

Literature Review on Howe Truss Bridge Using Hollow And Open Steel Section By Using STAAD Pro.

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Abstract- A Howe Truss Bridge is a widely used structural configuration known for its efficiency in load distribution and suitability for medium to long spans. This study presents a comparative analysis of a Howe truss bridge using hollow steel sections and open steel sections, modeled and analyzed with STAAD Pro. The primary objective is to evaluate the structural performance, material efficiency, and economic feasibility of both section types under identical loading and boundary conditions. The bridge models are subjected to dead load, live load, and environmental loads in accordance with relevant design standards. Key parameters such as deflection, stress distribution, weight of structure, and factor of safety are assessed. Hollow steel sections, due to their closed geometry, exhibit higher torsional rigidity and improved resistance to buckling, whereas open steel sections offer ease of fabrication and lower initial cost. The analysis results highlight the advantages and limitations of each section type in terms of strength, stability, and overall performance. The study concludes by identifying the more efficient section type for Howe truss bridges based on structural behavior and cost-effectiveness, providing useful insights for engineers in the design and optimization of truss bridge systems.

Keywords: Howe Truss Bridge, Hollow Steel Sections, Open Steel Sections, Structural Analysis, STAAD Pro.

I. INTRODUCTION

Bridges are vital components of transportation infrastructure, enabling efficient movement of people and goods across physical obstacles such as rivers, valleys, and highways. Among the various bridge types, the Howe Truss Bridge has gained significant importance due to its simplicity, strength, and effective load-carrying mechanism. Characterized by diagonal members in compression and vertical members in tension, this truss configuration is widely used for medium-span bridges and has proven to be structurally reliable over time.

With the advancement of construction materials and analysis techniques, the selection of appropriate steel sections has become a critical aspect in bridge design. Steel sections

are broadly categorized into hollow sections and open sections. Hollow steel sections, such as circular, square, or rectangular tubes, offer advantages like high strength-to-weight ratio, better torsional rigidity, and improved resistance to buckling. In contrast, open steel sections, including I-sections, channels, and angles, are traditionally preferred due to their ease of fabrication, availability, and cost-effectiveness.

The performance of a truss bridge largely depends on the behavior of its members under different loading conditions. Therefore, a comparative study of hollow and open steel sections is essential to determine their suitability in terms of structural efficiency, economy, and durability. Modern structural analysis tools like STAAD.Pro enable engineers to model complex structures and accurately evaluate parameters such as stresses, deflections, and internal forces under various load combinations.

This study focuses on the comparative analysis of a Howe truss bridge using hollow and open steel sections by employing STAAD Pro software. The objective is to analyze and compare their structural performance under identical loading conditions, and to identify the most efficient section type. The findings of this study aim to assist engineers in making informed decisions regarding material selection and design optimization for truss bridge structures.

Steel trusses are among the most efficient and economical structural systems used in engineering construction. They provide large clear spans with minimal material usage, making them suitable for industrial buildings, warehouses, and bridge structures. The Howe truss, characterized by its diagonal compression members and vertical tension members, is one of the most commonly adopted configurations due to its simplicity, strength, and ease of fabrication. The performance of a truss depends greatly on the type of cross-section used for its members. Traditionally, open steel sections such as angles, channels, and I-beams have been used because of their availability, low fabrication cost, and ease of connection detailing. However, with advancements in steel manufacturing and design practices, hollow structural sections (HSS) — including circular,

rectangular, and square hollow tubes — have gained increasing attention. These sections offer several advantages, such as higher torsional rigidity, better aesthetic appearance, improved buckling resistance, and reduced corrosion due to the absence of sharp edges.

In modern design practice, the choice between hollow and open sections must consider not only strength but also overall structural behaviour, weight efficiency, and economic feasibility. To accurately assess these factors, the Finite Element Method (FEM) provides a powerful computational approach that simulates real structural performance under various loading conditions.

