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Optimized Design and Analysis of a Minor Bridge Under Varying Parameters- A Review

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Abstract: - Bridges are one of the most important components of transportation infrastructure, playing a vital role in ensuring connectivity, economic growth, and social development. In recent years, the increasing demand for efficient, economical, and durable bridge structures has led to significant advancements in bridge design and analysis techniques. This review paper presents a comprehensive study of previously published research works related to the design, analysis, and optimization of bridge structures, with a special focus on minor bridges. A total of 26 research articles have been reviewed, covering various aspects such as structural analysis, optimization techniques, foundation systems, software-based modeling, machine learning applications, and innovative bridge designs. The review highlights those modern techniques such as finite element method (FEM), STAAD Pro, ANSYS, genetic algorithms, and reliability-based design optimization (RBDO) have significantly improved the accuracy and efficiency of bridge design. Additionally, studies on sustainable construction, box-type bridges, and precast methods have contributed to cost-effective solutions. However, it is observed that most research works focus on isolated parameters rather than considering multiple parameters simultaneously. The paper identifies key research gaps such as lack of integrated analysis, limited focus on minor bridges, and insufficient consideration of real-life conditions. The study concludes that there is a need for a comprehensive and optimized approach that considers varying parameters for minor bridge design. This review provides a strong foundation for future research and contributes to the development of efficient, safe, and economical bridge structures.

Keywords: - Minor Bridge, Optimization, STAAD Pro, Finite Element Method, Structural Analysis, IRC Codes, Bridge Design, Sustainability.

I. INTRODUCTION

Bridges are essential civil engineering structures constructed to provide passage over obstacles such as rivers, valleys, roads, and railways. They play a crucial role in transportation networks by ensuring uninterrupted movement of vehicles, goods, and people. With the rapid increase in population and urbanization, the demand for efficient and durable bridge structures has increased significantly. Minor bridges, which generally have spans up to 60 meters, are widely used in rural and semi-urban areas to cross small rivers and drainage systems. Despite their importance, minor bridges often receive less research attention compared to major bridges. However, their design requires careful consideration of factors such as loading conditions, soil properties, hydraulic conditions, and economic constraints. In recent years, advancements in computational tools and optimization techniques have revolutionized bridge engineering.

Software such as STAAD Pro, ANSYS, and other finite element tools allow engineers to analyze complex structures with high accuracy. Furthermore, optimization methods and machine learning techniques have been introduced to improve structural efficiency and reduce material usage. This paper aims to review existing literature on bridge design and analysis, identify research gaps, and highlight the need for optimized design approaches considering varying parameters.

II. LITERATURE REVIEW

Several researchers have carried out studies on the design, analysis, optimization, and performance evaluation of bridge structures. The important findings from previous research works are summarized below:

Nikhil Chaudhari and Dr. Asif M. Baig (2024) studied the design and construction methodology of precast box-type minor bridges. The study emphasized the importance of hydraulic design, site conditions, and optimal configuration selection. It was concluded that precast construction improves quality, reduces construction time, and enhances cost efficiency.

Palakpreet Kour et al. (2022) analyzed the vibration characteristics of steel girder bridges with and without cracks using ANSYS software. The study showed that the presence of cracks significantly reduces natural frequency and affects structural stability.

Qasim Zaheer et al. (2022) reviewed different optimization techniques used in bridge engineering and concluded that metaheuristic algorithms like genetic algorithms and particle swarm optimization are effective in solving complex design problems.

Rajesh Kr Pandey and Rakesh Varma (2026) studied sustainable and economical bridge foundation systems for small rivers. The study concluded that proper foundation selection improves durability and reduces overall construction cost.

Dilip Patidar and Rahul Sharma (2022) reviewed various bridge design and analysis techniques and highlighted the importance of advanced computational methods for accurate prediction of structural behavior.

Zhou Peng et al. (2024) conducted parameter optimization studies on cable-stayed bridges and concluded that structural performance depends significantly on parameters such as stiffness and span configuration.

Najib Zemed et al. (2025) introduced reliability-based design optimization (RBDO) for bridge girders considering long-term effects like corrosion and traffic growth. The study showed improved design efficiency and reduced computational cost.

Saurabh Thokane and Dr. Vinesh Thorat (2024) analyzed bridges with unequal pier heights and concluded that irregular geometry affects seismic performance and requires proper optimization.

Jiabao Jia (2024) studied static analysis and optimization of bridge structures under different loading conditions and found that optimization reduces structural weight and improves efficiency.

