

# Feasibility management and maintenance in highway construction zone

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## Abstract

This research endeavors to delve into the critical aspects of feasibility management and maintenance within highway construction zones, aiming to contribute valuable insights to the current practices in this domain. The primary objectives encompass the evaluation of existing feasibility management approaches, scrutinizing their effectiveness and identifying potential areas for improvement. Moreover, the study seeks to comprehensively assess the environmental and safety implications associated with highway construction zones, recognizing the need for sustainable and responsible practices. In pursuit of a holistic framework, the research aims to develop a comprehensive model for feasibility management that integrates environmental and safety considerations. Additionally, the investigation extends to the analysis of maintenance strategies, focusing on their long-term sustainability to ensure the durability and efficiency of constructed highways. By addressing these objectives, this research aspires to offer a nuanced understanding of the intricate dynamics involved in highway construction zone management and provide practical recommendations for enhancing feasibility and sustainability in this crucial infrastructure sector.

**keywords:** *Feasibility Management, Highway Construction Maintenance, Construction Zone, Infrastructure Feasibility.*

## 1. INTRODUCTION

Highway building and upkeep are vital projects that have a big influence on public safety, economic growth, and transportation infrastructure. The management of feasibility and upkeep of highway construction zones become essential components of guaranteeing successful project results and long-term infrastructure sustainability as the need for effective and sustainable transportation networks grows. Highway construction zones are dynamic settings where complicated construction tasks are carried out, temporary diversions are implemented, and traffic flow is constantly changing. In order to manage the profitability and practicality of planned highway building efforts, many elements are taken into account, including cost, time, environmental effect, and resource availability[1]. At the same time, maintenance plans are essential to maintaining the built-in roadways' lifetime, safety, and functioning. The below figure illustrates the process of road grading construction, involving leveling and shaping the ground surface for road development.



*Fig 1. Road Grading construction*

As per the above figure Fig 1.1 depicts the process of building a road. It likely shows construction equipment, such as graders and excavators, working on a designated path for the new road. The existing landscape, with hills and valleys, is also visible. Piles of dirt or gravel might be scattered around the site, designated for either filling in low areas or removing excess soil from high points.

This issue explores the many facets of feasibility management and maintenance in highway construction zones, including the methods, best practices, and obstacles that these procedures must overcome. Highway construction zones are dynamic environments that need a strategic approach to feasibility evaluations that balance stakeholder expectations, project requirements, and environmental concerns. Furthermore, efficient maintenance procedures are necessary to guarantee that the built roadways maintain performance standards, reduce possible hazards, and satisfy changing transportation requirements. Maintenance methods are essential for optimizing the return on investment for highway building projects, from regular upkeep to handling unanticipated challenges[1].

This investigation will traverse the complexities of feasibility management and upkeep in highway building zones, illuminating creative methods, cutting-edge developments in technology, and cooperative endeavors that support the prosperity and long-term viability of transportation infrastructure[3]. Understanding and optimizing the maintenance and feasibility elements of highway construction is critical to developing robust, efficient, and long-lasting transportation networks as the transportation environment continues to change. Highway building and upkeep are vital projects that have a big influence on public safety, economic growth, and transportation infrastructure. The management of feasibility and upkeep of highway construction zones become essential components of guaranteeing successful project results and long-term infrastructure sustainability as the need for effective and sustainable transportation networks grows[3].

### 1.1 The Crucial Role of Highways

Highways are the backbone of transportation infrastructure, playing a pivotal role in connecting communities, facilitating commerce, and driving economic development. These arterial roadways form an extensive network that spans regions and nations, serving as essential conduits for the movement of people and goods. The critical functions of highways are deeply intertwined with various aspects of daily life, commerce, and societal progress[4].

Highways serve as vital links, connecting cities, towns, and rural areas, fostering regional integration and accessibility. This interconnected network enhances mobility, allowing individuals to travel seamlessly between locations for work, education, healthcare, and leisure[4].

The above figure depicts various elements and components of highway infrastructures, including roads, bridges, interchanges, and traffic control systems.



Fig 2. Highway infrastructures

## 2. LITERATURE REVIEW

Highway infrastructure is a vital backbone for economic development, social connectivity, and regional growth, yet its construction, maintenance, and safety present multifaceted challenges that span technical, environmental, economic, and human factors. Recent research across various global contexts has advanced our understanding of these complexities and proposed innovative solutions to enhance highway project feasibility, safety, cost-efficiency, and sustainability. A critical concern in highway construction zones is worker safety, as highlighted by Sepehr Sabeti (2021), who reports 124 worker fatalities in highway work zones in 2018 due to insufficient predictive safety measures. To address this, Sabeti advocates for an AI-enabled augmented reality (AR) system designed to enhance situational awareness and reduce accidents. This system integrates edge-based AI for distant vehicle detection, real-time wireless communication, and an AR user interface providing multimodal alerts to workers. Early testing on the BDD100K dataset demonstrates promising results, with high frame rates and accurate object detection, alongside low-latency communication within work zones. Workers responded positively to this technology, emphasizing its potential to revolutionize highway work zone safety by proactively alerting personnel to hazards.

