes

5.3.1 General

The objective of this project is to check feasibility of upgrading NH-4. The link connecting Mumbai and Pune namely NH-4 will upgrade to 6-lane in most of the length. Anyhow, in some length, it is still 2 lanes and there is a strong demand from localities and the public representatives to remove all bottlenecks and improve the road. The existing NH-4 consists of four lane carriageways of flexible pavement with 1.50 m wide paved shoulder on either side. The Google image of stusy area is as shown in Figure 5.3 below.

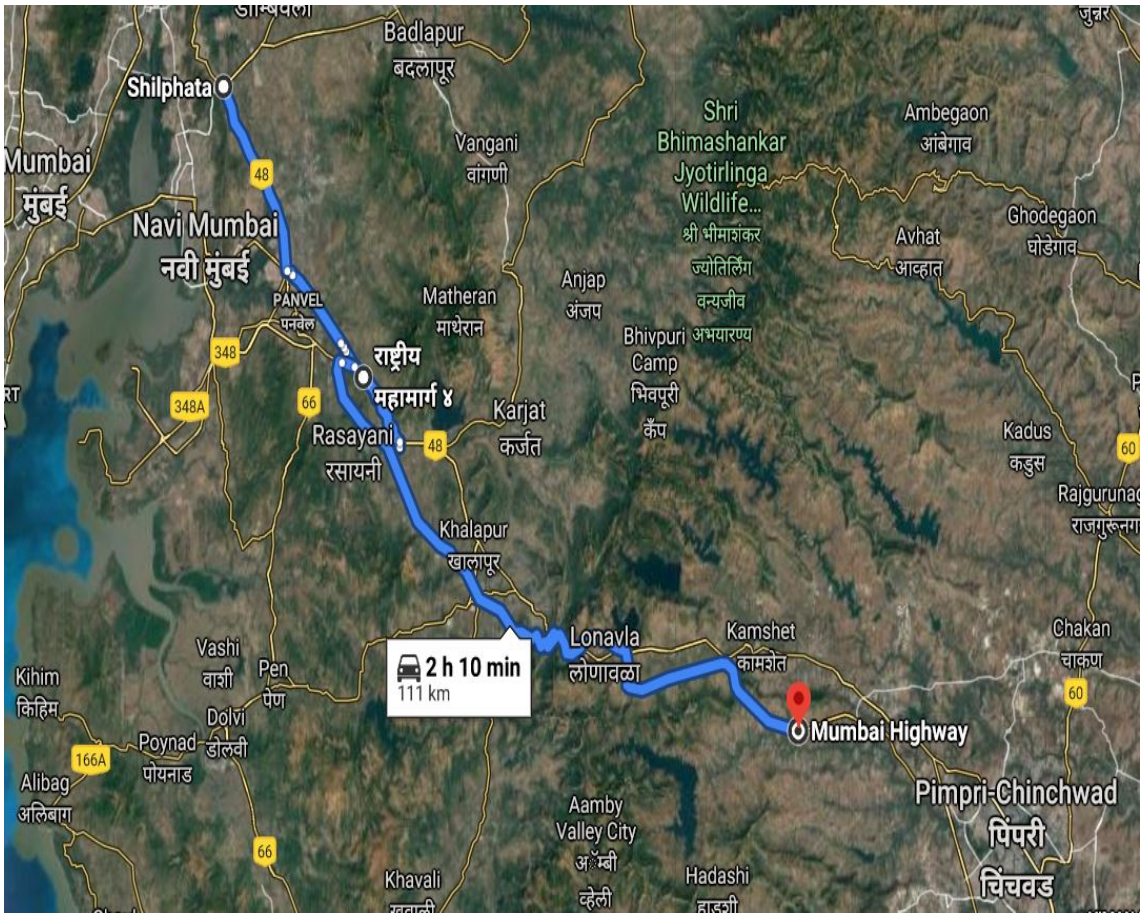


Figure 5.3: Google image of Mumbai Pune section of NH-4

5.3.2 Road Network Data

The road network data collection in the field included road Inventory data and road geometric details, structural evaluation (structural capacity), functional evaluation (pave-

ment condition and riding quality) and evaluation of pavement material. The characteristics of selected road sections are presented in Table 5.1.

Table 5.1: Road network data for Mumbai Pune section of NH-4

Pavement Type	Asphalt Mix on Stabilized Base (AMSB)
Surface class	Bituminous
Length (km)	111
Carriageway Width (m)	24
MT AADT	44940
AADT Year	2018
Rise + Fall (m/km)	30
Avg horizontal curvature (deg/km)	15

5.3.3 Project Economic Evaluation using HDM - 4

Economic evaluation for National Highway-4 is carried out by consideration of two alternatives In HDM – 4.

I. Alternative 1: Without Project

For without project consideration, project road will carry existing traffic on it without any improvement and maintenance in present condition that means No treatment is given to existing road for improving its capacity augmentation, functional and structural pavement quality and geometry standards.

II. Alternative 2: With Project

Widening the existing road to six lanes with 24 m roadway width including reconstruction, strengthening, bypasses and realignments to achieve the design speed of 100 kmph in plain/rolling area.

The project road is 111.00 km long and connects Mumbai and Pune towns. Project road is proposed to undertake work of strengthening, rehabilitation the existing road. Accordingly, economic analysis of the project road is being carried out as Table 5.2 below:

Table 5.2: Alternative details for NH-4

Alternatives	Existing Chainage		Design Chainage		Improvement
	From	To	From	To	
Alternative 2	131+200	20+400	131+290	20+200	6 lanes with PS

The project road with existing carriageway width of 14m is proposed for 6 lanes with paved shoulders facility which satisfies the project and traffic requirement. The Economic analysis was carried out for 30-year benefit period (2020-2049). For performing economic evaluation, a 'project' is formulated in which comparison is made between two scenarios namely (1) without any Improvements and (2) With different Improvements.

III. Capital Cost

The construction cost for each Alternative is tabulated in Table 5.3. The construction cost of project will be utilised in three phases i.e. 30% in first year, 40% in second year and other 30% in third year.

The cost estimate for project alternative has been calculated separately based on the quantities worked out for major items of work to be executed in the project on the basis of preliminary engineering design of roads, structures and the adopted rates. A conversion factor of 0.85 has been used to convert financial cost into economic costs.

Table 5.3: Total project cost of NH-4

Alternatives	**Civil Works Cost Per km**	**Economical Cost per km**
Alternative 2: With Project	15.30 Cr.	13.005 Cr.

4. Maintenance Cost

For Six lanes with Paved shoulder road

Routine maintenance cost – Rs 2.2 cr. per km per year

Special repair cost - Rs 238.32 cr. (5 years)

5.3.4 Project Benefits

All project benefits related to Vehicle Fleet for all the Three case studied are common and details are mentioned in this section only.

Project Benefits mainly occurs due to reduction in Vehicle operating cost and travel time savings.

The vehicle operating cost (VOC) components are,

- Fuel
- Lubricants
- Tyres
- Spare Parts
- Maintenance Labour
- Wages of Crew
- Fixed costs including overheads, administration, interest on borrowed capital
- Depreciations
- Travel time cost

1. Vehicle Fleet

Fleet Utilization

Fleet utilization data adopted for the analysis is based on the findings of Road User Cost study in 2019, IRC SP: 30-2009. The adopted values are summarized as shown in Table 5.4 below,

2. Vehicle Resources

- **Vehicle and Tyre Cost**

  Economic costs of vehicle and tyre are derived from the market survey Price for each category of vehicle have been collected and elements of taxes, duties, freight, dealer's margin and incentives as applicable have been removed to arrive at the economic costs. The adopted economic costs are summarized as presented in Table 5.5 below.

- **Fuel & Lubricant**

  The details of fuel and lubricant prices for the state of Maharashtra have been collected from the petrol pumps on the project road near Pune. Information on Excise, Levy, Cess, Sales Tax and Agency Charges has also been collected to arrive at economic cost for the analysis. Details of these are summarized in Table 5.6 below.

- **Maintenance Labour and Crew Wages**

  Adopted values for Maintenance Labour and Crew Wages are based on the enquiries made by the Consultant with transport operators and workshops in and around the project Road. The adopted values are summarized vide in Table 5.7 below.