Yuping Zhang et al. (2023) performed sensitivity analysis of cable-stayed bridges and concluded that girder stiffness is the most important parameter affecting performance.

Yaping Lai et al. (2024) applied topology optimization in pedestrian bridge design and concluded that generative design helps in achieving efficient and aesthetic structures.

Md. Manik Mia et al. (2023) used machine learning techniques to predict bridge condition ratings and found high prediction accuracy, improving maintenance planning.

Khuong Le Nguyen et al. (2026) developed a surrogate model for dynamic analysis of railway bridges and achieved significant reduction in computation time with high accuracy.

Shaoxiong Jiang and Faham Tahmasebinia (2025) developed a parametric design procedure for bridge construction equipment and concluded that advanced tools improve efficiency and safety.

Mohini Dhande and Dr. Saklecha (2016) compared effective width method and FEM for deck slab design and concluded that FEM provides more accurate results.

Ashwini Phule et al. (2025) analyzed minor bridge design using STAAD Pro and validated results with manual calculations, confirming software accuracy.

Avinash Upadhyay et al. (2020) studied foundation systems for minor bridges and concluded that well foundation is more economical for medium rivers.

Rakesh Varma et al. (2019) suggested box-type minor bridges as a sustainable option for alluvial regions due to better performance and reduced cost.

Saurabh Jamdhade et al. (2020) analyzed box-type bridges under various load combinations and concluded that box sections provide high torsional stiffness and stability.

Shivani Korpe and Dr. Ambadkar (2025) compared STAAD Pro and manual design methods for culvert bridges and concluded that software provides more reliable and faster results.

Kodur and Naser (2013) studied fire hazard effects on bridges and introduced importance factors to improve safety and design considerations.

Sunil Kumar Mali et al. (2024) studied innovative bridge designs and aesthetics and concluded that modern bridges should integrate functionality with visual appeal.

Rathod Chiranjeevi et al. (2016) designed a high-level bridge and concluded that proper hydraulic and structural design ensures safety during flood conditions.

III. RESEARCH GAP

From the above literature review, it is evident that although significant advancements have been made in bridge design and analysis, several research gaps still exist. Most of the studies focus on individual parameters such as loading, span, or material properties, without considering the combined effect of multiple varying parameters on bridge performance. There is limited research on minor bridges, despite their importance in rural infrastructure. Existing studies do not provide a comprehensive framework for optimizing minor bridge design considering multiple parameters such as span variation, loading conditions, material properties, and foundation type. Furthermore, many research works are theoretical or simulation-based, with limited practical validation under real-life conditions. The integration of modern techniques such as machine learning with structural design is still in the early stage. Additionally, the application of optimization techniques based on Indian standards (IRC codes) is not extensively studied. Another important gap is the lack of focus on long-term performance factors such as environmental effects, corrosion, and maintenance. The aesthetic aspect of bridge design is also not fully integrated with structural optimization. Therefore, there is a need for a comprehensive study that focuses on the optimized design and analysis of minor bridges under varying parameters, ensuring safety, economy, and efficiency.

CONCLUSION

This review paper presents a comprehensive analysis of existing research works related to bridge design, analysis, and optimization. It is observed that modern computational tools and optimization techniques have significantly improved the efficiency and accuracy of bridge design. Studies on sustainability, innovative design, and machine learning have also contributed to the advancement of bridge engineering. However, the review identifies several research gaps, particularly in the integrated analysis of multiple parameters, limited focus on minor bridges, and lack of practical validation. There is a need for a holistic approach that considers all influencing factors in bridge design. The findings of this review highlight the importance of developing optimized design methodologies for minor bridges, which can lead to safer, more economical, and durable structures. This study provides a strong foundation for future research and supports the development of advanced bridge engineering practices.