Complementing safety concerns are environmental considerations, especially when highways intersect sensitive ecological regions. Gaoru Zhu's (2020) study evaluates the feasibility of highway projects in environmentally fragile areas of Western China, particularly the Sanjiangyuan region. By employing a comprehensive evaluation model incorporating 17 construction necessity and 9 ecological friendliness indices, weighted via Analytic Hierarchy Process and expert scoring, Zhu presents a "magic cube" model that quantifies project feasibility while balancing ecological impacts. The study's insights are vital for planning sustainable highway networks in underdeveloped and environmentally sensitive zones, helping to guide infrastructure expansion without compromising ecological integrity. In parallel, Ahmed Jalil Al-Bayati (2023) addresses the persistent safety challenges in U.S. street and highway maintenance work zones, focusing on the critical role of Internal Traffic Control Plans (ITCPs). The research highlights the lack of mandatory ITCPs, contributing to frequent internal-source incidents and vehicle intrusions causing injuries and fatalities. Al-Bayati recommends regulatory enforcement through OSHA's general-duty clause and proposes improvements in investigation protocols and temporary traffic layouts, aiming to significantly enhance worker and motorist safety in maintenance zones.

The environmental impact of traffic delays caused by work zones is also a pressing issue. Yuanyuan Liu (2022) investigates the carbon footprint implications of different highway pavement maintenance types over a 15-year lifecycle in Shaanxi Province, China. The study reveals that traffic delays contribute nearly 30% of the total life cycle CO<sub>2</sub> emissions, predominantly during preventive maintenance activities due to vehicle speed changes and queuing. Mitigation strategies focusing on reducing traffic volume and controlling speeds within work zones were found more effective in lowering emissions than adjusting work zone length or timing. Liu's framework offers highway agencies a decision-support tool to integrate environmental sustainability into maintenance planning, highlighting the need for combined management strategies and enhanced pavement

design models. Economic viability remains a cornerstone of highway project planning. Pratiksha R. Patil (2020) evaluates the economic feasibility of widening and strengthening a key highway section between Mumbai and Pune using the Highway Development and Management (HDM-4) model. Given the significant traffic congestion due to rapid economic and industrial growth, the study confirms that upgrading the flexible pavement from four to six lanes is economically justified, with a favorable Economic Internal Rate of Return (EIRR) over a 20-year analysis period. This research underscores the necessity of comprehensive economic assessments to support infrastructure investment decisions that yield long-term social and economic benefits.

Management and control of feasibility planning in highway projects is another critical dimension, as explored by Gulnara A. Gareeva (2020). The study introduces a subsystem within the 1C software environment to automate the distribution of work orders among teams, improving processing speed and managerial efficiency. With a payback period of under a year, this information system enhances technical and economic planning, emphasizing the importance of digital tools in optimizing project management workflows in medium-sized enterprises. Cost control and construction management are further examined by Fei Shan (2021), who uses activity-based costing to analyze labor, material, and indirect expenses in rural highway projects. Shan's study identifies key cost drivers and proposes targeted control measures to improve financial efficiency. Additionally, the research stresses strengthening rural road maintenance through enhanced local governance and community engagement, which is critical for sustaining the national road network and fostering rural economic growth.

Similarly, Haniffan D. Baihaqi et al. (2023) address road management prioritization in East Java, Indonesia, where budget constraints necessitate strategic allocation of maintenance funds. Using multi-criteria analysis based on technical factors such as traffic and road stability, alongside economic indicators like vehicle operational costs and benefit-cost ratios, the study ranks maintenance priorities for several road links. This approach facilitates optimal use of limited resources, ensuring critical roads receive timely attention to maintain economic activity and transportation efficiency. Cost and duration optimization in road maintenance projects are explored through the "silver triangle" theory by Anna Kharchenko et al. (2022). Their conceptual model integrates pre-project quality indicators and multiple optimization strategies, improving project planning accuracy and cost control. Application to a long-term maintenance project demonstrates reduced administrative costs, enhanced accountability, and stable financing mechanisms, providing a holistic framework to balance time, cost, and quality in infrastructure projects.