This study presents a comparative FEM analysis of a Howe truss modelled using STAAD Pro software, where two separate models are analysed — one employing hollow steel sections and the other using open steel sections. The comparison focuses on critical parameters such as axial forces, deflection, buckling strength, and total structural weight. The objective is to identify the more efficient section type in terms of performance and economy while maintaining compliance with relevant Indian Standards (IS 800:2007 and IS 2062:2011). The outcome of this study will provide valuable insights for structural engineers in selecting optimal truss member sections for lightweight, safe, and cost-effective steel structures

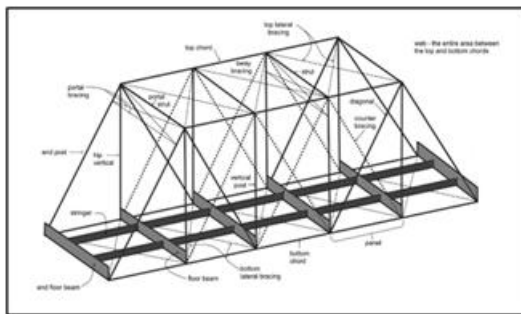


Fig.1 Elements of Howe Truss Bridge (Source:Internet)



Fig.2 Howe Truss Bridge (Source:Internet)

II. SCOPE OF THE STUDY

The scope of this study is limited to the structural analysis of a Howe truss bridge under specified loading conditions. The analysis includes:

- Consideration of dead load, live load, and standard design loads.
- Use of hollow steel sections (e.g., rectangular or circular hollow sections).
- Use of open steel sections (e.g., I-sections, channels, and angles).
- Linear static analysis using STAAD Pro.
- Comparison based on structural performance and material efficiency.

The study does not include detailed construction methods, fatigue analysis, or seismic design considerations, and is primarily focused on analytical comparison.

III. LITERATURE REVIEW

Rahul Vyas & M. K. Trivedi (2018) conducted the study presents a clear application of the ANSYS-based Finite Element Method for analyzing steel truss bridge behavior. It effectively compares Pratt and Lattice truss configurations using both I and C sections under identical loading conditions. The methodology is systematic, with proper modeling, meshing, and boundary condition application, which strengthens the credibility of results. Findings show that the **Pratt truss** performs better due to lower deformation and stress compared to the **Lattice truss**. The results also indicate minimal variation between I and C sections, suggesting section choice has less impact improve by including more realistic loading scenarios and validation with experimental data. Graphical comparisons enhance understanding, though presentation quality could be refined. Overall, the paper demonstrates a practical and insightful use of FEA in bridge design optimization.

ShujieShang , Lei Jiang, YongquanDong ,Zhengbo Li and Runsheng Pei (2024) conducts this study presents an advanced trial design of a composite truss bridge using rectangular steel tubes filled with ultra-high-performance concrete (UHPC), showing clear innovation in modern bridge engineering. The integration of finite element analysis with practical design optimization enhances the reliability of the proposed model. The use of prestressed UHPC effectively improves tensile performance and overcomes traditional limitations of concrete in tension zones. Compared to conventional steel truss bridges, the design demonstrates significant reductions in material usage and overall cost,

improving economic feasibility. The modular prefabrication approach also enhances construction efficiency and reduces onsite work. Additionally, the study highlights improved durability, seismic resistance, and fire performance due to the composite action. However, the reduction in safety factors for some members suggests the need for careful validation under extreme conditions. The research could further benefit from experimental verification to support numerical findings. Overall, it provides a strong foundation for future applications of composite truss bridges in large-span infrastructure.