Table 5.4: Vehicle fleet characteristics

Vehicle Type	**Two Wheeler**	**Car / jeep**	**LCV**	**Mini bus**	**Trucks**	**Govt. Bus**	**Private Bus**	**3 Axle**	**MAV**
No. of Wheels	2	4	4	4	6	10	10	10	18
No. of Axle	2	2	2	2	2	3	3	3	$\geq$4 to 6
Tyre Type	Radial	Radial	Radial	Radial	Radial	Radial	Radial	Radial	Radial
Service Life (Years)	10	10	10	8	10	10	10	10	10
Annual Working hours	400	550	1300	850	1200	1750	1700	2050	1650
Annual Km	10000	23000	30000	34000	40000	70000	72000	86000	81000
No. of Passengers	1	3	0	20	0	40	40	0	0
Private-Use percentage	100	75	50	25	0	0	25	0	0
Work-Related passenger trip	0	25	50	75	100	100	75	100	100
ESAL factor	0	0.000442	0.01	0.04	1.25	0.8	0.8	2.28	4.63
The Operating Weight (Ton)	0.2	1.2	1.5	2.5	7.5	10	10	13	28

Table 5.5: Prices of vehicles

Name	**New Vehicle Cost (Rs.)**	**Tyre Cost (Rs.)**
Two-Wheeler	50000	1500
Car / jeep	600000	5000
LCV	400000	3500
Mini bus	1000000	10000
Trucks	1200000	14000
Govt. Bus	1800000	20000
Private Bus	2200000	25000
3 Axle	1500000	18000
MAV	2000000	18000

Table 5.6: Economic cost of fuel & lubricants

Item	Rate	Taxes and Duties			Present Economic Cost/litre
		Excise Duty	Other Levy	Sales Tax	
Petrol	Rs./Litre	19.48	35.23	38.11%	79.20
Diesel	Rs./Litre	15.33	25.31	21.89%	70.03
Lubricants	Rs./Litre	16%	Nil	18%	100

Table 5.7: Labour and crew wages

Name	**Maintenance Labour (per hour)**	**Crew Wages (per hr)**
Two Wheeler	40	-
Car / jeep	70	50
LCV	100	70
Mini bus	100	150
Trucks	100	80
Govt. Bus	125	150
Private Bus	125	150
3 Axle	100	100
MAV	100	100

- **Annual Overhead**

  Recommendations of the "Study for Updating Road User Cost Data: 2001"and IRC SP: 30-2009 are considered to arrive at annual overhead cost per vehicle and are summarised in Table 5.8 below,

Table 5.8: Annual overheads

Name	**Annual Overhead**
Two Wheeler	1400
Car / jeep	240000
LCV	120000
Mini bus	450000
Trucks	360000
Govt. Bus	540000
Private Bus	660000
3 Axle	450000
MAV	600000

- **Annual Interest**

  An Economic Interest Rate of 12% has been adopted for the analysis.

- **Time Value of Passengers**

  Table 5.9 represents the calculation of Value of Travel Time from Net State Domestic Product (NSDP) for Bus. From the time value of bus passenger, the time value of mini bus, two wheelers, car was calculated and represents in Table 5.10.

Table 5.9: Value of travel time for bus

Parameter	Unit	2018
Net State Domestic Product (NSDP) as per state Economic review, Govt. of Maharashtra (A)	Rs. Million	1,99,60,980
Population (B)	Million	121.416
Working Population (C)	Million	91.06
Work Time Value with, 33% overhead (D)	Rs/hr	121.48
Non work Time Value at 30% (E)	Rs/hr	27.40

Table 5.10: Value of travel time for another vehicle type

Vehicle Type	Time Value (Rs/hr)	
	Work	Non Work
Bus	121.48	27.4
Mini Bus (= Bus * 1.2)	145.78	32.88
Car (= Bus * 1.75)	212.59	47.95
2 Wheeler (= Bus * 1.4)	170.07	38.36

- **Time Value of Cargo**

  Average value of commodity is based on "Manual of Economic evaluation of Highway Projects in India" (IRC SP: 30 – 2009). Time-delay cost is estimated with an economic interest rate of 12% and economic conversion factor of 0.85 and provided in Table 5.11

Table 5.11: Time value of cargo

Vehicle Type	Average Payload (Tonnes)	Average Running Time (hr/Year)	Time-delay Cost (Rs./hr)
LCV	8.25	1300	26.00
Trucks	15	1950	35.00
3 Axle	17	2050	60.00
MAV	17	2050	60.00

3. HDM Traffic

Following category of fast moving and slow-moving vehicles are considered for carrying out HDM 4 Analysis,

- 2 Axle Truck

- 3 Axle Truck
- Multi Axle Truck
- LCV
- Utility Car
- Bus
- Mini Bus
- Car / Jeep / Van
- Two-Wheeler

As in this study for analysis in HDM-4 does not include 3-Wheeler and Agricultural Tractor Categories of Vehicle therefore these categories are not considered in the analysis. Percentage compositions of assigned traffic in AADT on the project road as on year 2018 and adopted for the analysis for the Project road are summarized as given in Table 5.12 below and Adopted traffic growth rates as per traffic analysis is Presented in same Table.

Table 5.12: Traffic volume count and annual growth rate of NH-4

Vehicle Type	**Traffic Composition (%)**	**Annual Growth (%)**
Two Wheeler	1.22	2
Car / jeep	29.77	6
LCV	15.35	4
Mini bus	0.98	3.5
Trucks	11.35	4
Govt. Bus	4.56	3.5
Private Bus	5.03	3.5
3 Axle	15.82	5
MAV	14.4	5

5.3.5 Economic Internal Rate of Return of NH-4

Economic Analysis has been carried out for construction option discussed above. Variables considered in for economic analysis of the project are volatile and depend on various factors. In general, in case of economic analysis is also recommended that analysis period should not be long as it may lead to erroneous results.

However, in order to be able to draw the conclusions on common platform Economic

Analysis have also been carried out for 30 years of analysis period.

Economic Analysis was carried out following the methodology and input data discussed in the preceding paragraphs of this report using HDM-4 software.

Economic Analysis was carried out and results of Net Discounted Benefits Stream and Summary of Economic Internal Rate of Return (EIRR) for this case study are presented in Table 5.13 and Figure 5.4 below respectively.

HDM-4
HIGHWAY DEVELOPMENT & MANAGEMENT

Economic Analysis Summary

Study Name: **Capacity augmentation of Mumbai Pune section of NH-4**

Run Date: **30-06-2020**

This report shows total economic benefits using the following:
Currency: INR (millions).
Discount rate: 12.00%.
Analysis Mode: Analysis-by-Project

Alternative: With Project vs Alternative: Base Case

	Increase in Road Agency Costs			Savings in M VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	14,430.00	1,328.29	-12,154.50	-40,157.32	72,070.05	0.00	0.00	0.00	28,308.88
Discounted	12,933.62	705.38	-2,876.81	30,668.23	6,882.19	0.00	0.00	0.00	26,788.23

Economic Internal Rate of Return (EIRR) = 41.0% (No. of solutions = 1)

Figure 5.4: Economic analysis summary of NH-4

Table 5.13: Net discounted benefits stream of NH-4

Year	**Increase in Road Agency Costs**			**Savings in Road User Costs**		**Total Net Benefit**
	Capital Works	**Recurrent Works**	**Special Works**	**Normal (+ Diverted) Traffic**		
				MT VOC	**MT Time**	
2020	4,329.00	0	0	0	0	-43,290.00
2021	5,153.57	0	0	78.226	207.772	-51,249.71
2022	3,451.05	256.996	0	105.7919	183.718	-34,413.90
2023	0	50.229	0	109.4765	155.423	294.86
2024	0	44.847	-1,287.401	169.903	126.1	289.83
2025	0	40.042	0	189.666	118.393	288.79
2026	0	35.752	0	208.194	967.63	1,144.68
2027	0	31.922	0	208.575	683.258	859.53
2028	0	28.501	0	210.441	414.666	598.34
2029	0	25.448	-730.506	212.171	402.588	593.94
2030	0	22.721	0	212.802	390.862	590.31
2031	0	20.287	0	216.802	379.478	587.6
2032	0	18.113	0	222.173	368.425	585.96
2033	0	16.172	0	228.407	357.694	585.58
2034	0	14.44	-414.509	235.645	347.276	703.03
2035	0	12.893	0	244.056	337.161	762.34
2036	0	11.512	0	370.20	327.341	1,632.54
2037	0	10.279	0	438.07	317.807	3,236.56
2038	0	9.178	0	609.49	308.55	5,151.12
2039	0	8.195	-235.203	1,316.71	299.563	7,066.93
2040	0	7.317	0	2,929.03	290.838	8,743.85
2041	0	6.533	0	4,851.75	282.367	10,034.75
2042	0	5.833	0	6,775.56	274.143	10,847.50
2043	0	5.208	0	8,460.33	266.158	11,208.60
2044	0	4.65	-133.461	9,758.92	258.406	6,216.98
2045	0	4.152	0	-594.21	-250.88	-118.1
2046	0	3.886	0	-1,156.33	-243.572	-391.67
2047	0	3.707	0	-1,622.45	-236.478	-625.38
2048	0	3.47	0	-2,005.25	-229.59	-823.74
2049	0	3.098	-75.729	-2,315.91	-222.903	1,706.33
Total:	12,933.62	705.38	-2,876.81	30,668.23	6,882.19	26,788.23

5.4 Case Study-2) Widening of Existing Mumbai Pune Expressway (MPEW) to Eight lanes from Existing Six Lanes

5.4.1 General

The Mumbai Pune Expressway (MPEW), presently known as Yashwantrao Chavan Expressway (YCEW), starts from Kalamboli Junction at NH-4 and ends at Kiwale Junction of NH-4 Pune Westerly Bypass and is about 95 km long. It was constructed by MSRDC and opened for traffic in 2002. The concession period is up to 30.04.2030. The MPEW consists of six lane carriageways of rigid pavement with 2.50 m wide paved shoulder and 1.5 m wide soft shoulder on either side.