Cost management challenges in highway engineering during construction are further examined by Zhenghong Peng et al. (2022), who analyze the list pricing model's role in mitigating unnecessary expenses. The research identifies implementation difficulties, including managing changes, claims, and risks, which can undermine cost control. Peng emphasizes the need for improved supervision skills and professional training among engineering supervisors to enhance cost management effectiveness. Innovations in temporary traffic management are investigated by J. Skovajsa (2022), focusing on a mobile highway management system deployed during roadworks in

the Czech Republic. Field tests show a 20% increase in work zone capacity and a 30-second reduction in vehicle delays, validating mobile systems as viable solutions to mitigate congestion and safety risks during highway maintenance activities.

Ying Wang (2021) proposes a novel fuzzy evaluation model based on gray correlation degree to assess traffic safety maintenance on high-grade highways. The model incorporates detailed damage characteristics across highway components and uses analytic hierarchy process weighting to guide targeted maintenance efforts. Experimental validation shows the model's effectiveness in categorizing safety service levels and informing timely repair decisions. Addressing urban traffic congestion, M. Durga (2020) examines Bangalore's challenges, highlighting the impact of traffic bottlenecks on road conditions, fuel wastage, and economic losses. Interviews with municipal managers reveal that despite regulations, traffic violations persist, exacerbating congestion. Proposed solutions include constructing flyovers and ring roads, though these require extensive time and legal processes.

Gugilla Aruna (2003) contributes an integrated work zone management model to optimize traffic flow and minimize costs during highway maintenance. The research uses advanced optimization algorithms to configure work zones and traffic diversions effectively, reducing overall costs and improving safety for workers and commuters. In Saudi Arabia, Saleh M. Alsultan (2022) examines health and safety in temporary work zones, identifying driver behavior as a primary crash risk factor. The study advocates strict enforcement against safety protocol violations and emphasizes the need for comprehensive risk mitigation strategies to improve road work zone safety in the region. Sustainability considerations are advanced by Tejas Pawar (2021), who studies the feasibility of green roads constructed with plastic waste and recycled aggregates. Although initial construction costs for green roads are higher, lifecycle cost analyses show significant savings in maintenance and repair, supporting green road technologies as economically viable and environmentally beneficial alternatives to conventional bitumen roads.

The utilization of industrial waste materials in highway construction is explored by Abdel-Rahman Megahid (2020), demonstrating that incorporating fly ash and silica fume into bituminous mixes significantly improves pavement stability and reduces bitumen consumption. This approach promotes sustainability by recycling waste materials while enhancing pavement performance. Lu Lv (2021) addresses driving safety in work zone crossovers during highway reconstruction, finding that median opening widths must be tailored separately for entrance and exit bypasses due to differing driver behaviors. Simulation and actual driving data reveal optimal designs for enhancing traffic flow and safety in complex construction zones. Highway bridge maintenance challenges are detailed by Jingyu Li (2022), emphasizing the need for tailored solutions sensitive to local environmental conditions, regulatory contexts, and structural requirements. The study underlines that recommended maintenance strategies must be adapted to regional specifics to ensure long-term bridge safety and reliability. Finally, Qingguo Chang (2023) focuses on the maintenance optimization of electromechanical facilities in highway tunnels. By integrating advanced monitoring and predictive maintenance technologies, Chang proposes a refined approach that enhances operational reliability, safety,

and sustainability of tunnel infrastructure, highlighting the critical importance of proactive facility management.

### 3. METHODOLOGY

The methodology involves reviewing relevant literature to understand feasibility management and maintenance challenges in highway construction zones. Subsequently, a problem statement is formulated, followed by a detailed case study analysis. Life cycle cost analysis (LCCA) of road construction is conducted, and results are interpreted to draw conclusive findings for effective feasibility management and maintenance strategies[30].

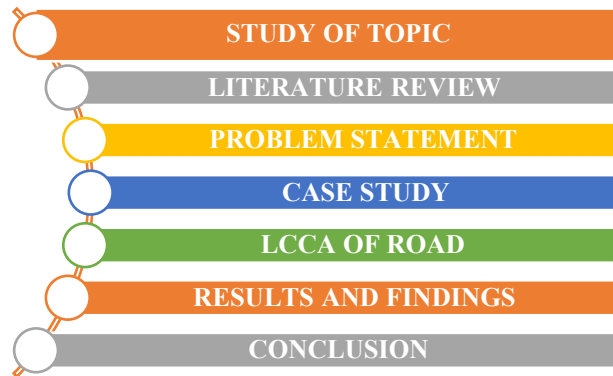


Fig 3. Flow Chart

As shown in Figure 3.1, the flow chart outlines a research project's steps on highway infrastructure. It starts with the "Study of Topic" to identify the research area, followed by a "Literature Review" to examine existing research. The "Problem Statement" defines the research issue, and a "Case Study" provides practical insights. "LCCA of Road" (Life-Cycle Cost Analysis) evaluates economic impacts. "Results and Findings" summarize the research data, leading to the "Conclusion," which encapsulates outcomes and recommendations[30].