Jatin Jain, Jyoti Vimal (2021) conducts this paper presents a comparative structural study of multiple truss configurations using ANSYS Workbench under dead load conditions, offering a clear practical approach to design optimization. The inclusion of four truss types—Pratt truss, Warren truss, Pratt Half-Hip, and a modified Pratt—provides a useful comparative framework. The application of finite element analysis is appropriate and helps evaluate deformation, stress, and internal forces effectively. Results indicate that the modified Pratt truss with top inclined members performs best in terms of minimum deformation and stress. The study is systematic, with clear modeling, meshing, and boundary condition definitions. However, the analysis is limited to dead load only, which restricts real-world applicability since bridges are subjected to dynamic and live loads. The presentation of results through charts enhances clarity, though deeper discussion on failure modes would improve the work. Additionally, validation through experimental or real-case data is lacking. Overall, the paper provides a good introductory comparison and highlights the potential of modified truss designs for improved performance.

Mohamad Ibrahim Zaed Ammar, Djoko Irawan, Data Iranata, Budi Suswanto this study provides a valuable experimental investigation into the failure mechanisms of cold-formed steel truss bridges, focusing on connection behavior. The comparison between screw-only and screw-plus-adhesive connections is well-structured and highlights the importance of joint design. The results clearly show that enhancing connections improves load capacity and stiffness significantly. The use of Warren truss specimens makes the study relevant to practical bridge applications. The experimental setup with strain gauges and displacement sensors strengthens the reliability of observations. Findings indicate that weak connections lead to premature failure, while improved joints shift failure to members, which is desirable. However, the study is limited to small-scale models and static loading conditions. Inclusion of fatigue or dynamic loading could improve real-world applicability. Overall, the research effectively demonstrates the critical role of connection design in truss bridge performance.

Xuran Yang, Xirui Li, & Puyu Sun conducts This paper focuses on the structural analysis and optimization of steel truss bridges using the finite element method (FEM). The authors highlight the limitations of traditional member-level safety analysis and emphasize the need for overall structural-level evaluation. By using ABAQUS and MIDAS software, both global and detailed analyses of the bridge are effectively performed. The study introduces the Elastic Modulus Reduction Method (EMRM) to simulate progressive failure and determine ultimate load capacity. Results show that internal forces are mainly axial, with maximum stress occurring at mid-span. The method improves accuracy and computational efficiency compared to nonlinear approaches. Safety factors are evaluated at both member and structural levels, ensuring reliability. The optimization process helps identify highly stressed members and improves material utilization. Overall, the study presents an efficient and advanced approach for safer and more economical truss bridge design.

Bowen Zhang (2024) conducts This paper focuses on the selection and optimization of truss bridge designs by comparing parallel, triangular, and parabolic trusses. The study evaluates their mechanical behavior and material efficiency under identical loading and span conditions using a structural mechanics solver. Results show that the parabolic truss is the most economical, requiring the least material. However, the triangular truss demonstrates superior mechanical performance due to better load distribution and structural stability. The parallel truss, although slightly less material-efficient, offers advantages in ease of construction and aesthetics. A comprehensive comparison suggests that the parallel truss is often the most practical choice in real-world applications. The study highlights the importance of balancing cost, performance, and constructability in design decisions. Limitations include neglecting variable cross-sections and material differences. Overall, the paper provides useful guidance for optimized truss selection in engineering practice.

Shreyash Watane, Ishant Dahat (2023) conduct This paper presents a comparative study of Pratt and Howe trusses using STAAD.Pro software for design and analysis. It highlights the importance of truss systems in efficiently carrying loads over long spans in civil engineering structures. The study models both truss types to evaluate parameters such as member forces, deflection, and support reactions. Results show that the Pratt truss performs better under tension-dominated conditions, while the Howe truss is more suitable for compression-heavy members. The use of STAAD.Pro enables accurate simulation and simplifies the design process with code-based analysis. The comparison helps in understanding the structural behavior and efficiency of each

truss type. It also emphasizes the influence of span length and loading conditions on performance. Overall, the study provides useful insights for selecting appropriate truss configurations in practical engineering applications.

