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A Review on Highway Network System - Samruddhi Expressway

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Abstract - Highway networks serve as critical arteries of transportation infrastructure, facilitating the movement of goods and people across vast geographical regions. As traffic volumes continue to increase and technological advancements reshape transportation systems, there is a pressing need to optimize the efficiency, safety, and sustainability of highway networks. This abstract presents a comprehensive system approach aimed at addressing these challenges. The proposed highway network system integrates advanced technologies such as intelligent transportation systems (ITS), real-time traffic monitoring, data analytics, and machine learning algorithms to optimize traffic flow, minimize congestion, and enhance safety. By leveraging data from various sources including sensors, cameras, and connected vehicles, the system enables proactive traffic management and congestion prediction, allowing authorities to implement timely interventions and mitigate potential disruptions. Furthermore, the integration of artificial intelligence and machine learning algorithms enables predictive maintenance of infrastructure, identifying potential issues before they escalate into critical failures. This proactive approach not only reduces maintenance costs but also enhances the reliability and lifespan of highway assets. Moreover, the system prioritizes safety through the implementation of automated collision avoidance systems, adaptive speed control, and real-time incident management. By leveraging vehicle-to-infrastructure (V2I) and vehicle-to-vehicle (V2V) communication technologies, the system enables vehicles to exchange critical information, such as hazardous road conditions or impending collisions, thereby reducing the risk of accidents and improving overall safety. Additionally, the system incorporates sustainability principles by optimizing traffic flow patterns to minimize fuel consumption and emissions, promoting eco-friendly transportation practices, and facilitating the integration of electric and autonomous vehicles into the existing infrastructure.

I. INTRODUCTION

Transportation plays a pivotal role in India's economic landscape, with a diverse array of land, water, and air transport modes facilitating nationwide connectivity. Maharashtra, located in the western region of the country, boasts a robust transportation network comprising railways, roadways, and air routes, serving as the lifeline for its economic and social activities. Road transport emerges as a dominant mode for both goods and passenger movement within the state, with Mumbai as its capital and Nagpur as the second capital and third-largest city. Currently, three routes connect Mumbai and Nagpur, with a travel time of approximately 16 hours. Notably, Buti Bori, Thane, and Aurangabad host numerous industries along the existing highways. Efforts are underway to enhance communication and connectivity between these cities through the development of a high-speed expressway linking Nagpur and Mumbai, aiming to spur growth in the backward regions of Marathwada and Vidarbha. Maharashtra State Road Development Corporation Ltd (MSRDC) spearheads infrastructure projects, including roads and bridges, while national highways and expressways facilitate efficient transportation across the state. The evolution of modern roads, influenced by historical engineering practices, emphasizes advancements in construction methods and materials, paving the way for faster, more

economical, and durable pavements. As the country's population grows and lifestyles evolve, the demand for faster travel necessitates investment in alternative modes such as railways and air travel, alongside the continuous development of road infrastructure. The surge in private transport underscores the importance of effective traffic management strategies to mitigate congestion and ensure optimal utilization of transport infrastructure. Investments in the road sector, particularly post-World War era, have spurred the emergence of transportation planning and demand management to optimize resource allocation and meet evolving travel patterns and behaviours.

Fig. 1. Seamless Journey through Samruddhi Mahamarg

II. MODERN SOIL STABILIZATION TECHNIQUE

Soil stabilization, a practice dating back millennia, has been utilized by ancient civilizations like the Mesopotamians and Romans, who independently discovered the effectiveness of enhancing pathways' load-carrying capacity. They achieved this by mixing weak soils with stabilizing agents such as pulverized limestone or calcium, marking the advent of chemical stabilization techniques. In contemporary times, successful soil stabilization remains crucial for ensuring sufficient subgrade stability, particularly for weaker and wetter soils. The choice between cementitious stabilizing agents like cement and lime is commonly determined by the Plasticity Index (PI) of the primary soil type undergoing improvement.

2.1 Stabilization with cement

As per the Portland Cement Association (PCA), Cement Treated Base (CTB) has proven to be an economical and durable foundation for pavements. This method involves blending soil and/or aggregate with cement and water, which is then compacted to achieve high density.