### 4. RESULT AND DISCUSSION

The "Results and Discussion" section provides an essential analysis of the data obtained throughout the study, addressing the effectiveness of different highway management and maintenance practices. The research evaluates both rigid and flexible pavements using Life Cycle Cost Analysis (LCCA) and other methodologies to assess their feasibility and cost-effectiveness over time.

The findings reveal that rigid pavements, although having higher initial construction costs, prove to be more cost-effective in the long run due to their lower maintenance requirements. The break-even point occurs in 2029, after which rigid pavements outperform flexible ones in terms of overall life cycle costs, achieving a cost reduction of about 12.93% by 2048. Furthermore, the study emphasizes the importance of implementing environmentally conscious and safety-oriented construction practices in highway projects, such as minimizing traffic congestion and reducing CO2 emissions, particularly during maintenance activities. Another important aspect discussed is the application of Artificial Neural Networks (ANN) to predict future maintenance costs, demonstrating the integration of advanced technology in highway maintenance strategies. The study highlights how proactive management strategies that account for future costs

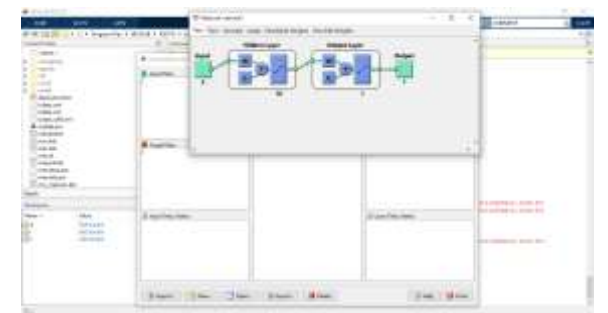
can ensure sustainability and minimize unforeseen expenses, making rigid pavements the preferred option for long-term highway infrastructure maintenance. In summary, the results underscore the importance of adopting a strategic approach that integrates cost analysis, environmental considerations, and safety practices to improve the sustainability and efficiency of highway construction and maintenance.

#### 1. Create network Data



The image displays the creation of a neural network in MATLAB using the Neural Network Toolbox. The network, named "network1," is a feed-forward backpropagation type, which processes input data ("i") to predict corresponding target data ("t"). The training function selected is "TRAINLM," the Levenberg-Marquardt algorithm, known for its efficiency in training small to medium-sized networks. The learning function, "LEARNGDM," uses gradient descent with momentum, optimizing the learning process by improving convergence speed. The network's performance is measured using the Mean Squared Error (MSE) function, which evaluates the accuracy of the network's predictions compared to the target values. The neural network consists of two layers, with the first layer having 10 neurons. The activation function used in this layer is the "TANSIG" (tangent sigmoid) function, which introduces non-linearity to the model. This configuration is typical for simple feed-forward networks and aims to map inputs to targets effectively, capturing underlying patterns in the data.

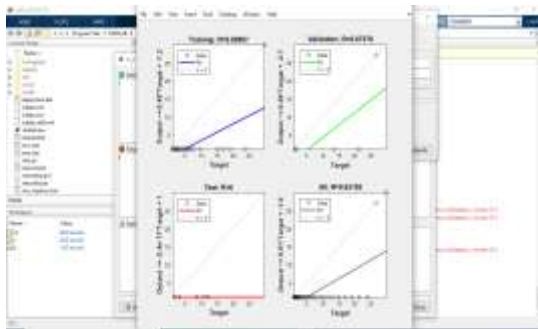
#### 2. Gives time (in terms of days) as input.



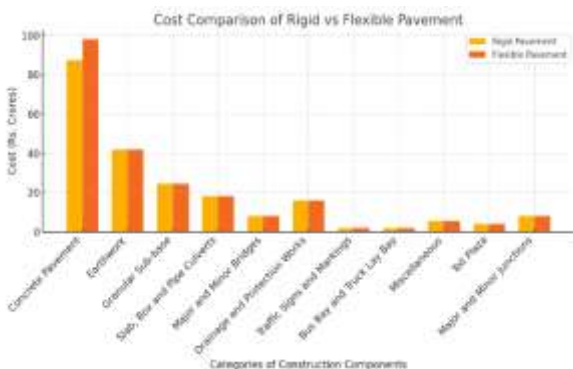
The Figure shows a neural network model in MATLAB, specifically "network1," which consists of three layers: an input layer, a hidden layer, and an output layer. The input layer has 5 neurons, representing the 5 input features of the dataset. These features are processed by the network during the training phase. The hidden layer contains 10 neurons, where the input data undergoes transformation via weights ("w") and biases ("b"). The activation function applied in this layer introduces non-linearity, allowing the network to learn complex patterns. The output layer has a single neuron, producing the final prediction. This neuron receives the weighted input and applies an activation function to generate the result. The weights and biases are learned and adjusted during training to minimize prediction errors. This graphical

representation illustrates how data flows through the network, from input to output, and shows the core structure of the neural network used for model training in MATLAB.

