Implementation of Infrastructure development technologies -A Case Study

Mr. Anand Akotkar[1], Mr. Rutvik Sadatkar[2], Mr. Pratik Bhande[3], Mr. Nilesh Patil[4], Mr. Krushna Karale[5]

U.G. Students, Department of Civil Engineering & Management [1,2,3,4,5]
P. R. Pote (Patil) College of Engineering & Management, Amravati, India, Amravati, India

ABSTRACT: Humans settled at one place after agriculture and slowly civilizations were formed. After urbanization, civilizations were differentiated into two categories i.e. rural and urban. Cities started growing at a rapid pace and soon enough need of communication was at peak. India has one of the oldest railway networks in the world but still the preferred mode of transport is roadways. More than 80% of the passenger traffic and 65% of the freight traffic is carried by the national highways of India. The current road network in the country is not enough to fulfill the need of growing traffic and hence a lot of highways are being upgraded. At the same time, various new expressways or economic corridors are being constructed across the country. The aim of the Maharashtra Samruddhi Mahamarg is to create connectivity to the last mile with best public transport facilities for quick and easy movement of people and goods. The expressway will enable a large population to have easy access to major centers in Maharashtra for a wide range of self-employment and wage employment opportunities, business, trade, education, health care and other necessary services.

KEYWORDS: **Infrastructure development, route alignment, travel time, technologies.**

I. INTRODUCTION

1.1 General

Road transportation in India is an important part of a national economy. Development of a country depends on the connectivity of various places with adequate road network. Roads are the major channel of transportation for carrying goods and passengers. They play a significant role in improving the socioeconomic standard of a region. Road constitute the most important mode of communication in the areas where railways have not developed much and form the basic infrastructure for the development and economic growth of country. The benefits from the investment in road sectors are indirect, long term and not immediately visible. Roads are important assets for any nations. The expressway will pass through ten districts, namely Nagpur, Wardha, Amravati, Washim, Buldhana, Aurangabad, Jalna, Ahmednagar, Nashik and Thane. It will connect Nagpur to Mumbai and have direct connectivity with the country's largest container port - JNPT. This will connect another fourteen districts, namely Chandrapur, Bhandara, Gondia, Gadchiroli, Yavatmal, Akola, Hingoli, Parbhani, Nanded, Beed, Dhule, Jalgaon, Palghar and Raigad. In this manner, a total of twenty-four districts in Maharashtra will be connected via this expressway.

1.2 Need

Development of infrastructure within the country has progressed at a rapid pace, and today there is a wide variety of modes of transport by land, water and air. The State of Maharashtra has a transportation network consisting of railways, roadways and airways, which form the lifeline for the economic and social activities of the state. Road transport is a dominant mode in the State for the transport of goods and for the movement of passengers. Mumbai is the capital of Maharashtra, and Nagpur is the second capital and is the third largest city in Maharashtra after Mumbai and Pune. Presently following three routes are available between Mumbai and Nagpur.

Route 1: National Highway NH-6 from Nagpur-Amravati-Akola-Dhule and thereafter following NH-3 from Dhule-Nashik to Mumbai. (Route length @ 790 Km)

Route 2: Nagpur-Buti-Bori-Karanja-Mehkar-Sindhkhedraja-Jalna-Aurangabad- Sinnar-Ghoti–Mumbai, also known as the NASGM Road developed by MSRDC. (Route length @ 760 Km)

Route 3: Nagpur-Amravati-Akola-Khamgaon-Chikhli-Aurangabad-Pune-Mumbai. (Route length @ 800 Km)

Currently, the travel time between these two major cities is more than 14 hours (Nagpur to Vadape).