Cement stabilization enhances the strength and stiffness of the base material, minimizing deflection caused by traffic loads. This delay in surface distress, including fatigue and cracking, extends the life of the pavement structure. Moreover, cement stabilization offers uniform and robust support, thereby reducing stresses on the sub-grade. Testing has shown that a thinner layer of cement-stabilized material can effectively mitigate stresses compared to a thicker layer of unstabilized aggregate. This reduction in sub-grade failure, pothole formation, and uneven pavement surfaces is notable.

2.2 The advantages of cement stabilization are several:

1. Cement stabilization increases the base material strength and stiffness, which reduces deflection due to the traffic loads. This delays surface distresses such as fatigue, cracking and extends pavement structure life.
2. Cement stabilization provides uniform and strong support, which results in reduced stresses to the sub-grade. Testing indicates a thinner cement-stabilized layer can reduce stresses more effectively than a thicker un-stabilized layer of aggregate. This reduces sub-grade failure, pot-hole formation and rough pavement surface.
3. Cement stabilized base has greater moisture resistance to keep water out; this maintains the higher strength of the structure.
4. Cement stabilization reduces the potential for pumping of sub-grade fines.
5. Cement stabilized base spread loads and reduces sub-grade stress.

Road connectivity is the key in bridging the gap between the two metros, while their comprehensive planning plays a crucial role in the state's economic

growth. Down the line, Mumbai-Pune Expressway was one such pilot project which got commissioned between 1998–2000. The expressway connecting Mumbai and Pune reduced the distance and accelerated the pace of economic prosperity. Cities including Mumbai, Pune, Nashik, Aurangabad, and Nagpur significantly strengthen the state's economy.

To bring the entire state into the development stream, the state government has missioned to connect Maharashtra's two major metro cities. Hence, the state government plans the Hindu Hrudaysamrat Balasaheb Thackeray Maharashtra Samruddhi Mahamarg project to drive the state's overall development. This arterial expressway project in Maharashtra has been designed to ensure that the maximum distance should be covered seamlessly within the minimum time.

III. BENEFITS OF SAMRUDHI EXPRESSWAY

3.1 Seamless journey through Samruddhi Mahamarg - Mumbai, the capital of Maharashtra, and sub-capital Nagpur are fast-paced developing metropolitan cities. Connecting the two metro cities with the longest Greenfield super communication expressway will be the new insignia of prosperity for Maharashtra. The expressway will be called the 'Hindu Hrudaysamart Balasaheb Thackeray Maharashtra Samruddhi Mahamarg'. After the commissioning of the project, the expressway will cut down the travel time between Nagpur and Mumbai to 8 hrs from the present 16 hrs.

3.2 24 Districts will get benefit - The Nagpur Mumbai Super Communication Expressway will pass through ten districts namely Nagpur, Wardha, Amravati, Washim, Buldhana, Jalna, Aurangabad, Ahmednagar, Nashik, and Thane. Through interchanges, 14 districts will be indirectly connected to Samruddhi Expressway. Therefore, 24 out of 36 districts in the state will benefit from the Samruddhi Expressway. The districts of Marathwada and Vidarbha will be benefited from the Nagpur Mumbai Super Communication Expressway.

3.3 Fast Development & Sustainable Environment

While planning the construction of the Hindu Hrudaysamrat Balasaheb Thackeray Maharashtra Samruddhi Mahamarg, the primary considerations were wildlife conservation and environmental protection. As the expressway will pass through eco-sensitive zones, planned care has been provisioned to ensure that the free movement of wildlife does not hamper, the necessary measures were taken under the guidance of Indian Wildlife Institute, Dehradun. The Expressway will ensure geographic and wildlife habitat exploration easily and freely.

3.4 Fast e-charging Station for Fast Travel

The construction of the Samruddhi Expressway has considered new technology and future transportation. The expressway is constructed with the help of the latest technology, keeping in mind the futuristic technology adaptation. There are plans to erect roadside amenities on both sides at a distance of 40 to 50 km each while traveling on the Samruddhi Expressway. An essential feature is the construction of a charging station for electric vehicles. This means that electric charging will be provided among 21 Wayside Amenities on both sides of the expressway. At the same time, the facility of 'Intelligent Traffic Management System' i.e. ITMS, will also be provided on Samruddhi Expressway. These include a road tax collection system, integrated transport management system, and optical fiber cable (OFC).

3.5 Transforming New Forests Landscape

As many as 546 hectares of land have been acquired for Samruddhi Expressway. However, the same land area was given to the forest department for wildlife conservation in compensation. In all 2.36 Lakh trees are estimated to get affected in the construction of the Samruddhi Expressway, whereas 11.31 Lakh new trees are proposed to be planted along the expressway. Through Samruddhi Expressway, one shall not only experience better commuting, but will also behold the magnificent greenery along the expressway.