### 3. LCCA Results in MATLAB

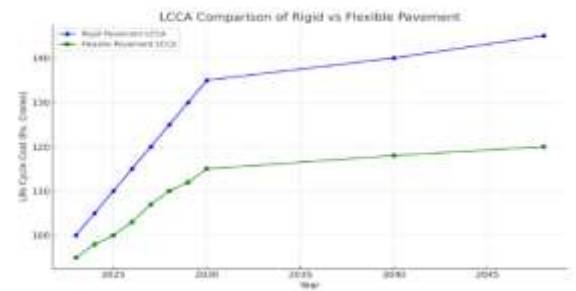


The figure displays the performance evaluation of a neural network in MATLAB through four plots: Training, Validation, Test, and All. Each plot compares the network's predicted output against the actual target values, with data points represented by circles and the fitted line showing the network's predictions. The Training Plot shows the network's performance on the training data, with an R-value of 0.60887, indicating a decent fit between the predictions and actual values. The Validation Plot demonstrates the network's performance on validation data, achieving an R-value of 0.67576, which suggests that the model generalizes well to unseen data, though some discrepancies remain. The Test Plot reveals the network's performance on test data, with a significantly lower R-value of 0, indicating poor prediction accuracy and potential overfitting or a lack of generalization. Lastly, the All Data Plot combines results from all datasets, yielding an R-value of 0.63182, showing moderate performance across all stages. The overall analysis points to a need for further model optimization, particularly for improving test data accuracy and generalization.



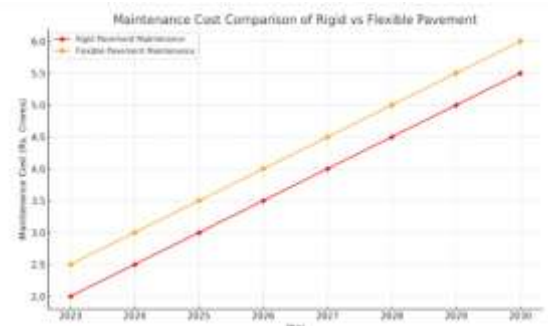
Graph 1. Cost Comparison between Rigid and Flexible Pavement

The graph compares the cost breakdown of Rigid and Flexible Pavements across various construction components. It shows that for most categories, rigid pavements tend to have higher costs, particularly for concrete pavement, which is the most expensive component. However, both pavements share similar costs for Earthwork, Granular Sub-base, Slab, Box, and Pipe Culverts, and other components. Rigid pavements incur higher initial costs, mainly due to the concrete material used for construction. The chart illustrates how the higher initial costs of rigid pavements may be offset by longer-term benefits, such as lower maintenance costs, in some cases.



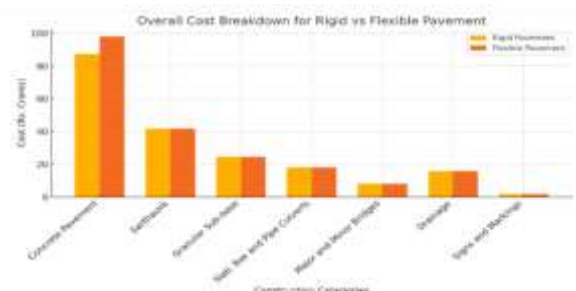
Graph 2. LCCA Comparison (Rigid vs Flexible Pavement)

The graph illustrates the Life Cycle Cost Analysis (LCCA) for both Rigid and Flexible Pavements over several years. It shows that rigid pavements, while having higher initial costs, gradually become more cost-effective over time. Starting at a higher cost, rigid pavements' costs increase at a slower rate compared to flexible pavements, which experience faster increases. By the end of the analysis period, the gap between the two pavements' costs widens, with rigid pavements showing a more sustainable, lower growth in life cycle costs. This suggests that rigid pavements may provide better long-term financial value despite higher upfront costs.