The proposed Access Controlled Expressway would have a huge impact on development of the areas along the proposed corridor. Industrial Areas at ButiBori, Aurangabad, Jalna, Sinnar-Ghoti, and Thane between Nagpur and Mumbai, which are major growth areas along the desired corridor, would get faster and better connectivity. Growth and development of Towns/cities of Butibiori, Wardha, Pulgaon, Karanja, Malegaon, Mehkar, SIndhkhedraja, Jalna, Aurangabad, Shirdi, Nashik, Sinnar-Ghoti will have a positive impact. Connectivity from Mumbai/Nagpur to Regional Headquarters (Revenue divisions) of Nagpur, Amravati, Aurangabad, Pune, Nashik and Konkan will improve considerably. In addition to the connectivity, the proposed Expressway would have a direct impact on the development of the under-developed regions in Marathwada and Vidarbha in Maharashtra State. The proposed Access Controlled expressway would cater to the need to reduce travel time and ensure faster communication between all the above said towns/cities.

1.3 Objectives

Government of Maharashtra has entrusted Maharashtra State Road Development Corporation Ltd., (MSRDC) to undertake the development of the Nagpur – Mumbai Super Communication Expressway with Access Control for a length of about 706.209 km. The proposed Expressway with Access Control will be a Greenfield alignment with a design speed of 150 Kmph. This will reduce the travel time to almost half of the current travel time.

• To study the current highway networks.

• To identify the causes of delays in Transportation of National Highways.

• To Study the various technologies used in the construction of samruddhi mahamarg.

1.4 Key features

• The expressway will be 701 km long, directly connecting ten districts, twenty-six talukas and around 392 villages.

• It will have a speed limit of 150 km which will bring Nagpur and Mumbai within 8 hours reach.

• The expressway, having a total width of 120m with a central median of 22.5m will follow the international standards

of design. There will be 8 lanes, 4 on each side.

• It will have service roads on both sides that will connect through underpasses.

• The expressway will be a Zero Fatality Mahamarg, it will have CCTV surveillance and free telephone booths at every

5 km.

1.5 Route Alignment

The Mumbai-Nagpur Expressway will travel through 10 key districts directly and 14 districts indirectly via feeder roads, 24 Talukas, and 392 villages. The 10 main districts are Nagpur, Wardha, Amravati, Washim, Buldhana, Jalna, Aurangabad, Nashik, Ahmednagar and Thane. The other 14 districts include Chandrapur, Bhandara, Gondia, Gadchiroli, Yavatmal, Akola, Hingoli, Parbhani, Nanded, Beed, Dhule, Jalgaon, Palghar and Raigad.

1.6 Construction details

To expedite the pre-construction work on the expressway, MSRDC decided to divide the construction work into 5 packages and hired a separate consultancy firm to prepare the Detailed Project Report (DPR) for each package. On 31 May 2017, the Government of Maharashtra incorporated 'Nagpur Mumbai Super Communication Expressway Limited', a special purpose vehicle (SPV) to manage the financial requirement for the construction and operation of this project. The construction work of 701 km long Mumbai–Nagpur Expressway is divided into 16 packages, with work awarded to 13 different contractors including Afcons Infrastructure, Larsen & Toubro (L&T) and Reliance Infrastructure.

II. RELATED WORK

The study is carried by various researches related to samruddhi mahamarg and construction process of Expressways & Highways are described below:

- **Richard Kim** (North Carolina state university, USA-Journal of traffic and transportation Engineering Provides a platform for the exchange and discussion of novel and creative ideas on theoretical and experimental research in the field of transportation. In the journal of traffic and transportation he introduces the scope of-Road engineering, bridge and tunnel engineering, Automotive Engineering, design, manufacture and operation of vehicle. Analysis, operation, optimization and planning of transportation system & network. Travel behavior, information technology, traffic control and traffic flow theory. Economics, safety, and management of transportation. Material science.
- **Prof. Ahsan rabbani, et.al** - Studied different parameters for designing rigid pavements. The hypothesis performed includes relationship between time and deflection for different truck speed and effect on compressive and flexural strength with steel fibers in rigid pavements. Study of compressive strength with eco-friendly material like fly ash is carried out in rigid pavements. Hypothesis reveals cost benefits in pavement if UFS (Used Foundry Sand) are used as an ingredient for M-20 mix design concrete. Relationship between various physical-mechanical characteristics of recycled aggregates and calculation of relationship between nodal deflection and pavement thickness are also studied.
- **Manohar K M, et.al** (Department of Highway Technology VTU regional center kalaburgi)(2018) - The rigid pavements which are made up of concrete shows some detrimental structural characteristics such as a very low tensile strength, limited ductility, little resistance to cracking, brittle failure mechanism in tension etc. Due to these undesirable characteristics of concrete, generally the reinforcement is provided in the form of continuous steel bars placed in the concrete structure in the appropriate positions to withstand the imposed tensile and shear stresses. Rigid pavement is those which contain sufficient beam Strength Bridge over the localized sub-grade failures and areas of in adequate support.