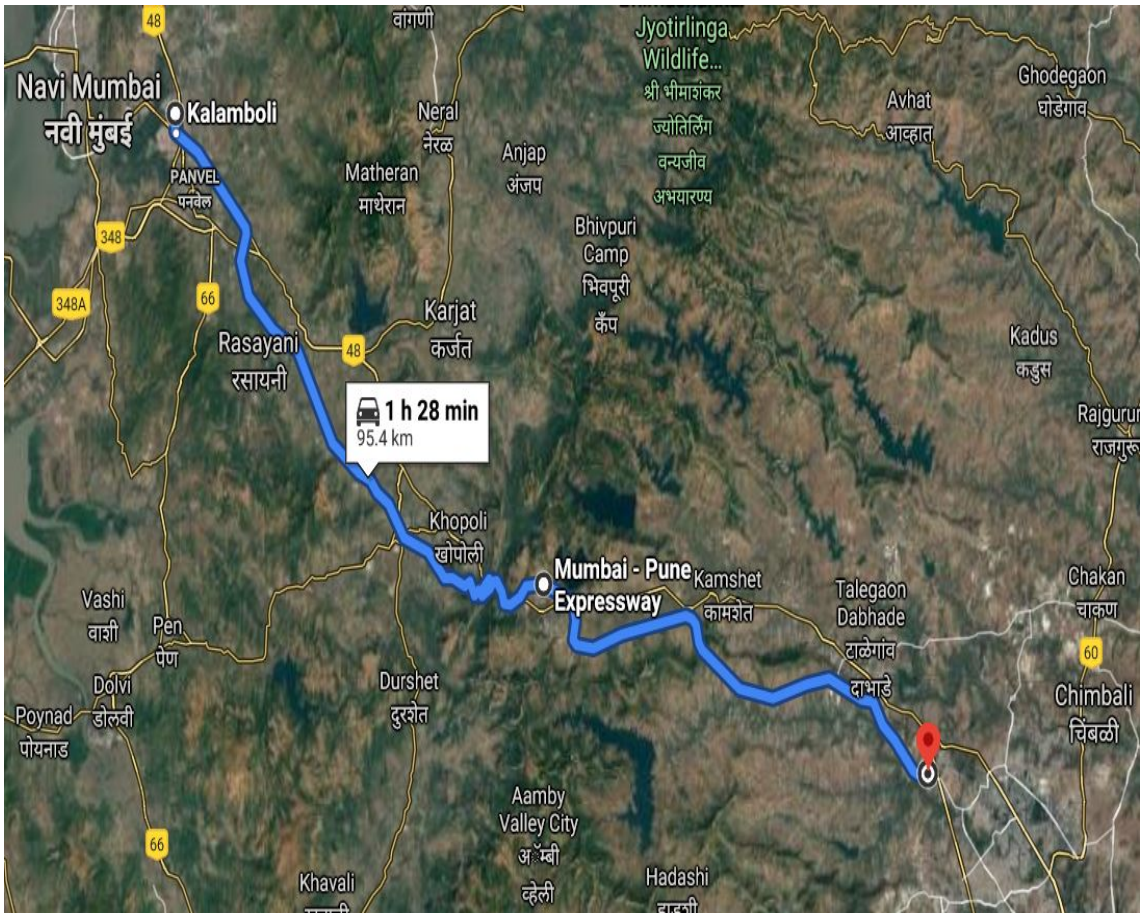


Figure 5.5: Google image of Mumbai Pune Expressway

5.4.2 Road Network Data

The road network data collection in the field included road Inventory data and road geometric details, structural evaluation (structural capacity), functional evaluation (pavement condition and riding quality) and evaluation of pavement material. The character-

istics of selected road sections are presented in Table 5.14

Table 5.14: Road network data for Mumbai Pune Expressway (MPEW)

Pavement Type	Surface Treatment on Stabilised Base
Surface class	Cement Concrete
Length (km)	95
Carriageway Width (m)	32
MT AADT	82870
AADT Year	2018
Rise + Fall (m/km)	10
Avg horizontal curvature (deg/km)	15

5.4.3 Project Economic Evaluation using HDM - 4

Economic evaluation for Mumbai Pune Expressway is carried out by consideration of two alternatives In HDM – 4.

I. Alternative 1: Without Project

For without project consideration, project road will carry existing traffic on it without any improvement and maintenance in present condition that means No treatment is given to existing road for improving its capacity augmentation, functional and structural pavement quality and geometry standards.

II. Alternative 2: With Project

Widening the existing road to six lanes with 32 m roadway width including reconstruction, strengthening, bypasses and realignments to achieve the design speed of 120 kmph in plain/rolling area.

The project road is 95.00 km long and connects Mumbai and Pune towns. Project road is proposed to undertake work of strengthening, rehabilitation the existing road. Accordingly, economic analysis of the project road is being carried out as Table 5.15 below:

Table 5.15: Alternative details for MPEW

Alternatives	Existing Chainage		Design Chainage		Improvement
	From	To	From	To	
Alternative 2	0+000	94+600	0+000	95+000	8 lanes with PS

The project road with existing carriageway width of 32 m is proposed for 8 lanes with paved shoulders facility which satisfies the project and traffic requirement.

The Economic analysis was carried out for 30-year benefit period (2020-2049). For performing economic evaluation, a 'project' is formulated in which comparison is made between two scenarios namely (1) without any Improvements and (2) With different Improvements.

III. Capital Cost

The construction cost for each alternative is tabulated in Table 5.16. The construction cost of project will be utilised in three phases i.e. 30% in first year, 40% in second year and other 30% in third year.

The cost estimate for each alternative has been calculated separately based on the quantities worked out for major items of work to be executed in the project on the basis of preliminary engineering design of roads, structures and the adopted rates. A conversion factor of 0.85 has been used to convert financial cost into economic costs.

Table 5.16: Total project cost of MPEW

Alternatives	**Civil Works Cost Per km**	**Economical Cost per km**
Alternative 2: With Project	17.25 Cr.	14.66 Cr.

IV. Maintenance Cost

For Eight lanes with Paved shoulder road

Routine maintenance cost – Rs 2.46 cr. per km per year

Special repair cost - Rs 151.50 cr. (for 7 years interval)

5.4.4 HDM Traffic

Following category of fast moving and slow-moving vehicles are considered for carrying out HDM 4 Analysis.

- 2 Axle Truck
- 3 Axle Truck
- Multi Axle Truck
- LCV
- Bus
- Mini Bus
- Car / Jeep / Van

As in this study for analysis in HDM-4 does not include 3-Wheeler and Agricultural Tractor Categories of Vehicle therefore these categories are not considered in the analysis. Percentage compositions of assigned traffic in AADT on the project road as on year 2018 and adopted for the analysis for the Project road are summarized as given in Table 5.17 below and Adopted traffic growth rates as per traffic analysis is Presented in same Table.

Table 5.17: Traffic volume count and annual growth rate of MPEW

Vehicle Type	**Traffic Composition (%)**	**Annual Growth (%)**
Car / jeep	40.77	7
LCV	10.22	3.5
Trucks	14.36	3.25
Private Bus	7.96	3
3 Axle	15.9	4
MAV	10.86	4

5.4.5 Economic Internal Rate of Return for MPEW

Analysis have been carried out for 30 years of analysis period and results of Net Discounted Benefits Stream and Summary of Economic Internal Rate of Return (EIRR) for Mumbai Pune Expressway are presented in Table 5.18 and Figure 5.6 below respectively.

HDM - 4
HIGHWAY DEVELOPMENT & MANAGEMENT

Economic Analysis Summary

Study Name: **Capacity augmentation of Yashwantrao Chavan Expressway (MPEW)**
Run Date: **02-07-2020**

This report shows total economic benefits using the following:
Currency: INR (millions).
Discount rate: 12.00%.
Analysis Mode: Analysis-by-Project

Alternative: With Project vs Alternative: Without Project

	Increase in Road Agency Costs			Savings in M VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	10,288.49	2,180.73	-36,699.45	-139,324.65	-66,142.02	0.00	0.00	0.00	67,752.69
Discounted	18,443.18	511.676	-16,005.95	20,990.235	6,157.748	0.00	0.00	0.00	24,199.08

Economic Internal Rate of Return (EIRR) = 26.4% (No. of solutions = 1)

Figure 5.6: Economic analysis summary of MPEW

Table 5.18: Net discounted benefits stream of MPEW

Year	**Increase in Road Agency Costs**			**Savings in Road User Costs**		**Total Net Benefit**
	Capital Works	**Recurrent Works**	**Special Works**	**Normal (+ Diverted) Traffic**		
				MT VOC	**MT Time**	
2020	6,173.10	0	0	0	0	-6,173.10
2021	7,348.93	0	0	8.96	308.69	-7,031.28
2022	4,921.16	0.386	0	33.559	299.70	-4,588.28
2023	0	57.476	0	56.619	290.97	290.11
2024	0	51.318	0	78.276	282.50	309.45
2025	0	45.820	0	98.704	274.27	327.15
2026	0	40.910	-6,197.69	104.353	266.28	6,527.42
2027	0	36.527	0	104.956	258.52	326.95
2028	0	32.614	0	105.804	250.99	324.18
2029	0	29.119	0	106.927	243.68	321.49
2030	0	25.999	0	108.354	236.59	318.94
2031	0	23.214	0	110.118	229.69	316.60
2032	0	20.727	0	112.27	223.00	314.55
2033	0	18.506	-2,803.52	114.858	216.51	3,116.38
2034	0	16.523	0	117.95	210.20	311.63
2035	0	14.753	0	121.634	204.08	310.96
2036	0	13.172	0	126.013	198.14	310.98
2037	0	11.761	0	131.218	192.37	311.82
2038	0	10.501	0	145.46	186.76	321.72
2039	0	9.376	0	164.519	181.32	336.47
2040	0	8.371	-1,268.17	263.785	176.04	1,699.63
2041	0	7.474	0	288.918	170.91	452.36
2042	0	6.673	0	599.378	165.94	758.64
2043	0	5.958	0	1,413.85	161.10	1,569.00
2044	0	5.320	0	1,561.07	156.41	1,712.16
2045	0	4.750	0	1,749.83	147.43	1,892.51
2046	0	4.241	0	2,093.09	223.390	2,312.24
2047	0	3.787	-5,736.56	2,655.06	166.708	8,554.54
2048	0	3.381	0	4,170.29	134.048	4,300.95
2049	0	3.019	0	4,244.41	101.505	4,342.90
Total:	18,443.18	511.676	-16,005.95	20,990.24	6,157.75	24,199.08

5.5 Case Study-3) Construction of New Alignment

5.5.1 General

Maharashtra State Road Development Corporation (MSRDC) has constructed Mumbai Pune Expressway (presently known as Yashwantrao Chavan Expressway -YCEW) in the year 2000. At the time of construction of the Expressway, the alignment between Khopoli and Lonavala could not be constructed due to viability gap funding issues. In the hilly alignment therefore, the length of the Expressway and NH-4 is common and entire traffic from NH-4 as well as MPEW merge in this section and hence causes congestion. A need therefore is felt to adopt another alternative alignment for the Expressway in this stretch. The proposed new alignment starts in km 39 of Mumbai Pune Expressway and diverts towards South –East passes through high mountains of Bor Ghat and meets again with Mumbai Pune Expressway in km 58 near Singhad Institute. The link will have designed speed of 120 Kmph with Expressway standards.