Graph 3. Maintenance Cost Comparison (Rigid vs Flexible Pavement)

The graph compares the maintenance costs for Rigid and Flexible Pavements over time. It shows that maintenance costs for both types of pavements increase gradually as the years progress. However, flexible pavements have consistently higher maintenance costs than rigid pavements throughout the period. This is likely due to the more frequent repairs required for flexible pavements, such as resurfacing and patching. In contrast, rigid pavements tend to require less maintenance, resulting in lower long-term maintenance costs. This graph emphasizes that although flexible pavements are less expensive initially, their higher maintenance costs could lead to greater expenses over time.



Graph 4. Overall Cost Breakdown for Rigid vs Flexible Pavement

The graph provides a detailed breakdown of the overall costs for Rigid and Flexible Pavements across various construction categories. It reveals that Rigid Pavement incurs the highest costs in categories like Concrete Pavement and Drainage. Flexible Pavement, on the other hand, shows a similar pattern but with slightly lower costs for most components. Concrete Pavement is the most significant cost driver for rigid pavements, whereas flexible pavements allocate more of their budget to the Pavement category itself. This chart highlights how the cost distribution differs between the two types of pavements, with rigid pavements facing higher initial construction costs but similar overall costs in other categories.

#### 4. FUTURE SCOPE OF THE STUDY

Future research in feasibility management and maintenance within highway construction zones holds significant promise for advancing safety, efficiency, and sustainability. Emerging technologies such as AI-enabled augmented reality systems, as explored by Sepehr Sabeti, can be further developed to provide real-time hazard detection and worker alerts, reducing fatalities and improving situational awareness. Integration of smart communication networks with low latency will enhance coordination across work zones, enabling more dynamic and adaptive traffic control.

Environmental considerations will increasingly shape feasibility assessments, especially in ecologically sensitive regions. Advanced multi-criteria models incorporating ecological, economic, and social factors, like those proposed by Gaoru Zhu, will be essential for balancing infrastructure growth with sustainability. Additionally, comprehensive life cycle assessments focused on carbon emissions due to traffic delays during maintenance, as highlighted by Yuanyuan Liu, should be expanded to optimize work zone operations for environmental benefits.

Cost management will continue to evolve through digital tools and automated planning systems that enhance decision-making efficiency, as suggested by Gulnara Gareeva. Combining activity-based costing with predictive analytics can improve resource allocation and maintenance scheduling. Finally, future studies should emphasize the development of integrated frameworks combining safety, environmental impact, economic feasibility, and advanced technologies. This holistic approach will support resilient highway infrastructure, optimized for safety, cost-efficiency, and minimal environmental disruption in increasingly complex construction environments.

#### 5. CONCLUSION

The study emphasizes the critical role of evaluating current feasibility management practices to ensure the success of highway construction projects. Detailed cost analyses comparing rigid and flexible pavements reveal the necessity of precise financial planning. For example, the cost for rigid pavement projects ranged around Rs. 223.54 to Rs. 243.56 crores, whereas flexible pavement projects were comparatively lower, between Rs. 203.06 and Rs. 211.03 crores. This cost difference underscores the importance of comprehensive financial assessments to establish project feasibility. Environmental and safety considerations were thoroughly evaluated, particularly through processes like bitumen spray application and road compaction, which enhance road durability while ensuring user safety. The study advocates for environmentally friendly and safety-conscious

construction practices, vital for the long-term sustainability of highway infrastructure. Maintenance strategies implemented on the Mumbai-Pune Expressway focus on long-term sustainability through regular renewals, cost-effective upkeep, and detailed planning. A strategic combination of rigid and flexible pavements tailored to specific highway sections helps manage wear and prolong infrastructure lifespan. The development of a feasibility management framework, incorporating Life Cycle Cost Analysis (LCCA), emerged as a key outcome. The Mumbai-Pune Expressway case study demonstrated how effective resource allocation and continuous monitoring rely on structured feasibility management. LCCA findings suggest that concrete pavements outperform bituminous ones, with concrete overlays serving as viable rehabilitation options for existing bituminous surfaces. The study also used Artificial Neural Networks (ANN) to predict future maintenance costs, reflecting a proactive approach. Despite higher initial costs—rigid pavements being 10-12% more expensive than flexible ones—they prove more cost-effective over time. Over a 40-year span, rigid pavements show approximately 6.83% lower life cycle costs compared to flexible pavements. This highlights the economic advantages of selecting appropriate pavement types based on long-term maintenance. Additionally, flexible pavements offer quick construction and maintenance benefits, reducing congestion while providing safe, durable roads. Overall, the research advances highway construction by promoting sustainable, feasible, and environmentally conscious practices, ensuring optimized investment and maintenance trade-offs for long-term cost efficiency.