III. METHODOLOGY

The field surveys and investigations were performed to understand the terrain profile and features of the project corridor.

3.1 Topographic survey

The basic objective of the topographic survey was to collect the essential ground features such as the land use, topography, natural and manmade features along the alignment approved by MSRDC. The data collected was constructive for the detailed design and for the computation of quantities. To undertake the Topographic Survey of the area in earliest possible time, and to get a more comprehensive visual representation of the project area, it was proposed to use the Aerial Vehicles (Drone) to collect the Topographic Data of the Area, and using it to produce topographic maps of the area. For conducting

topographic survey using Drone, Primary Ground Control Points were established at site using DGPS. The GCPs were uniformly distributed across the area in order to maintain uniform level of accuracy across the survey area. For this project, the arrangement adopted for putting GCPs on the ground at approximately 500 m interval in a crisscross manner.

3.2 Reconnaissance Survey

To carryout reconnaissance survey, Consultant's team of Senior Engineers belonging to relevant disciplines was deputed to site. A detailed visual inspection of the project road was done and the required details were recorded. These details include broadly as under:

- Topographic features of the area
- Access-control measures
- Proposed Service Road locations
- Traffic pattern and preliminary identification of traffic homogenous links
- Inventory of major aspects of existing road
- Roadway Width and ROW
- Grade Separators, Bridges & Culverts
- Intersections
- Waterlogged/ Overtopped areas
- Erosion potential/ landslide prone areas
- Widening options proposed for existing structures;

The General Land use is predominantly Agricultural with main crops being Cotton, Jowar, Wheat, Orange (fruit), Soybean, chana dal and Tur dal apart from other crops/horticulture in this region.

3.3 Hydrological and Hydraulic Investigation

To understand the drainage pattern of the area and its Hydrology, following studies were conducted,

3.3.1 Field visits to the catchment areas of major rivers.

3.3.2 Study and review of MRSAC maps

3.3.3 Study and review of Topo sheets of all the streams and rivers crossing the alignment

3.3.4 Study and review of Satellite images.

3.3.5 Study of rainfall patterns and data including maps.

3.3.6 Existing span arrangements of upstream & downstream sides of proposed bridge location in the same stream. 3.3.7 Tentative drainage area to be served by the CD structures. Information obtained from Satellite Images/MRSAC maps & 1:50,000 scale SOI topo sheets covering catchment boundaries of bridges.

3.4.8 Number of CD structures (2 structures per km) obtained from as build drawings from Karanja to Malegaon, Package-, have been kept in mind while proposing CD structures in proposed expressway.

It has also been kept in mind that rain water from expressway & from ROW would not be discharged into the canals. One culvert at deepest point between two canals has been provided to discharge rain water to the either side of expressway from a catchment area covering by two canals & proposed road.

3.4 Geotechnical Investigation

Sufficient information about the arrangement & behaviour of the underlying materials and their physical properties for adopting and designing the structural foundation is hence essential. Soil exploration through field investigation and laboratory testing of the substrata are helpful in arriving at required parameters for designing of safe and economical foundations.

3.5 Traffic Surveys

To capture traffic flow characteristics, travel pattern, speed characteristics, users' preference regarding toll imposition on traffic passing through the project road and other characteristics related to miscellaneous requirements on the project road, following primary traffic surveys were conducted.