Figure 5.7: Google image of New Alignment

5.5.2 Road Network Data

The road network data collection in the field included road Inventory data and road geometric details, structural evaluation (structural capacity), functional evaluation (pavement condition and riding quality) and evaluation of pavement material. The characteristics of selected road sections are presented in Table 5.19.

Table 5.19: Road network data for New Alignment

Pavement Type	Surface Treatment on Stabilised Base
Surface class	Cement Concrete
Length (km)	19
Carriageway Width (m)	30
MT AADT	44560
AADT Year	2018
Rise + Fall (m/km)	10
Avg horizontal curvature (deg/km)	30

5.5.3 Project Economic Evaluation using HDM - 4

Economic evaluation for National Highway-4 is carried out by consideration of two alternatives In HDM – 4.

I. Alternative 1: Without Project

The first is a 'without project' (do minimum) where the existing six lane project road is considered as such in its present condition and without any alternative alignment. In this case, the future traffic volume is assumed to continue to flow along the existing road only. In the HDM model analysis, this 'do minimum' alternative will form the first / base strategy against which all other strategies will be compared.

II. Alternative 2: With Project

This comprises of the strategy of the 'with project' situation in the HDM model. In order to arrive at the net benefits associated with this strategy, these are compared to the 'do minimum' / 'without project' alternative. The improvement proposals considered for 'with project situation' are as mentioned in Table 5.20 below:

By comparing the above alternatives, the net agency costs, the net user costs and the net project benefits associated with the project during its analysis period of 30 years, are calculated for the proposed improvement options. These calculations are performed in order to arrive at their economic internal rate of return (EIRR) and economic net

Table 5.20: Alternative details of New Alignment

Corridor	Section	Existing Length (Km)	Proposal
Mumbai – Pune	Km 39/00 to 59/00 of Mumbai – Pune Expressway	19	New alignment with 8lane concrete road including 2 tunnels of total length 8.5 km, viaducts, 2 interchanges

present value (ENPV). Based on the results of the analysis, the economic feasibility for the project is determined.

III. Capital Cost

The construction cost for each alternative is tabulated in Table 5.21. The construction cost of project will be utilised in three phases i.e. 30% in first year, 40% in second year and other 30% in third year. The cost estimate for each alternative has been calculated separately based on the quantities worked out for major items of work to be executed in the project on the basis of preliminary engineering design of roads, structures and the adopted rates. A conversion factor of 0.85 has been used to convert financial cost into economic costs.

Table 5.21: Total project cost of New Alignment

Alternatives	**Civil Works Cost per km**	**Economical Cost per km**
Alternative 2: With Project	252.50 Cr.	214.625 Cr.

IV. Maintenance Cost

For Eight lanes with Paved shoulder road

Routine maintenance cost – Rs 2.7 cr. per km per year

5.5.4 HDM Traffic

Following category of fast moving and slow-moving vehicles are considered for carrying out HDM 4 Analysis.

- 2 Axle Truck
- 3 Axle Truck
- Multi Axle Truck
- LCV

- Bus
- Mini Bus
- Car / Jeep / Van

As in this study for analysis in HDM-4 does not include 3-Wheeler and Agricultural Tractor Categories of Vehicle therefore these categories are not considered in the analysis. Percentage compositions of assigned traffic in AADT on the project road as on year 2018 and adopted for the analysis for the Project road are summarized as given in Table 5.22 below and Adopted traffic growth rates as per traffic analysis is Presented in same Table.

Table 5.22: Traffic volume count and annual growth rate of New Alignment

Vehicle Type	**Traffic Composition (%)**	**Annual Growth (%)**
Car / jeep	37	7
LCV	11	3.5
Mini Bus	2	3.25
Trucks	16	3.25
Bus	7	3.5
3 Axle	16	4
MAV	11	4

5.5.5 Economic Internal Rate of Return for New Alignment

Analysis have been carried out for 30 years of analysis period and results of Net Discounted Benefits Stream and Summary of Economic Internal Rate of Return (EIRR) for New Alignment is presented in Table 5.23 and Figure 5.8 below respectively.

Table 5.23: Net discounted benefits stream for New Alignment

Year	**Increase in Road Agency Costs**			**Savings in Road User Costs**		**Total Net Benefit**
	Capital Works	**Recurrent Works**	**Special Works**	**Normal (+ Diverted) Traffic**		
				MT VOC	**MT Time**	
2020	12,233.63	0	0	0	0	-12,233.625
2021	14,563.84	0	0	0.786	955.971	-13,607.081
2022	9,752.57	93.099	0	0.86	539.179	-9,305.631
2023	0	126.118	0	0.94	190.539	65.361
2024	0	112.606	0	1.14	174.370	62.904
2025	0	100.541	0	1.22	169.291	69.968
2026	0	89.769	0	1.301	164.361	75.893
2027	0	80.151	0	1.392	159.573	80.814
2028	0	71.563	0	1.489	155.036	84.962
2029	0	63.895	0	1.593	150.413	88.111
2030	0	5.2	0	1.705	146.032	142.537
2031	0	4.643	0	1.826	141.779	138.962
2032	0	4.145	0	1.957	137.649	135.461
2033	0	3.701	0	2.097	133.640	132.036
2034	0	3.305	0	2.248	129.748	128.691
2035	0	2.951	0	2.41	125.969	125.428
2036	0	2.634	0	2.585	122.300	122.251
2037	0	2.352	0	2.774	118.738	119.160
2038	0	2.1	0	2.976	115.279	116.155
2039	0	1.875	0	3.197	111.922	113.244
2040	0	1.674	0	3.436	108.662	110.424
2041	0	1.495	0	3.692	105.497	107.694
2042	0	1.335	0	3.969	136.664	139.298
2043	0	1.192	0	215.263	99.441	313.512
2044	0	1.064	0	200.176	96.545	295.657
2045	0	0.95	0	214.602	93.733	307.384
2046	0	0.848	0	230.067	91.002	320.221
2047	0	0.757	0	246.646	88.352	334.241
2048	0	0.676	0	264.420	85.779	349.523
2049	0	0.604	0	283.476	63.237	346.109
Total:	36,550.03	781.242	0.00	1,700.24	4,910.698	30,720.339

HDM - 4
HIGHWAY DEVELOPMENT & MANAGEMENT

Economic Analysis Summary

Study Name: **Mumbai- Pune Missing Link**

Run Date: **04-07-2020**

This report shows total economic benefits using the following:
Currency: INR (millions).
Discount rate: 12.00%.
Analysis Mode: Analysis-by-Project

Alternative: With Project vs Alternative: Base Case

	Increase in Road Agency Costs			Savings in M VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	40,778.75	1,680.09	0.00	3,225.32	8,367.34	0.00	0.00	0.00	360,609.87
Discounted	36,550.03	781.24	0.00	1,700.24	4,910.70	0.00	0.00	0.00	30,720.339

Economic Internal Rate of Return (EIRR) = 23.2% (No. of solutions = 1)

Figure 5.8: Economic analysis summary for New Alignment

5.6 Closure

The chapter explains the details of three case studies use for economic analysis along with road network data, vehicle fleet, characteristics data, maintenance and improvement standards used for each case study and finally represents the results for each case study with net discounted benefit stream for 30 yrs project life and summary of economic analysis.

Chapter 6

RESULTS AND DISCUSSION

6.1 General

Discussion of results is carried out based on economic performance of the proposed components by comparing the with-project and without project scenarios. Also, socio economic benefits of research work are explained.

6.2 Results and Discussion

The project were analysed by comparing base case (without improvement) and project case (with improvement) alternatives in the discounted total cost connected with project for three case studies and values of discounted costs for capital work, vehicle operating costs and travel time costs are explain with the help of graphs of cost comparison for each case study.

The variation in costs for particular variants related to total costs of base case and project case of Mumbai Pune section of NH-4 is as given in Table 6.1 and Figure 6.1.