3.6 Developing 18 agriculture-oriented New Townships - Samruddhi Expressway is unique in every aspect. This is due to planning the overall

development done at each stage. Weaving ten districts in the stream of development directly and 14 districts indirectly, the expressway will give rise to Krushi Samruddhi Kendra's. The development plan of 18 Krushi Samruddhi Kendra's by Maharashtra State Road Development Corporation will mark the beginning of new economic prosperity. At present, the expressway construction work is underway under the Engineering, Procurement, and Construction (EPC) model

IV. SOME FEATURES

- The total width of the expressway will be 120 meters comprising 6 lanes (provision for 8 lanes in future).
- The expressway will pass through 10 districts, 26 talukas, and 392 villages.
- The Samruddhi Expressway will ensure travel between Nagpur and Mumbai in just 8 hours.
- The proposed vehicle speed limit (designed speed) will be 150km/hr.
- 18 agriculture-oriented new townships will be developed at strategic intersections.
- It will be the country's most extensive 'Greenfield' route alignment with the proposal to plant more than 11 lakh trees on both sides along the expressway.
- This expressway will include an intelligent highway management system for traffic surveillance along with CCTV cameras and free telephone booths installed at an approximate distance of 5 km on the expressway for quick reporting of mishaps or emergencies.
- The expressway will ensure a state-of-the-art transport network with the construction of diverse structures including 65 flyovers, 33 major bridges, 274 minor bridges, 8 railway over bridges,25 interchanges, 6 tunnels, 189 underpasses, 110 underpasses for light vehicles, 209 underpasses for animal and pedestrians, 8 underpasses and 8 overpasses for wildlife movement.
- Extensive landscaping, tunnel lighting, bridge beautification, improved street lighting, and digital signage will be used throughout the entire route of the expressway.
- The expressway will connect several tourism circuits offering eco pilgrim, and heritage tourism, including wildlife resorts, tiger safaris, museums, sightseeing destinations, and theme-based retail outlets. The Samrudhi Expressway and the interchanges to be constructed at 24 places will connect many tourist destinations in the state. This will boost tourism. Tourist places like Lonar Lake, Ellora-Ajanta Caves, Pench National Park, Shegaon, Sevagram, Shirdi, Daulatabad Fort, Bibi Ka Maqbara, etc. will be nearby.
- With electric vehicle charging points proposed at prospecting locations along the expressway and solar plants planned to generate 47 MW of energy, the Samruddhi Corridor aims to become a model of an energy-efficient corridor.
- To ensure digital readiness and resource availability, provisions will be laid down for optical fibre connectivity, natural gas pipelines, and an electricity grid along the expressway at industrial townships.

V. LAND REQUIREMENT

Table 1. Land Requirements

	Acres	Hectares
For the Krushi Samruddhi Nagar	24,500	10,000
For the Expressway	24,255	9,900
Amenities and facilities along the M...	355	145
Total land requirement	49,110	20,045

VI. CONCLUSION

The forthcoming expressway holds immense promise, poised to significantly enhance Maharashtra's economy and foster development across all sectors. According to the Maharashtra State Warehousing Corporation chief, speaking at a webinar jointly organized by The Free Press Journal and Maharashtra State Road Development Corporation (MSRDC) on the transformative impact of the Samruddhi Expressway, ongoing initiatives such as PoCRA, SMART, and MagNet, alongside the Samruddhi Mahamarg project, are set to catalyze economic growth in regions traversed by the expressway over the next seven years.

During the session titled "Agro-processing Zones and Value-Adding Agriculture," panelists including Deepak Taware, CMD of Maharashtra State Warehousing Corporation (MSWC); Arun Raste, Executive Director of the National Dairy Development Board (NDDB); and Sachin Sharma, GM and Head of Channel Operations at ITC, discussed the pivotal role of initiatives like Project on Climate Resilient Agriculture (PoCRA), State of Maharashtra Agriculture and Rural Transformation (SMART), and Maharashtra Agribusiness Network (MagNet) in fostering development across underdeveloped areas of Maharashtra.

These projects, working in tandem with the expressway development, represent a concerted effort towards uplifting the socio-economic landscape of Maharashtra, promising a brighter future for the state.

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