#### Statements and Declarations

##### Ethical Approval

"The submitted work is original and not have been published elsewhere in any form or language (partially or in full), unless the new work concerns an expansion of previous work."

##### Consent to Participate

"Informed consent was obtained from all individual participants included in the study."

##### Consent to Publish

"The authors affirm that human research participants provided informed consent for publication of the research study to the journal."

##### Funding

"The authors declare that no funds, grants, or other support were received during the preparation of this manuscript."

##### Competing Interests

"The authors have no relevant financial or non-financial interests to disclose."

##### Availability of data and materials

"The authors confirm that the data supporting the findings of this study are available within the article."

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### Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

### REFERENCES

1. D. Yadav, A. Prof, A. Varsha, K. Kumar, and M. P. U. Planning, "Sustainability in Highway Projects: A Concise Review," pp. 987–992, 2022.
2. J. Al-Bayati, "Managing Work Zone Safety during Road Maintenance and Construction Activities: Challenges and Opportunities." 2023. [Online]. Available: <https://trid.trb.org/view/2072101>
3. R. Radzi, "Decision making in highway construction: a systematic review and future directions," no. September, 2021, doi: 10.1108/JEDT-06-2021-0306.
4. Z. Abdelmohsen, M. Asce, K. El-rayes, and M. Asce, "Optimizing the Planning of Highway Work Zones to Maximize Safety and Mobility," no. November, 2017, doi: 10.1061/(ASCE)ME.1943-5479.0000570.
5. A.-R. Megahid, H. Younis, T. Abdel-Wahed, and E. Abdel-Sabour, "Utilization of Industrial Waste Material in Highway Construction," JES. J. Eng. Sci., vol. 48, no. 2, pp. 373–382, 2020, doi: 10.21608/jesaun.2020.107604.
6. Du and S. Chien, "Feasibility of shoulder use for highway work zone optimization Feasibility of shoulder use for highway work zone optimization," vol. 7564, no. August 2014, 2015, doi: 10.1016/S2095-7564(15)30269-5.
7. R. Huebschman, "Construction Work Zone Safety." 2003. [Online]. Available: <https://docs.lib.purdue.edu/jtrp/43/>
8. F. Shan, "Research on Rural Highway Project Construction Management and Maintenance," Proc. Bus. Econ. Stud., vol. 4, no. 4, pp. 178–185, 2021, doi: 10.26689/pbes.v4i4.2422.
9. F. Shan, "Research on Rural Highway Project Construction Management and Maintenance," Proc. Bus. Econ. Stud., vol. 4, no. 4, pp. 178–185, 2021, doi: 10.26689/pbes.v4i4.2422.
10. G. A. Gareeva, D. R. Grigoreva, and I. I. Mahmutov, "The Process of Management and Control of Feasibility Planning of Road Construction Using the Financial Information System," Int. J. Financ. Res., vol. 12, no. 1, p. 184, 2020, doi: 10.5430/ijfr.v12n1p184.
11. G. ARUNA, "Integrated Management of Highway Maintenance And Traffic," Dep. Civ. Environmental Eng, vol. 8, no. 2, pp. 337–345, 2003.
12. G. Zhu et al., "Feasibility study of highway project in the environment sensitive area of Western China -- Based on the magic cube model of construction necessity and ecological friendliness," vol. 02023, 2020.
13. H. Ceylan, A Feasibility Study on Embedded Sensors and Systems (MEMS) for Monitoring Highway Structures, no. June. 2011.
14. H. D. Baihaqi and C. A. Prastyanto, "Analysis of Determining Priority of Road Handling Program in the Region of Kediri Road and Bridge Management Department of Highways East Java Province Using Multi Criteria Analysis (Mca) Method," J. Civ. Eng., vol. 38, no. 1, p. 16, 2023, doi: 10.12962/j20861206.v38i1.15972.
15. H. Lord, "Highway Code: road rules." 2022. [Online]. Available: [https://demo.tagdiv.com/newspaper\\_chained\\_news\\_pro/2022/03/24/td-post-highway-code-everything-you-need-to-know-as-road-rules-change-from-today-check-the-new-restrictions/](https://demo.tagdiv.com/newspaper_chained_news_pro/2022/03/24/td-post-highway-code-everything-you-need-to-know-as-road-rules-change-from-today-check-the-new-restrictions/)
16. C. MEDINA, "Geographic Information System Applications in the Heart of Illinois Highway Feasibility Study." 1995. [Online]. Available: <https://trid.trb.org/View/452724>
17. M. FAKUDZE, "Feasibility Study to Determine The Potential For The Privatization Of Routine Road Maintenance In Swaziland," no. November, 2005.
18. J. Angara, "Wireless Sensors for Concrete Temperature Monitoring." 2021. [Online]. Available: <https://www.akcp.com/blog/wireless-temperature-sensors-for-concrete-curing/>
19. J. Skovajsa, O. Příbyl, P. Příbyl, M. Ščerba, and A. Janota, "Evaluation of a Mobile Highway Management System at Roadwork Zones," Int. J. Eng. Trans. B Appl., vol. 35, no. 5, pp. 900–907, 2022, doi: 10.5829/ije.2022.35.05b.06.
20. K. B. Salling and D. Banister, "Feasibility risk assessment of transport infrastructure projects: The CBA-DK decision support model," Eur. J. Transp. Infrastruct. Res., vol. 10, no. 1, pp. 103–120, 2010, doi: 10.18757/ejtir.2010.10.1.2871.
21. L. Lv, Y. Sheng, C. Song, Y. Li, and Z. Guo, "Driving Safety Assurance Method in Work Zone Crossovers of Highway Reconstruction and Expansion Project," J. Adv. Transp., vol. 2021, 2021, doi: 10.1155/2021/5708779.
22. M. Bhanushali, "Application of Artificial Neural Network (ANN) Methodology in Conducting Life Cycle Cost Analysis (LCCA) For Roads," Int. J. Innov. Res. Sci. Eng. Technol., vol. 13, no. 4, 2024, doi: 10.15680/IJRSET.2024.1304298.
23. M. Durga, A. Shanmuganathan, and P. Srivastava, "Evaluating the feasibility of different approaches to decrease road traffic congestion in India," Int. J. Adv. Res. Eng. Technol., vol. 11, no. 5, pp. 34–43, 2020, doi: 10.34218/IJARET.11.5.2020.005.
24. M. J. Markow, "Feasibility Study Of Changes To The Highway Maintenance And Operations Cost Index." 1999. [Online]. Available: <https://trid.trb.org/view/348902>
25. Pratiksha Patil, "Economic Feasibility Analysis of Highway Project using Highway Development and Management (HDM-4) Model," Int. J. Eng. Res., vol. V9, no. 07, pp. 1042–1045, 2020.
26. Q. Chang, X. Chen, Q. Kuang, and Z. Chen, "Research on Maintenance and Management Optimization of Electromechanical Facilities in Highway Tunnel," Acad. J. Sci. Technol., vol. 5, no. 3, pp. 169–171, 2023, doi: 10.54097/ajst.v5i3.8008.
27. Q. Jin and J. Li, "Common Problems and Maintenance Management of Highway Bridges," J. World Archit., vol. 6, no. 6, pp. 29–34, 2022, doi: 10.26689/jwa.v6i6.4540.
28. S. M. Alsultan, F. K. Alqahtani, and K. F. Alkahtani, "Health and Safety in Temporary Work Zone Road Construction Project in Saudi Arabia: Risks and Solutions," Int. J. Environ. Res. Public Health, vol. 19, no. 17, 2022, doi: 10.3390/ijerph191710627.
29. S. Nepali, S. S. Bohara, N. Lama, and R. Rabin Thapa, "Assessment of Traffic Characteristic at Major