Table 6.1: Costs for particular variants of NH-4

Kind of Costs	**Base Case**	**Project Case**
Capital Cost	18%	1%
Vehicle Operating Costs	51%	65%
Travel Time Costs	31%	34%

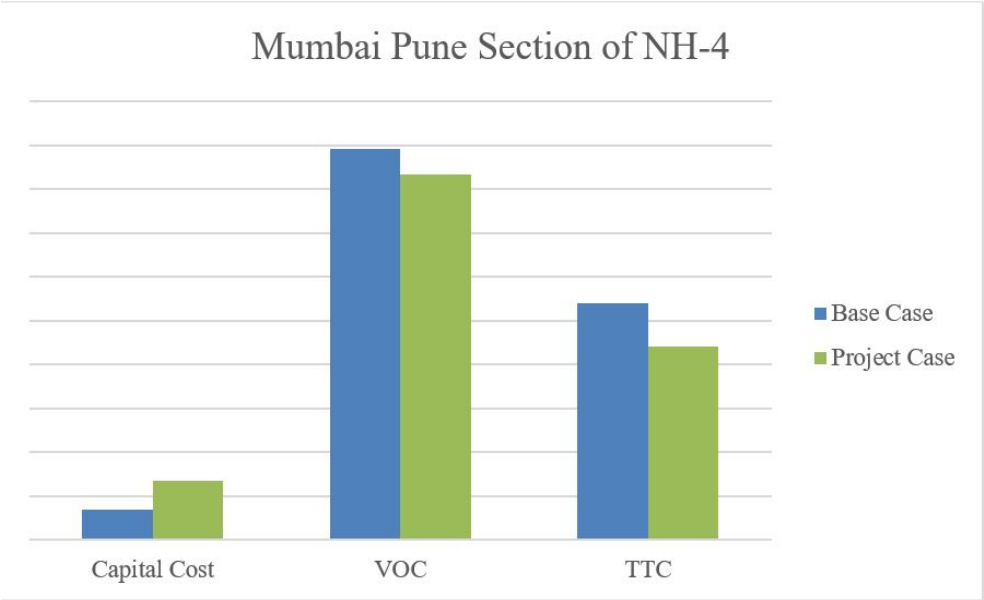


Figure 6.1: Graph of costs variation for NH-4

The variation in costs for particular variants of Mumbai Pune Expressway is as shown in Table 6.2 and Figure 6.2.

Table 6.2: Costs for particular variants of MPEW

Kind of Costs	**Base Case**	**Project Case**
Capital Cost	5%	1%
Vehicle Operating Costs	59%	61%
Travel Time Costs	36%	38%

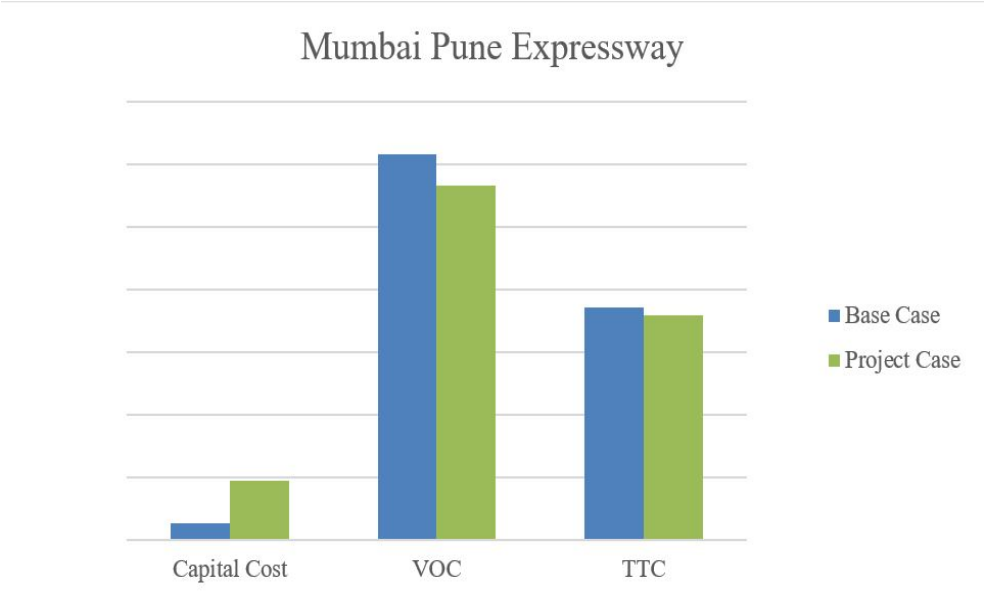


Figure 6.2: Graph of costs variation for MPEW

The variation in costs for particular variants of New Alignment is as shown in Table 6.3 and Figure 6.3.

Table 6.3: Costs for particular variants of New Alignment

Kind of Costs	**Base Case**	**Project Case**
Capital Cost	13%	7%
Vehicle Operating Costs	57%	60%
Travel Time Costs	31%	32%

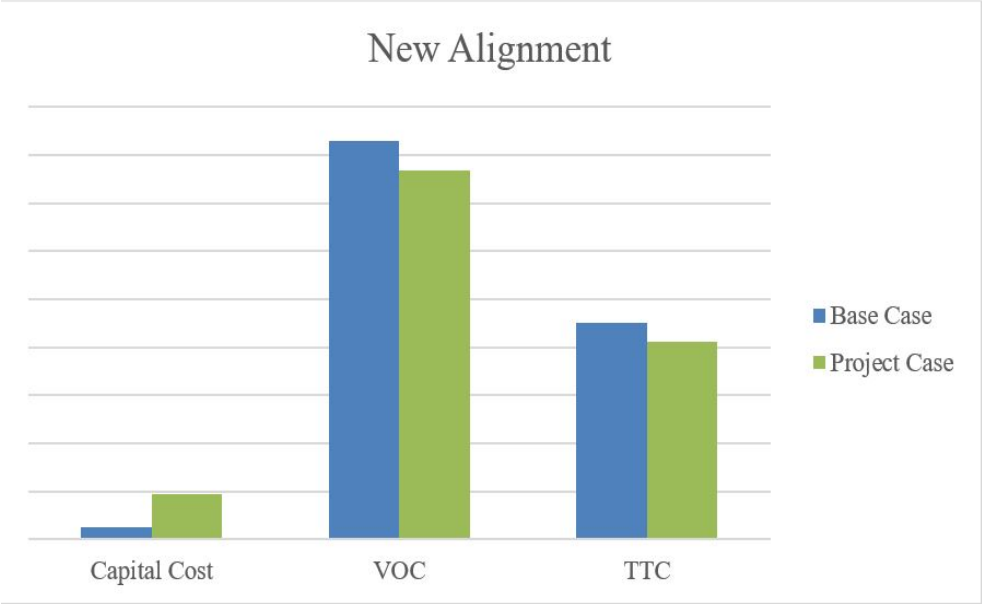


Figure 6.3: Graph of costs variation for New Alignment

Above results shows that, comparing total costs of the base case and total costs of the project case provides the result proving good intention to carry out the project. The project case option brings bigger costs for investor connected with the investment (the construction and the recurrent), also vehicle operation costs are bigger in the case of the base option. Other socio-economic costs connected with the travel time is lower in the case of the project variant and users always wanted to at least 30% reduction in their current travel time cost. In those cases, it possible to expect quite interesting cost savings.

To test the economic viability, the EIRR was calculated based on the incremental cost and benefit streams associated with each case study. The economic analysis evaluated the economic performance of the proposed components by comparing the with-project and without project scenarios. The results summary of project case studies is summarised in Table 6.4 below. All project costs in below table are in million.

Table 6.4: Result summary of economic analysis

Case Study	Road Agency Cost		Road User Cost		ENPV	EIRR
	Capital Cost	Recurrent Cost	VOC	TTC		
Mumbai Pune Section of NH-4	12,933.62	705.38	30,668.23	6,882.19	26,788.23	**41.00%**
Mumbai Pune Expressway	18,443.18	511.676	20,990.24	6,157.75	24,199.08	**26.40%**
New Alignment	36,550.03	781.242	1,700.24	4,910.70	30,720.34	**23.20%**

6.3 Socio Economic Benefits

The socio-economic benefits of highway projects are depending on reduction in vehicle operating cost, reduction in travel time cost, reduction in accident cost and environment emission cost. As this project work has not consider accident cost and environment emission cost. Therefore, comparing the Socio-economic benefit connected with VOC and TTC for all the three case studies, provide good results. The comparative analysis graph presented in Figure 6.4 below shows great reduction in vehicle operating costs and travel time costs as comes from improvement of existing routes to construction of new alignment in required section. Though, the economic internal rate is lower as compared with case study-1 and case study-2 because capital work cost is higher for case study-3.

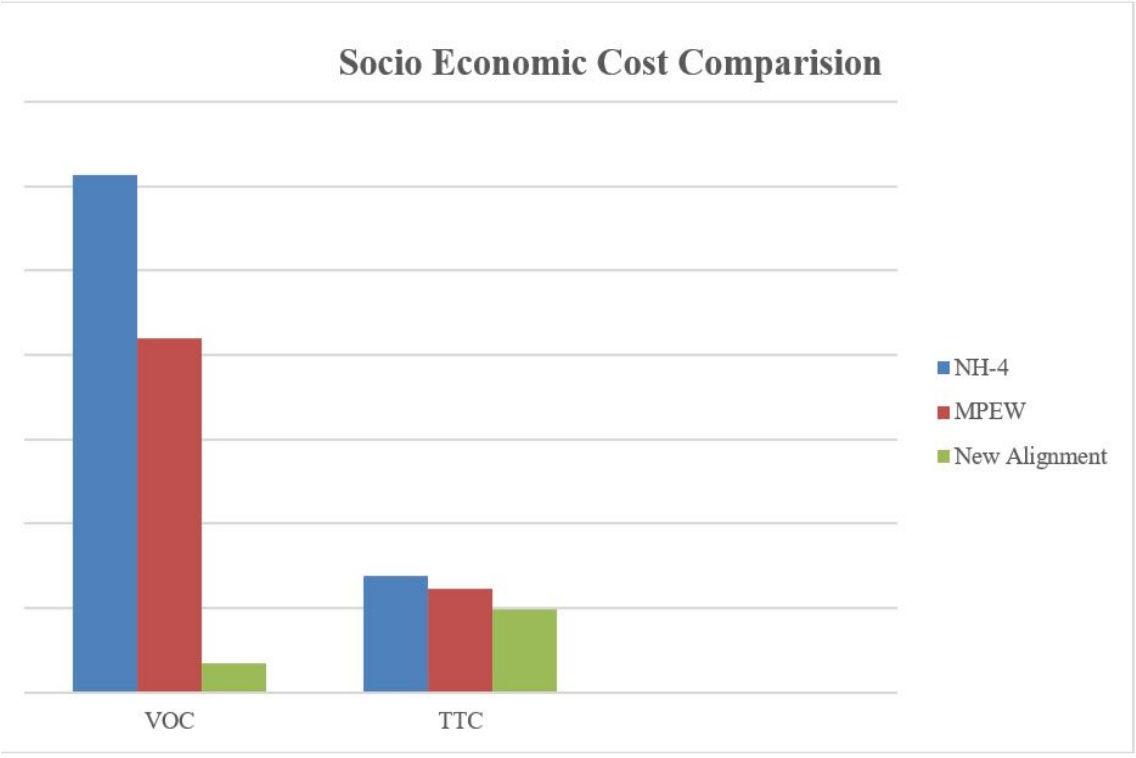


Figure 6.4: Graph of VOC and TTC comparison for 3 case studies

Other Expected Socio-Economic Impacts for Highway Projects:

Better road, free and fast movement of goods and traffic, direct link with the adjoining places of the cities will not only earn economic benefits to these cities but also bring in many more inputs towards social development. Some of socio-economic benefits of the project are being enumerated out as below.

- Travel times will greatly reduce and local communities will enjoy enhanced accessibility to socio-economic services (health centres, markets, employment opportunities), with reduction in travel time.
- Reduced travel times will reduce vehicle operating costs (VOCs) for local communities and auto rickshaw, bus, and truck operators, thereby reducing maintenance costs and increasing profits.
- More services will be available along the route (large/small buses, trucks/pickups, three-wheelers, etc.) via private and public sector operators. More frequent and better-quality services will be available around the clock.
- Income and employment opportunities will increase as a result of the diversification of commercial enterprises.
- Improved connectivity will give better access to opportunities in non-agricultural work, including the ability to commute every day.
- Opening of new enterprises with new job opportunities for locals.
- Roadside land values will increase as a result of better accessibility and new business opportunities in the area.
- Adequate road communication will link local communities to mainstream development programs.
- Local communities will be able to access the local government health centres and hospitals.
- Accessibility to educational institutes will encourage students to pursue higher education. Convenient transportation will increase social interaction and cultural bonding.

6.4 Closure

The chapter conclude that by comparing without project and with project scenario proves that with project scenario is more beneficial and comparison of VOC and TTC for all case studies gives socio economic benefits of project, also this chapter include other social benefits of this highway projects.

Chapter 7

CONCLUSION

7.1 General

The chapter comprises of the conclusions which are obtained after analysing percentage of EIRR and discussion of the results is carried out. Based on all scenario conclusion procured as in below section.

7.2 Conclusion

1. This research work uses internal rate of return method for economic evaluation of projects and for flexible economic decision process, there is software tool HDM-4, which is most widely used. Thanks to its complexity and flexibility to include high number of factors and selected economic inputs of road conditions, geometry, vehicle basic characteristics, their economic costs have found this tool as suitable.

2. The traffic analysis performance considers traffic composition and percentage of annual traffic growth for 30 years of benefit period from the opening year i.e., 2018.

3. For the present purpose, the viability has been established by assessing the Economic Internal Rate of Return (EIRR) and Net Present Value (NPV) using the discounted cash-flow technique for the NH-4, MPEW and New alignment. The EIRR has been compared with the accounting rate of return of 12 percent. As in all these scenario EIRR is higher than 12%, the proposed investment projects are economically viable.

4. Performing comparative analysis of VOC and TTC for all case studies shows socio economic performance of proposed new alignment proves more beneficial than others.

7.3 Future Scope

The proposed work provides analytical structure to examine the ability of a project to improve social welfare and decision making but not consider the factors for financial analysis. The future research will analyse profit, solvency, liquidity and efficiency from financial analysis and it will give more exact picture for managerial decision.

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LIST OF PUBLICATIONS ON PRESENT WORK

[1] Pratiksha Patil, Dhananjay S. Patil, "Economic Feasibility Analysis of Highway Project using Highway Development and Management (HDM-4) Model ", *International Journal of Engineering Research and Technology*, Vol. 9, Issue: 7, 2394-1529, July 2020. (Published)

Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 9 Issue 07, July-2020

Economic Feasibility Analysis of Highway Project using Highway Development and Management (HDM-4) Model

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***Abstract*— A well-developed transportation system plays vital role in economic development of the country. The huge increase in vehicular population creates traffic congestions on city roads. Thus, to reduce traffic bottleneck, creation of new road infrastructure as well as improvement of existing one has long term economic and social benefits. The economic benefits are calibrated on the basis of Economic Internal Rate of Returns (EIRR). The Mumbai and Pune are the major cities of Maharashtra state, due to economic and industrial development in those cities faces frequent and heavy traffic jam on highway connecting to both cities. The scope of present study consists of evaluating the impact on traffic and checking economic viability of the project. Strengthening and widening for six lanes flexible pavement which named as, Mumbai Pune section of NH-4. The HDM-4 is software used for checking the engineering and economic viability of the investment in this road project. It was observed that results obtained with improvement alternatives are economic viable.**

Keywords— Traffic congestions; Economic Internal Rate of Returns (EIRR); HDM-4 software; Economic viability; Social benefits.

I. INTRODUCTION

Highways are the dominant mode of transportation in India. Due to improvement in transportation network, reduction in transportation costs can be realized in numerous ways, such as reduction in travel time, decrease in vehicle operating costs, increased safety and reduction in the level of

II. OVERVIEW OF HDM-4

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. Following are the three main areas of analysis in HDM-4 which can be undertaken using the following applications: Project analysis, Programme analysis and Strategy analysis:

World Bank for the global use has developed it. Following are the three main areas of analysis in HDM-4 which can be undertaken using the following applications: Project analysis, Programme analysis and Strategy 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 project analysis can be done for maintenance of existing roads, improvement of existing roads, new construction, Stage construction, Project evaluation.
- Program Analysis: Multi-year rolling program for road network through maximization of NPV/Cost ratio. It deals primarily with the prioritisation of a defined long list of candidate road projects into a one-year or multi-year work programme under a defined budget constraint.


International Journal of
Engineering Research & Technology
ISSN : 2278 - 0181, www.ijert.org
(Published by : ESRSA Publications)
CERTIFICATE
OF PUBLICATION
This is to certify that
Pratiksha Patil
Has published a research paper entitled
Economic Feasibility Analysis of Highway Project using Highway Development and Management (HDM-4) Model
In IJERT, Volume 9, Issue 7 , July - 2020
Registration No: IJERTV9IS070384
Date: 25-07-2020
Chief Editor,IJERT

Analyse Effect of Maintenance and Rehabilitation on Flexible Pavement using HDM-4 Model

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Abstract— **The huge growth in vehicle population directly impacts on pavement deterioration trends. Road network deteriorates extensively due to the traffic and environmental factors which directly effects Vehicle Operating Cost (VOC). For well-developed transportation it is important to maintain existing road network and check economic viability of various maintenance and rehabilitation alternatives. The Highway Development and Management (HDM-4) is software used for taking decision to management by predict future economic, social, technical and environmental outcomes while taking the investment decisions. This paper has been aimed at studying the best maintenance and rehabilitation alternative on National Highway NH-4 at Maharashtra State. The most effective and economic maintenance strategy is determined and HDM-4 software proves an appropriate design tool for pavement with properly calibrated model.**

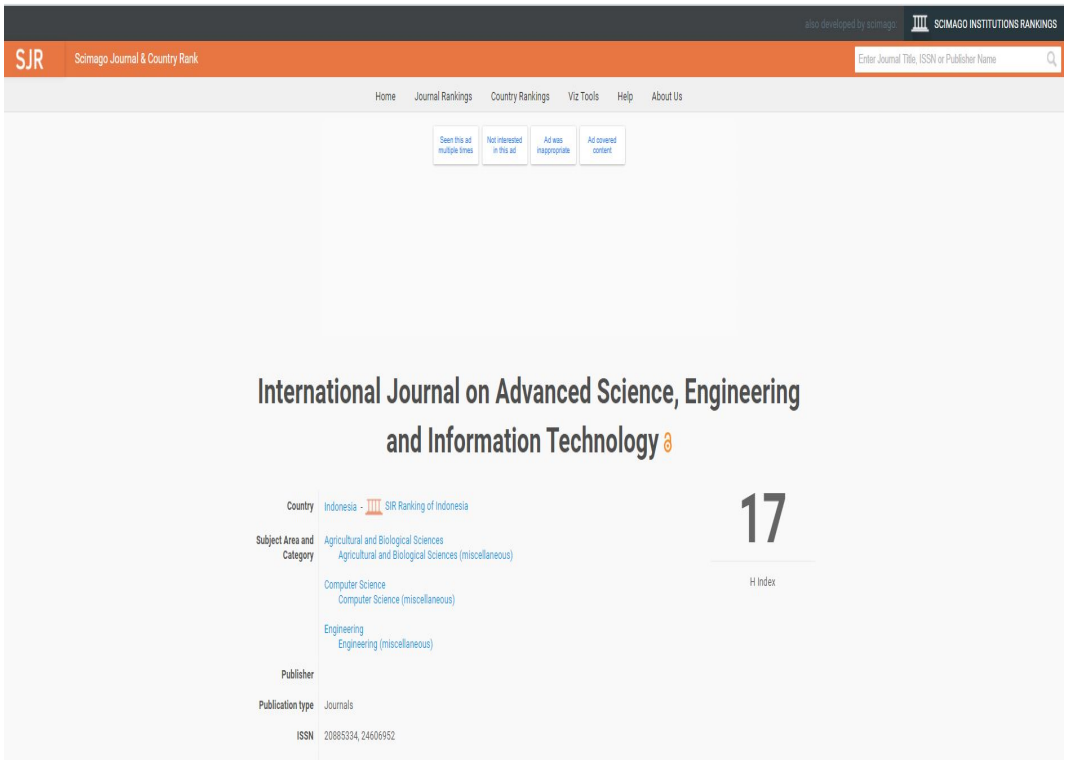
Keywords— **Maintenance and Rehabilitation, Economic Analysis, HDM-4 software**