REFERENCES

[1] Ambadkar, S., & Korpe, S. (2025). A Review Paper on Modelling and Analysis of Bridge Using STAAD Pro. International Journal of Science, Engineering and Technology, 13(1).
[2] Chaudhari, N., & Baig, A. M. (2024). Comprehensive Study on Design and Construction Methodology of Precast Box-Type Minor Bridge.
[3] Dhande, M., & Saklecha, P. P. (2016). Comparative Analysis and Design of Solid Deck Slab of Minor Bridge by Effective Width Method and Finite Element Method. International Journal of Engineering Research & Technology (IJERT).
[4] Jia, J. (2024). Static Analysis and Optimization Design of Bridge Structures under Different Load Conditions. SHS Web of Conferences. https://doi.org/10.1051/shsconf/202419603009
[5] Jiang, S., & Tahmasebinia, F. (2025). Developing New Design Procedure for Bridge Construction Equipment Based on Advanced Structural Analysis. Applied Sciences, 15(5), 2860. https://doi.org/10.3390/app15052860
[6] Jamdhade, S. R., & Mulay, S. B. (2020). Analysis and Design of Minor Type Box Bridge. International Journal of Advances in Engineering and Management (IJAEM). https://doi.org/10.35629/5252-0206587591
[7] Kodur, V. K. R., & Naser, M. Z. (2013). Importance Factor for Design of Bridges against Fire Hazard. Engineering Structures, 54, 207–220. https://doi.org/10.1016/j.engstruct.2013.03.048
[8] Kour, P., Tangri, A., & Tiwary, A. K. (2022). Analysis and Design Optimization Approach of Vibration Characteristics of an I-Shaped Steel Girder Bridge. Materials Today: Proceedings. https://doi.org/10.1016/j.matpr.2022.12.043
[9] Lai, Y., Li, Y., Liu, Y., Chen, P., Zhao, L., & Xie, Y. M. (2024). Application of Bi-Directional Evolutionary Structural Optimization to the Design of an Innovative Pedestrian Bridge. AI in Civil Engineering.
[10] Mali, S. K., Dewangan, B., Sahu, S., Niyazi, I., & Rathore, M. (2024). Introduction to Innovative Bridge Designs and Aesthetic. International Journal of Creative Research Thoughts (IJCRT).
[11] Mia, M. M., & Kameshwar, S. (2023). Machine Learning Approach for Predicting Bridge Components' Condition Ratings. Frontiers in Built Environment. https://doi.org/10.3389/fbuil.2023.1254269
[12] Nguyen, K. L., Pham, T. M., Nguyen, K., & Banihashemi, S. (2026). Automation in Dynamic Analysis and Generative Design of Prestressed Concrete Railway Bridge Infrastructures. Computers in Industry, 176, 104440. https://doi.org/10.1016/j.compind.2026.104440
[13] Pandey, R. K., & Varma, R. (2026). A Review of Sustainable and Economical Bridge Foundations for Small Rivers. Journal of Emerging Technologies and Innovative Research (JETIR).
[14] Patidar, D., & Sharma, R. (2022). Review on Design and Analysis of Bridge Structures. International Journal of Scientific Research & Engineering Trends.
[15] Phule, A., Jadhav, S., Jichkar, U., Late, A., Pardeshi, S., & Shingare, S. (2025). Analysis and Design of Minor Bridge Using STAAD Pro Software. IJARIIT.
[16] Rathod, C., Ramyakala, S., & Reddy, S. S. (2016). Design of High Level Bridge Across River. International Journal of Engineering Research & Technology (IJERT). https://doi.org/10.17577/IJERTV5IS090230
[17] Thokane, S., & Thorat, V. (2024). Comparative Analysis and Design of Bridge with Unequal Pier Length and Varying Span Length.
[18] Upadhyay, A. K., Srivastava, R. K., & Bajpai, A. (2020). Study of Foundations for Minor Bridge over Small River. Journal of Civil Engineering and Environmental Technology.
[19] Varma, R., Anand, M. R., & Srivastava, R. K. (2019). Box Type Minor Bridge as a Sustainable Option over Small Rivers in Alluvial Region. International Journal of Engineering and Advanced Technology (IJEAT). https://doi.org/10.35940/ijeat.A2085.109119
[20] Zaheer, Q., Yonggang, T., & Qamar, F. (2022). Literature Review of Bridge Structure Optimization and Its Development Over Time.
[21] Zhang, Y., Huang, W., & Tang, X. (2023). Sensitivity Analysis of Structural Parameters of Cable-Stayed Bridge. Applied Sciences. https://doi.org/10.3390/app13063831
[22] Zemed, N., Moulay Abdelali, H., Mouzoun, K., Cherradi, T., & Bouyahyaoui, A. (2025). Optimization of Reinforced Concrete Bridge Girders Using Reliability-Based Design. Advances in Bridge Engineering.
[23] Jia, J. (2024). Optimization Design of Bridge Structures under Different Load Conditions Using Genetic Algorithms.
[24] Jiang, S., & Tahmasebinia, F. (2025). Advanced Parametric Design Approach for Bridge Construction Equipment Using OMSS.
[25] Nguyen, K. L., Pham, T. M., Nguyen, K., & Banihashemi, S. (2026). Generative Design Optimization of Prestressed Concrete Railway Bridges Using Surrogate Modeling.