- Classified traffic volume count (CTVC) by videography
- Origin – destination survey (OD)
- Axle load survey
- Turning movement survey (TMC)
- Speed and delay study

3.6 Land Acquisition Cost

MSRDC had planned for land pooling during the initial phase of DPR study. Under this scheme, raw land was supposed to be pooled from land owners and farmers with a commitment in the form of fixed annual compensation to them along with promise to return 25% of pooled plot as developed land. Krishi Vikas Kendra (Node) were planned along the Nagpur Mumbai Expressway and annual compensation was supposed to be given till the time Node Development is complete. However as the DPR study progressed, it was observed that land pooling is complex and time consuming and it is not feasible to pool large hectares of land in a stipulated time. Hence it was decided by MSRDC in consultation with concerned stakeholders to follow the Land Acquisition approach as it was less complex and relatively a quicker process as compare to pooling. Estimates were prepared to acquire land for the expressway to understand requisite financials. For package two, the cost of acquiring land has been estimated at 1712 Crore.

IV. CONSTRUCTION DETAILS OF SAMRUDDHI MAHAMARG

4.1 Material

1) The cost of materials like murum (soil), aggregates and sand includes the basic cost at source, transportation charges to work site, loading and unloading charges, etc. While estimating lead of materials, for the material lead MSRDC has advised to adopt the following vide MOM dated 12.12.2017, 26.12.2017 and 27.12.2018

i. Borrow earth (murum) for embankment construction, the lead charges shall be adopted as 2.5 km from Borrow area to site.

ii. Bitumen will be supplied in bulk from refinery in Port Mumbai, while cement will be ordered in bulk from the manufacturers or nearby vicinity of the site.

iii. Crushed stone aggregate would be transported to the Hot Mix / Batching Plant site within a lead of 5 km. The lead for bituminous material as well as GSB / WMM / Cement – Concrete works has been considered about 10

km from plant to site for Construction Package-3 to Construction Package 7.
2) The specifications of materials shall be governed by section 1000 of MORTH Specifications for Road and Bridge Works.
3) Cement to be used in structural items considered for estimates is 43 grade OPC

4.2 Adopted Unit Rates

The Rate analysis has been carried out as per the detailed procedure mentioned above. The Basic rates for various materials adopted for rate analysis are as per the rate in PWD DSR Amravati 2016-2017. The Base rates are listed below.
1. Cement (incl. tax) = Rs. 4200/MT excluding GST
2. River/natural Sand = Rs. 1500/ cum (As per SSR 2017-18)
3. Reinforcement Steel = Rs. 33425 / MT.
4. Bitumen (excluding GST) = Rs. 24441/MT (calculated as per lead and basic rate ex-refinery, Mumbai)

The item-wise detailed Rate Analysis based on the SSR PWD 2017-2018 dated 22.09.2017 based on the MOM circulated by MSRDC dated 12.12.2017,26.12.2017 and 27.12.2018 is attached in Volume-VI as - Rate Analysis. A Specifications for Implementation of Project Road For arriving at unit rates for items of works, the specifications / amendments, unless otherwise specified, generally conform to the stipulations made in "Specifications for Road and Bridge Works" of MoRT&H – 5th Revision; relevant IRC codes wherever applicable and Bureau of Indian Standards which are detailed in Specification Volume.

B. General Road Cross – Section Requirements Based on requirements of the project road, different types of cross sections are designed by the consultants. The detailed descriptions and Drawings for the Cross Sections are as per the Manual of Specifications and Standards for Expressway IRC:SP:99-2013. The provision of service road is considered as per the requirement of Manual. The proposed Concrete carriageway configurations for the Expressway consist of the following requirements.
1. Concrete Carriageway Six Lane=11.25 x 2 = 22.5m
2. Concrete Paved Shoulder 3 x2 = 6.00m
3. The Proposed Median = 15.0Mm
4. Earthen Shoulders = 2.0 m
5. Service Roads = 3.75 to 7.00m
6. Camber for Paving = 2.0%

4.3 Rigid Pavement Design

Rigid pavement has been designed for the critical stress condition. Stresses due to combined action traffic load and temperature differential between the top and bottom surface of the slab is considered for the design of concrete slab. Fatigue damage analysis is done for two stress combination. Bottom up cracking – Load + Positive temperature differential top down cracking – Load+ Negative temperature differential. The design parameters considered are summarized below in given table.