Vedashri Panjabrao Jadhao, Dr. Zeeshan A. Ahmed, Prof. S.S. Zambani (2025) conducts This study presents a comparative evaluation of four steel truss bridge configurations—Pratt, Howe, Warren, and K-truss—using finite element analysis in STAAD Pro. The results show that the K-truss provides the least deflection, indicating superior stiffness, while the Warren truss demonstrates the most uniform stress distribution and lowest material consumption. Although Pratt and Warren trusses are nearly equal in cost and steel usage, they offer a good balance between performance and constructability. The Howe truss performs comparatively poorer in terms of deflection and material efficiency. From a practical perspective, Warren and Pratt trusses emerge as the most economical and feasible options due to moderate complexity and efficient load distribution. The K-truss, despite high stiffness, involves greater construction complexity and cost. Overall, the study highlights that truss selection should consider not only structural performance but also cost, material efficiency, and ease of construction for optimal bridge design.

Ankit Sharma & Sumit Pahwa (2018) This review study highlights the importance of truss bridge analysis with a focus on minimizing deformation and optimizing material usage under dynamic loading conditions. It emphasizes that steel trusses remain the most widely used structural system due to their high strength, durability, and efficiency in carrying axial loads. The paper discusses key components such as chords, diagonals, verticals, and joints, explaining their roles in load transfer. It also outlines fundamental assumptions in truss analysis, such as pin-jointed connections and load application at nodes, which simplify calculations. The literature review shows that modern tools like finite element methods (e.g., ANSYS, ABAQUS) are essential for analyzing vibration, fatigue, and seismic behavior. Additionally, studies on materials like GFRP highlight advancements in lightweight and corrosion-resistant bridge components. The paper concludes that locally fabricated steel truss bridges are a viable and economical solution, especially for short-span and temporary structures, while also supporting local industry and reducing construction time.

Kashish Nagaori (2025) This study presents a comparative evaluation of bowstring girder bridges analyzed using STAAD Pro and MIDAS Civil, particularly in challenging hilly terrain conditions. It highlights the advantages of steel structures over concrete due to better

strength-to-weight ratio, seismic performance, and adaptability to environmental constraints. The methodology is well-structured, incorporating realistic parameters such as wind, snow, and seismic loads, along with multiple lane configurations. Results indicate slight variations in deflection between the two software tools, primarily due to differences in finite element modeling approaches. The study effectively demonstrates that MIDAS Civil is more suitable for complex bridge analysis due to its advanced features, while STAAD Pro remains efficient for simpler and general structural applications. The literature review supports the evolution and relevance of bowstring bridges in modern engineering. However, the paper could improve by providing deeper quantitative comparisons and validation with real-world data. Overall, it offers practical insights for selecting appropriate software tools in bridge design and optimization.

IV. CONCLUSION

Across the reviewed studies, it is evident that finite element analysis (FEA) tools such as ANSYS, STAAD.Pro, MIDAS Civil, and ABAQUS play a central role in modern truss bridge design and optimization. Most researchers consistently highlight that truss configuration significantly influences structural performance in terms of deflection, stress distribution, and load-carrying efficiency. Pratt and Warren trusses generally show better overall performance due to efficient load transfer and balanced geometry, while Howe and K-truss systems exhibit specific advantages under certain loading conditions but may suffer from higher complexity or material usage. Studies on composite and UHPC-filled trusses indicate strong potential for improving strength, durability, and cost efficiency in future bridge systems. Experimental and numerical comparisons also confirm that joint behavior is critical, as connection strength often governs overall structural failure. Software-based comparisons reveal that MIDAS Civil is more suited for advanced bridge-specific analysis, whereas STAAD.Pro remains effective for general structural applications. Research on bowstring and modern optimized trusses emphasizes the importance of balancing material efficiency, cost, and constructability rather than focusing on a single performance parameter. Dynamic effects, seismic behavior, and fatigue considerations are increasingly being integrated into analysis for more realistic predictions. However, many studies still rely heavily on numerical simulations with limited experimental validation, which restricts real-world certainty. Overall, the literature shows a clear trend toward optimized, material-efficient, and software-driven bridge design. It concludes that no single truss type is universally best; instead, selection depends on span, loading conditions, terrain, and construction feasibility.

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