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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 environmental pollution. Improvement of highway network 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.

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.

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.
- Strategic Analysis: Analysis of whole network for long term planning under different budget scenarios.

III. STUDY AREA

General

Mumbai and Pune cities situated at western part of Maharashtra and is a section of NH-4 as shown in *"Fig. 1"*, having total length of 111 Kilometre. The project road lies between 18°55' longitude and 72°54' latitude.

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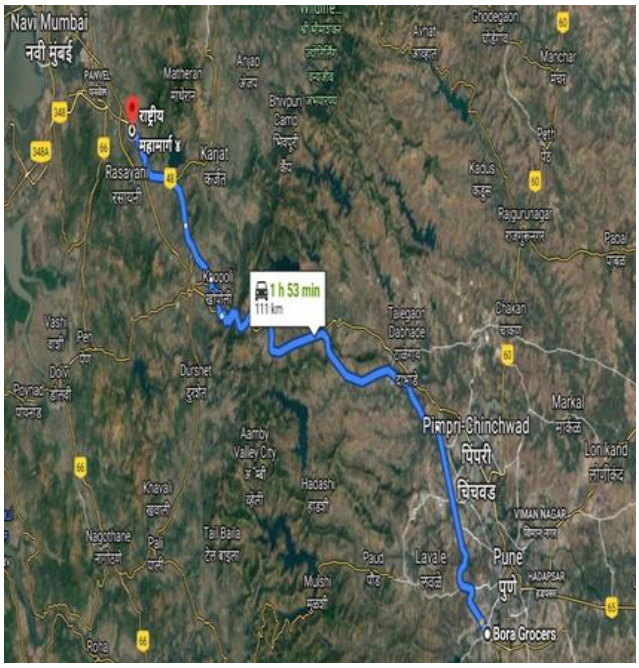

Fig. 1. Google Image of Study Area

Climate

Climatic condition parameters are represented in Table I.

TABLE I CLIMATE PARAMETER VALUES

Parameters	Value
Temperature range	20.7-35.8
Moisture Classification	Arid
Yearly Precipitations	1445 mm
Typical Moisture Index:	62-70

IV. INPUT DATA

The input data for HDM-4 Model consists of various parameters which are classified as below,

Road Network Data

The road network data included road Inventory data, road geometric details, structural evaluation, pavement condition and evaluation of pavement material as given in Table II.

TABLE II ROAD NETWORK DATA

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

Vehicle Fleet Data

The vehicle fleet data included the collection of traffic volume count & growth factors, basic vehicle characteristics and economic cost details of vehicles and as shown in Table III, IV and V respectively.

TABLE III TRAFFIC VOLUME COUNT & ANNUAL GROWTH RATE

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

Project Analysis

In set up to the analysis, the Base Case (Without improvement) is compare With improvement i.e. strengthening and widening to six lanes with paved shoulder of flexible pavement is confirmed and a discount rate of 12 percent is specified. While running the project analysis, comparison is done against the Base Case, and reports are generated.

V. SOCIO ECONOMIC BENEFITS

The main of objective of the project is to improve the performance of the highway network. Some of expected socio-economic benefits of the project are being enumerated out as below:

- All the road users will benefit from the proposed improvement through increased comfort and reduced travel time.
- The society will benefit economically from the saving in vehicle operating costs due to enhanced speed and better geometric.
- The project also will open up the areas adjacent to the project road to increased economic activity.
- Local communities will have greater access to public infrastructure and increased mobility through enhanced transport facilities.

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TABLE IV VEHICLE FLEET BASIC CHARACTERISTICS

Vehicle Type	Two-Wheeler	Car / jeep	LCV	Mini bus	Trucks (2 Axle)	Govt. Bus	Private Bus	Trucks (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	≥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 V ROAD USER ECONOMIC COST DATA FOR REPRESENTATIVE VEHICLES

Name	Two-Wheeler	Car / jeep	LCV	Mini bus	Trucks	Govt. Bus	Private Bus	3 Axle	MAV
New Vehicle Cost	50000	600000	400000	1000000	1200000	1800000	2200000	1500000	2000000
Tire Cost	1500	5000	3500	10000	14000	20000	25000	18000	18000
Fuel (per liter)	76	76	70	70	70	70	70	70	70
Lubricating Oil (per Liter)	100	150	150	150	150	150	150	150	150
Crew Wages (per hr.)	0	50	70	70	70	70	70	70	70
Annual Overhead	1400	240000	120000	450000	360000	540000	660000	450000	600000
Cargo Holding (per hr.)	0	0	8.42	0	26.31	0	0	58.34	58.34
Passenger Working (per hr.)	75	218.7	0	145.8	0	121.48	130	0	0
Passenger Non-working (per hr.)	20	49.35	0	32.9	0	27.4	32.5	0	0

VI. RESULTS & CONCLUSION

This research paper deals with checking economic feasibility of highway project. As it is important to evaluate economic efficiency of road construction for decision maker to decide whether the proposed is credible of investment keeping in view of social benefits. The proposed project road strengthing and widening from 4 lane flexible pavement to six lanes of Mumbai-Pune section of NH-4. In order to find results both options of Without improvement and with improvement are compared with each other. However, economic analysis is also recommended that analysis period should not be too long, that it may find inaccurate results, so 20-year analysis period is considered. The summary of Economic Internal Rate of Return (EIRR), as investment option for life cycle cost analysis is presented in Table VI and output summary of economic analysis is as shown in Fig. 2.

TABLE VI RESULTS OF ECONOMIC ANALYSIS

Section Name	Net Economic Benefit (12% Discounted Rate)	Economic Internal Rate of Return (EIRR)
Mumbai Pune Section of NH-4	23,834.62	24.5%

As generated results shows Economic returns are acceptable for all components and calculated Economic Internal Rate of Return (EIRR) is more than 12% which is benchmark for rate comparison and substantially proves the project is economically viable for proposed improvement. Furthermore, the Highway Development & Management (HDM-4) tool can forecast budget allocation over entire analysis period and plays important role in selection of optimum budget constraints.

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HDM - 4
HIGHWAY DEVELOPMENT & MANAGEMENT

Economic Analysis Summary

Study Name: **Widening of Mumbai – Pune Section of NH-4**
Run Date: **22-06-2020**

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	72,150.00	1,424.62	0.00	113,871.80	97,477.95	0.00	0.00	0.00	137,775.15
Discounted	12,933.62	782.18	0.00	30,668.23	6,882.19	0.00	0.00	0.00	23,834.62

Economic Internal Rate of Return (EIRR) = 24.5% (No. of solutions = 1)

Fig. 2. Output Summary of Economic Analysis

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