Table 01-Design Parameters

Design Parameters	
Design life	30 Years
Traffic	8327
Temperature differential, ^{o}C	21
Flexural Strength of cement concrete	45 Kg/cm^2
Sub grade CBR	8%
Elastic Modulus of concrete	3×10^5 Kg/cm^2
Poisson's ratio of concrete	0.15
Coefficient of Thermal expansion of concrete	$10 \times 10^{-6}/^{o}C$
Tire pressure	8 Kg/cm^2
Spacing of contraction joint	4.5
Width of slab	3.5

Table 02-Proposed Pavement Compositions

Crust Details	**Thickness**	**Remark**
PQC (mm)	350	-
DLC (mm)	150	-
GSB (mm)	150	300mm GSB to be considered for 15% of stretch in Package II. In view of recent Unprecedented Rain in General area of the Project Road and explicit concerns of the Predominant Drainage requirements. (Use of combination of Gap graded; Grading III & IV for lower layer of Granular Sub Base and Well graded; Grading I & II for upper layer of Granular Sub Bas. It may be envisaged to keep minimum compacted thickness not less than 300 mm as per Cl. 6.3.3 of IRC:15-2011.)

4.4 Alignment

4.4.1 Horizontal alignment

Alignment will be fluent and blend with the topography. The horizontal curves are designed to have largest practical radius and will consist of circular portion flanked by spiral transitions at both ends. The minimum radii of the curve corresponding to the design speed and limiting super elevation to a maximum of 5% would be applied as per IRC stipulations.

4.4.2 Vertical Alignment

The vertical alignment will provide a smooth longitudinal profile. Frequent Grade changes are avoided to reduce kinks and visual discontinuities in the profile. Desirably there should be no change in grade within a distance of 150 m. The directions given in IRC: 73 and IRC: SP: 23 are being complied. Decks of small cross drainage structure (i.e. culverts or minor bridges) will follow the same profile as the flanking road section, without any break in the grade. The aspect of efficient drainage will be kept into consideration for designing vertical profile and cross-sections of the Project Expressway as stipulated in IRC: SP: 42 and IRC SP:50. The vertical alignment is coordinated with the horizontal alignment.

4.5Advance Traffic Management Systems (ATMS)

Advance Traffic Management Systems (ATMS) will be provided as per Clause 816 of MORTH Specifications for road and bridge works. It is consist of the following sub-system

- Emergency Call Boxes
- Mobile Communication System
- Variable Message Signs System
- Meteorological Data System
- Automatic Traffic Counter and Vehicle Classification
- Video Surveillance System
- Video Incident Detection System (VIDS)

4.6 Intelligent Transportation Systems (ITS)

The Republic Of Korea will be sharing its technology with India to monitor and manage the 701-km Mumbai-Nagpur Super Communication Expressway, set to be the country's longest expressway. This will be the first time in the country that an intelligent transportation system (ITS) will be implemented on an expressway for the safety of motorists and to prevent accidents. Vehicle detection, traffic violation control and surveillance, video incident detection, visual messaging service, drone-based surveillance of the route, lane control systems, tunnel management system, weigh in motion, speed and lane enforcement are some of the systems that comprise the transportation system, said an MSRDC official. The ITMS will consist of toll collection systems (TCS), integrated traffic management systems (ITMS) and optical fibre cable (OFC) network.

4.7 Delays in construction of highway

Construction of highway is a very complex process with lot of activities which must be dealt properly to achieve efficiency in construction. IRC: 15 has specified the construction process of a rigid pavement. Some of the common factors causing delay in construction of highway are listed below in their respective category.