I. Introduction

Road transportation plays a dominating role in the total transportation system of India. The road transportation system plays a key role in the economic and social development of the country. More preference is given to road transport because it provides easy access, flexibility, door-to-door service and reliability for both passengers as well as freight movement compared to other modes of

II. METHODOLOGY

The scientific methodology adopted for this research paper include data collection of selected road section and data analysis. This data includes all primary data, traffic data, previous road condition data and cost related data. The HDM-4 is software use this data at project level for 15 years analysis period. Selected road stretch is divided into four sections each of 15 KM according to their roughness and



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A

Synopsis Report On

"Economic Feasibility Analysis and Social Implication of Highway Project Using Highway Development and Management (HDM-4)"

Submitted

In partial fulfillment of the requirements for the degree of

Master of Technology

In

Civil-Construction Management

By

Ms. Patil Pratiksha Ramchandra

(Roll No. 1827008)

Under the Supervision of

Prof. D. S. Patil

(Head of Program, RIT Islampur)

Mr. Vinod Chougule

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Department of Civil Engineering

K. E. Society

Rajarambapu Institute of Technology, Rajaramnagar

(An Autonomous Institute, Affiliated to Shivaji University, Kolhapur)

2019 – 2020

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RAJARAMBAPU INSTITUTE OF TECHNOLOGY, RAJARAMNAGAR

(An Autonomous Institute, Affiliated to Shivaji University, Kolhapur.)

SYNOPSIS OF M. TECH. DISSERTATION

1. Name of Course	: M. Tech. Civil-Construction Management
2. Name of the Student	: Ms. Pratiksha Ramchandra Patil
3. PRN of Student	:1827008
4. Month of registration	: September 2019
5. Name of Guide	: Prof. D. S. Patil
6. Name of Co-Guide	: Mr. Vinod Chougule
7. Sponsored by	: Dhruv Consultancy Services Ltd., Navi Mumbai.
8. Proposed Title	: "Economic Feasibility Analysis and Social Implication of Highway Project Using Highway Development and Management Model (HDM-4)".

9. Synopsis of Proposed Work:

Introduction and Relevance:

Roads are the dominant mode of transportation in India. Roads carry almost 85 percent of the country's passenger traffic and more than 62 percent of its fright traffic. Due to improvement in transportation network, reduction in transportation costs can be realized in numerous ways, such as reduction in travel time, decrease in vehicle operating costs, increased safety and reduction in the level of air and noise pollution. In addition to reduction in transportation cost, it also increases comfort to passengers and also enhancing land value [Pavan R. Vyas, et. al. 2016].

A well-connected transportation network ensures a faster and more reliable travel times. This is important as time spent in traffic jam resulted in wasteful expenditure on fuel, out of pocket expenses as well as time which could have been utilized in other productive activities. A high-quality road network is important for high level of economic performance. It helps in sustained economic growth, increases the productivity, helps in increment in regional development and increases competitiveness. The infrastructure projects bring economic benefits in long-term by raising the productivity, innovation, lower prices, increases the income and overall creates more jobs thus bring more boom to the economy. A well-plan transportation network helps the business to expand. It allows businesses to manage their inventories and transport goods more cheaply and efficiently as well as access a variety suppliers and markets for their products making it more making it more cost-effective for manufacturers to keep productions in and out Thus, the priority to reduce the infrastructure bottleneck is important for any government. This requires

creation of more and more road infrastructures and maintenance of the existing one [Dr. Dipti Rajan, 2015].

The decision-making process for development of best suitable infrastructure strategy for highway section suffers from lack of customized economic evaluation tools. The Word Bank's Highway Development and Management Tool (HDM-4), developed by the International Study of Highway Development and Management (ISOHDM) funded by World Bank, presents a good frame work for economic evaluation of road investments on improvements.

About Study Area: For economic analysis of Mumbai Pune Expressway (presently known as Yashwantrao Chavan Expressway -YCEW), this research work will show comparison between three alternative routes which are:

i) Existing Four lane alignment in the ghat section of stretch 24 km.

ii) New alignment of 12 km with tunnel and viaduct.

iii) Widening to 6 lanes of existing route of stretch 24 km.

Literature Review:

1) **Mohammadsina Semnarshad. al. (2018) "Evaluation of the Effects of Maintenance and Rehabilitation Projects on Road User Costs via HDM-4 Software"**

   This paper includes the calculation and comparison of Road Agency Costs (RACs) with Road User Costs (RUCs) resulted from certain types of M&R interventions on a selected roads network located in eastern part of Iran. HDM-4 was used to carry out economic analysis using localized data and calibrating the software as well as collecting the required information, long-term effects of preservation alternatives associated with their costs. To collect the distresses on the selected road network, the procedure presented in ASTMD6433 was used. According to the standard, the area of 230±90 square meter has been specified for a sample unit. Results showed that RUCs were approximately 10 times higher than RACs on each route of selected road network. It was concluded that vehicle fuel consumption was in direct relationship with pavement roughness.

2) **Pavan R. Vyas, et. al. (2016) "Project Level Analysis using Highway Development and Management Model (HDM-4): A Case Study"**

   The author states that HDM-4 is a support system for taking decision by highway administrators and engineers by predicting the economic, social and environmental impacts which might occur while making the investment decisions. This paper includes a case study of road section of a State Highway SH5 in Karnataka State.

The decision-making process for selection of maintenance and rehabilitation strategy rehabilitation strategy for road section suffers from lack of customized economic evaluation tools. The Word Bank's Highway Development and Management Tool (HDM–4), developed by the International Study of Highway Development and Management (ISOHDM) funded by World Bank, presents a good frame work for economic evaluation of road investments on maintenance.

This study includes collection and analysis of functional condition and structural condition data of the road section under study. The previous maintenance and rehabilitation data, Traffic data, and other cost related data are obtained from secondary sources. Using the above data, a Project level analysis id carried out in HDM – 4 software form 10 years. The obtained results are analyzed and the final optimum strategy for each rad section is decided based on the economic indicators like IRR and Net Present Values/ Cost ratios.

3) **Ing. Radan Tomek et al. (2016), "Improvement of Economic Effectiveness of road highway projects."**

The author studied deficiencies in the current investment decision process to the highway network and with the major problems and in effectivities in the consecutive phase of realization. The approach of this research paper is to reveal the possibilities to improve effectivity of realization phase through proposal of the very concrete measures. This paper depicts the current road infrastructure situation in the Czech Republic, local state offices and agencies and uses local transport infrastructure data. The author analyses global experience and its findings aspire to be of general validity and applicability. The author concluded that evaluating competing bids on the basis of the investor's own flowless control budget and rejecting those bids of the abnormally low or high values by a pre-set strict rule. Also he concluded that the execution of own technical supervision i.e. none outsourcing being acceptable for this task.

4) **Dr. Dipti Ranjan Mohapatra et al. (2015),"An Economic Analysis of Improvement of Road Infrastructure : A Case Study"**

The author studied about transportation network. Traffic congestions are major bottleneck of smooth functioning of a city transportation network. The sensitivity analysis also proved the economic viability all the projects. Overall the proposed investment programs are economically viable. In this paper a benefit-cost analysis has been carried out to find out the economic viability of road infrastructure improvement projects in the city of Chandigarh. The author concluded that the EIRR (Economic Internal Rate of Return) has been compared with the accounting rate of 12%. The annual cost and benefit streams are used to derive the net cash

flow for the project. For the present purpose the viability has been established by assessing the EIRR and Net Present Value (NPV) using the discounted cash-flow technique for the flyover/bridge/underpass projects respectively. A sensitivity analysis was carried out to test the economic strength of the project.

5) **B. Malsawmkima et al. (2015), "Impact of road construction on the socio-economic condition of the communities in the hilly terrain of Lunglei district, Mizoram, India."**

Roads are the major means of transportation and communication. The author studied that the impact of roads and road construction on the socio-economic status of community directly within the project site. Author studied and analyzed pre-construction and post-construction conditions of the community through collection of various parameters. The study revealed that the construction of roads not only improves the livelihood community but also increases the number of educational institutions and health centers as well. Author concluded that the construction of proper road channels increases the efficiency of import and export of goods and services to a great extent. The increased in number of educational institutions as a result of this project also improves the literacy of villagers.

6) **Shah Yogesh U. et. al. (2014) "Adaptation of HDM-4 Tool for Strategic Analysis of Urban Roads Network"**

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 analysis was carried out to maximize the net present value (NPV) and minimize the costs to achieve a desirable target international roughness index (IRI). Min areas of analysis in HDM-4 include Project analysis, Program analysis and Strategy analysis. Data collection for all pavement sections was aimed to meet the requirements of HDM-4 input system. The process of data collection was classified as Road Network Data, Vehicle Fleet Data and Maintenance and Rehabilitation Works History. This analysis presented the need for the optimal capital and recurrent maintenance required to maintain the urban road network in serviceable condition. It was found that the urban roads can be managed and maintained effectively using the strategy application of HDM-4.