Urban Road Intersection of Kathmandu Valley: A Case Study of Khanivivag, Kesarmahal, and Narayanhiti Intersections,” J. Civ. Constr. Eng., vol. 10, no. 1, pp. 22–31, 2024, doi: 10.46610/jocce.2024.v010i01.003.

29. T. Pawar and H. Ambre, “Feasibility Study of Green Road over Conventional Road,” Int. Res. J. Eng. Technol., no. July, 2021, [Online]. Available: [www.irjet.net](http://www.irjet.net)

30. Y. Kumar, “Role of National Highways In Economic Development Of India,” vol. 10, no. 4, pp. 19–29, 2022, [Online]. Available:

<https://ijcrt.org/papers/IJCRT2204685.pdf>

31. Y. Liu, X. Zhu, X. Wang, Y. Wang, Q. Yu, and S. Han, “The Influence of Work Zone Management on User Carbon Dioxide Emissions in Life Cycle Assessment on Highway Pavement Maintenance,” Adv. Meteorol., vol. 2022, 2022, doi: 10.1155/2022/1993564.

32. Y. Wang and Y. Chen, “Evaluation Method of Traffic Safety Maintenance of High-Grade Highway,” Appl. Math. Nonlinear Sci., vol. 6, no. 1, pp. 65–79, 2021, doi: 10.2478/amns.2021.1.00007.

33. Z. Peng, “Cost Management Strategy of Highway Engineering Construction Stage Using the List Pricing Model,” J. World Archit., vol. 6, no. 5, pp. 47–52, 2022, doi: 10.26689/jwa.v6i5.4408.