More than 25% of the projects are failing to meet the scheduled timeline and are putting an extra burden on already stressed economy. Delays in infrastructure project not only impact the project deadline but also budget of the project touches new skies. Over last few years, many infrastructural projects in India are delayed and due to which the cost of the project has also increased upto 20% in recent year of 2019-20. Government of India has launched several highway Projects including Golden Quadrilateral, Bharatmala, DelhiMumbai Economical Corridor (1350 km), Delhi-Amritsar Katra Expressway (600 km), Amritsar-Jamnagar Expressway and Indore- Hydrabad Expressway (713 km).of the projects are set to be opened till 2025 but they are lagging behind their schedule.

V. CONCLUSION

In overall terms population is increasing in one hand and the quantum of natural resources, like, crude oil, aggregates, iron core and land is finite and getting depleted gradually on the other hand. In this scenario it seems like quite a challenge to reach sustainability in highway construction since the latter by nature of its activity generates lots of energy and consumes a lot of fossil resources.

- The Maharashtra Samruddhi Mahamarg will link the state of Maharashtra to Delhi-Mumbai Industrial Mahamarg and Western Dedicated Freight Mahamarg. Parts of Maharashtra will have direct connectivity to these Mahamarg and JNPT, the country's largest container port. This, in turn, will enhance the export and import trade activity of the state.
- No significant deterioration in the eco-system is likely to occur during construction and operation phase of the project.
- The Krushi Samruddhi Kendra will provide excellent business opportunities, pre-eminent infrastructure, good transport links and highly suitable atmosphere to the investors. Further, these Kendra's would also generate self and wage employment thereby preventing forced migration.
- Reduce accidents- mainly as a result of reduce travel time and congestion but also because of provision of safety infrastructure and warning signs though this later elements was impossible to quantify- it was however estimated that benefits from 50% reduction in accidents.
- There will be no harmful impact on the environment as the plantation of tress have been done along the expressway for the amount of trees which have been cut during construction.
- The implementation of project lead to sustainable development of area.
- Currently there are 3 routes are there from Mumbai to Nagpur and their time of travel is about 16 hours but this samruddhi expressway

will allow the user to cover the distance in just 8 hours, so the time of travel has been reduced up to 50%.

- Samruddhi mahamarg will travel through 10 key districts and 14 districts which will cover most of the tourist places of Maharashtra due to which tourism gets developed and will indirectly helped to improve economy of the state.

REFERENCES

[1] Richard Kim, (North Carolina state university, USA)-Journal Of traffic and transportation Engineering (English edition), volume 9, 2022.

[2] Ahsan Rabbani, Ashlesha Deshmukh, Prof.N.K.Dhapekar, Dr.Goawardha Bhatt - "Design Of rigid Pavement: Hypothesis" (IJCIET), volume 8, Issue 6, pp.450 – 456, June 2017.

[3] Manohar K M, P Narsimha Reddy, Siddu Dana, Mahantesh - "Construction of Rigid Pavement",(IJERT) volume 7 , Issue 5, May 2018.

[4] SwapnilGarg , Vishvandra Singh, Anmol taneja, Nikhil kumar, Mayur Ghayal, A jain- "Study Of Hybrid Annuuity Model On Samruddhi Mahamarg", 2019.

[5] Detailed Project Report of Access Controlled Nagpur-Mumbai Super Communication Expressway (MSRDC).

[6] Chand Smriti (2007), "Indian Roadways: Importance; Development and Classification of Indian Roadways"

[7] Das Subhasis (2016), "Road V Rail Transport – Their Contribution to Indian Economy"

[8] Hamzah N., Khoiry M.A., Arshad I., Tawil N.M., Che Ani A.I. (2011), "Cause of Construction Delay", Procedia Engineering 20

[9] Indian Road Congress (2017), "IRC:15-2017 Code of Practice for Construction of Jointed Plain Concrete Pavements".

[10] Maharashtra State Road Development Corporation (2019), "8th Review Meeting Status Report for Samruddhi Highway"

[11] Ministry of Road Transportation & Highways (2017), "Basic Road Statistics of India 2016-17

[12] Planning Commission, Government of India (2011), "Working Group Report on Road Transport for 11th Five-Year Plan".

[13] Uddin Aftab, Ahmad Syed, Danish Mohd, "Types and Causes in Construction Delays", IRJET, Volume 4 Issue 7, 2017.