7) **Ross B. Corotis (2007), "Highway User Travel Time Evaluation"**

In this paper the improved highway network is how to benefit to society is studied of which the reduction of travel time is one of the most important. A full life cycle of cost assessment of project requires a future savings in travel time projected over

a project's life time. The author has investigated an alternative approach to the very important valuation of user time which is beneficial for the new projects and cost items during construction and maintenance. Author hypothesized in this paper that the amount of work time remains relatively independent of commuting time and instead of amount of time left for other activities is directly affected. Author discussed some issues in this paper include regional differences and discounting. This paper suggests that the lifestyle actions taken by individuals differ greatly under those different circumstances. The value of user travel time is a very important aspect of transportation project and must be included.

Research Gap:

The above researches do not consider alternative routes for highway development project. These mentioned researches have considered maintenance and improvement strategies for selected highway case studies. But by considering future traffic growth, there is need to develop highways for carrying traffic. Modification and implementation of alternative options can be useful for controlling the heavy traffic demand on major transportation routes. These proposed alternatives must be economically viable and also achieves social benefits.

Problem Statement:

The most important aspect which effects on highway construction is economical returns of project. The project aims to study economic benefits from the investment. Also help in raising the welfare of society. So, this project aims to use suitable strategy for economic analysis using HDM-4 software and states the social benefits from project.

Proposed Objectives:

Following are the objectives of the proposed work,

1. To choose the economic parameters for economic analysis of highway projects.
2. To perform traffic analysis for application on Highway Development and Management (HDM-4) software.
3. To analyze economic viability of proposed alternatives in terms of economic internal rates of return by HDM-4 software.
4. To perform comparative analysis and show socio-economic benefits of proposed alternatives from results obtain.

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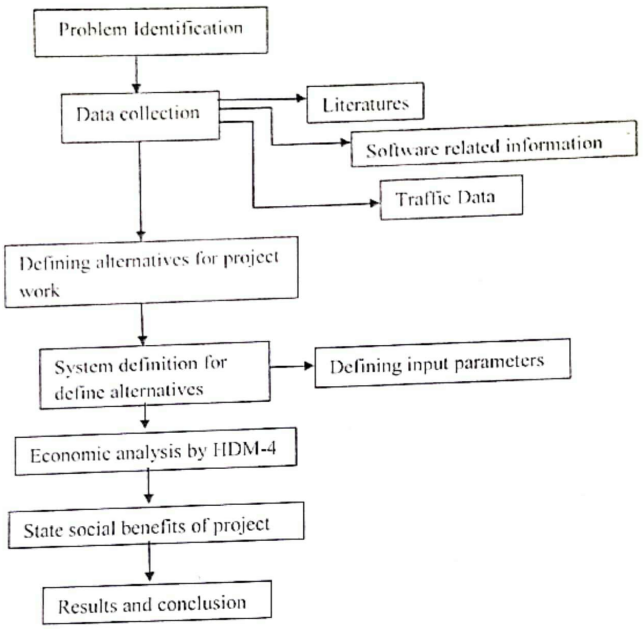
Proposed Methodology:

To meet the objectives of dissertation work following methodology has been proposed.



Plan of Proposed Work:

Phase-I (July-Sept 2019)

a) Study of literature related to economic analysis for transportation project.
b) Collecting literatures and information of HDM-4 software.
c) Deciding study area for research work.

Phase-II (Oct-Dec 2019)

a) In-detail learning of HDM-4 software.
b) Collection of data of traffic, accidents and the data of various survey.
c) Defining the inputs required for three different alternatives.

Phase-III (Jan-March 2020)

a) Economic analysis of three alternative routes through HDM-4 software.

Phase-IV (April-May 2020)

a) Results i.e. comparison between alternatives on the basis of obtain EIRR value and define socio-economic benefits of alternative.
b) Conclusion and Report writing.

Following table shows the expected time required to complete phase work.

Activity	Month (July 2019 to June 2020)												
	JUL	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL
Phase I	←	—	→										
Phase II			←	—	—	—	→						
Phase III							←	—	—	→			
Phase IV										←	—	→	

10. Facilities Available:

The following facilities to carry out experimental and software work are available at Dhruv Consultancy Services Ltd., Navi Mumbai and Rajarambapu Institute of Technology, Rajaramnagar.

1. College central library for refer journals and books.
2. Digital library for refer literature from national and international journals.
3. Departmental computer lab for structural software.
4. External Source-Dhruv Consultancy Services Ltd., Navi Mumbai.

11. Expenditure for Project

- The whole expenditure for the project will be sponsored by Dhruv Consultancy Services Ltd., Navi Mumbai.
- The Material, equipment's and software's will be sponsored by the same.

12. Expected Date for Completion of Work: - Jun 2020

References:

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Project report

ORIGINALITY REPORT

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6	Jana Korytárová, Vít Hromádka. "The Economic Evaluation of Megaprojects – Social and Economic Impacts", Procedia - Social and Behavioral Sciences, 2014 Publication	1%


Writer
INTRODUCTION
1.1 General
Roads are the dominant mode of transportation in India. Roads carry almost 85 percent
of the country's passenger traffic and more than 62 percent of its fright traffic. Due to
improvement in transportation network, reduction in transportation costs can be realized
in numerous ways, such as reduction in travel time, decrease in vehicle operating costs,
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More...
increased safety and reduction in the level of air and noise pollution. In addition to reduction in transportation cost, it also increases comfort to passengers and also
Repeated Word
enhancing
land value [1].
A well-connected transportation network ensures a faster and more reliable travel time.
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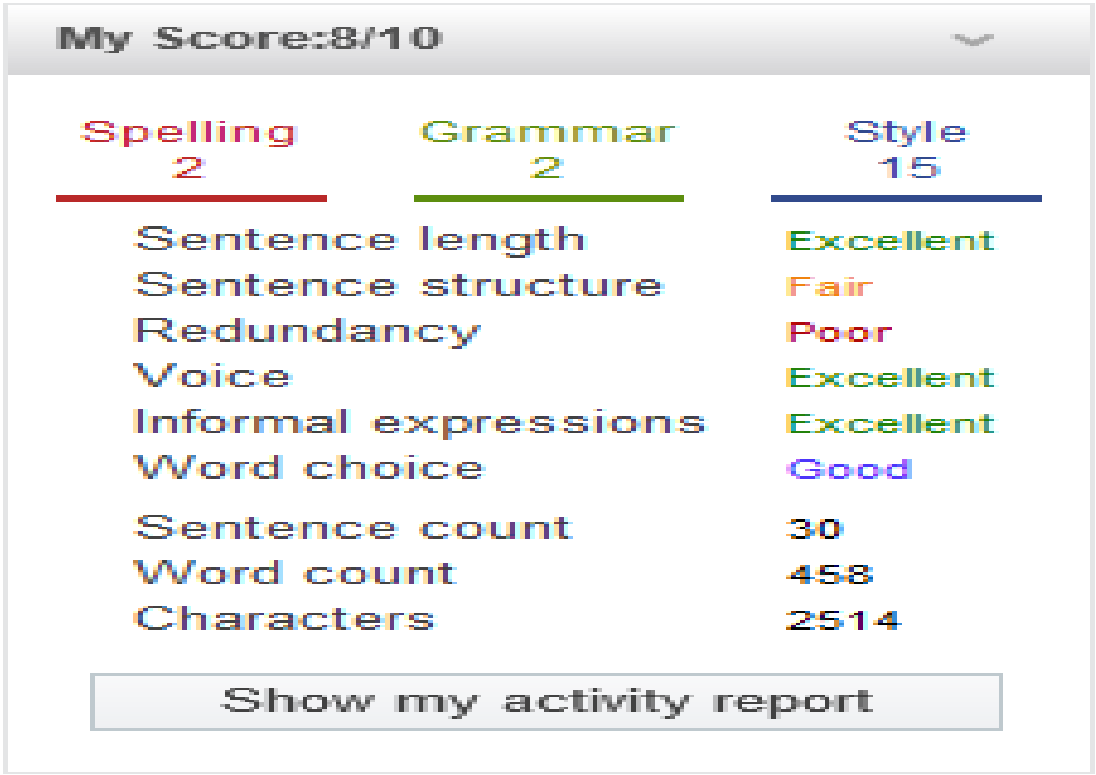
This is important as time spent in traffic jam resulted in wasteful expenditure on fuel, out


My Score:8/10
Spelling
2
Grammar
2
Style
15
Sentence length
Excellent
Sentence structure
Fair
Redundancy
Poor
Voice
Excellent
Informal expressions
Excellent
Word choice
Good
Sentence count
30
Word count
458
Characters
2514
Show my activity report

is
The following are the parameters required for the economic analysis of a highway project.

4.3.1 Analysis Period

Analysis period includes the construction period as well as the benefit period.

4.3.2 Project Cost

Construction cost for economic analysis includes Land Acquisition, Resettlement & Rehabilitation, environment and utility shifting a cost along with civil construction cost.

4.3.3 Road and Pavement Characteristics

Road and pavement characteristics that are used for economic analysis include road

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length, carriageway width, width of paved shoulders, existing pavement composition,

sub-grade CBR, roughness of the existing road (IRI), structural number and cracking,

raveling and other pavement distress parameters.

4.3.4 Routine and Periodic Maintenance Cost

VITAE

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