# DESIGN AND ANALYSIS OF STEEL BRIDGE USING STAAD.Pro

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**Abstract –** Steel and steel-concrete composite bridges are widely used across the globe due to their combination of aesthetic appeal and efficient structural performance. These bridges not only reflect the vision and inspiration of their designers but also symbolize a nation's development and aspirations for a better future. Compared to traditional reinforced concrete (RC) bridges, steel bridges offer numerous advantages, including a high strength-to-self weight ratio, rapid and flexible construction, ease of modification, repair, and recycling, enhanced durability, and superior architectural adaptability. The high strength-to-self weight ratio reduces dead loads, which is especially beneficial in areas with poor ground conditions, and facilitates easier transportation, handling, and erection of large components—sometimes even allowing entire bridges to be installed in short durations. Steel components can be customized to meet site access limitations, and once in place, steel girders provide a stable platform for further construction activities. The adaptability of steel bridges allows for modifications such as widening to support increased traffic, and structural reinforcements using steel plates or advanced composites can be applied to meet higher load demands. Additionally, steel bridges are recyclable at the end of their service life or when site conditions change. When properly designed, maintained, and protected from corrosion, steel bridges are highly durable and capable of accommodating complex architectural forms that are often unfeasible with traditional RC structures

***Key Words*:** Steel bridges, Composite bridge, Durability, Recyclability, Modification and repair.

## 1. INTRODUCTION

Bridges play a crucial role in connecting regions and improving transportation networks by allowing movement over physical obstacles such as rivers, roads, or valleys. The design and analysis of bridges require detailed planning to ensure that the structure can safely withstand various forces throughout its lifespan. Modern structural engineering makes use of advanced software tools to enhance accuracy and efficiency in design. One such tool is STAAD.Pro, a widely used structural analysis and design software developed by Bentley Systems. In the context of bridge engineering, STAAD.Pro provides powerful capabilities for modelling, load application, structural analysis, and member design according to relevant codes and standards. The B-8 design process involves creating a digital model of the bridge, applying realistic loads such as dead loads, live loads, wind, and seismic forces, and analysing the resulting behaviour of the structure. Based on this analysis, structural components like decks, girders, and supports are designed to meet strength and serviceability requirements. Using STAAD.Pro not only improves the precision of the design process but also saves time and resources, making it a valuable tool in modern bridge construction projects.

## 2. LITERATURE SURVEY

1. Ramesh et al. (2018) conducted a study on the analysis of T-beam bridges using STAAD.Pro, demonstrating the software's capability to handle live, dead, and seismic loads efficiently. The study concluded that STAAD.Pro provided accurate bending moments, shear forces, and deflection results, making it suitable for real-time bridge design.
2. Patel and Shah (2019) evaluated the performance of a steel-concrete composite bridge using STAAD.Pro and found that composite bridges designed through the software offered better load distribution and reduced deflection compared to conventional RC bridges. Their study emphasized the software's efficiency in optimizing material usage and structural safety.
3. Verma and Singh (2020) compared the manual design of slab bridges with STAAD.Pro results and observed close correlation in output values. However, the use of STAAD.Pro significantly reduced analysis time and allowed for easy revision and modification, supporting its use in professional practice.
4. Kumar and Mehta (2021) explored the impact of different support conditions and loading patterns on a box girder bridge. Their research utilized STAAD.Pro to simulate real-time loading scenarios and concluded that the software accurately reflected the behaviour of bridge components under varying stress conditions.
5. Sharma (2022) used STAAD.Pro for seismic analysis of a multi-span bridge and validated the results with IS code provisions. The study demonstrated that STAAD.Pro could be effectively used to evaluate structural stability during earthquakes, which is crucial for bridges located in high seismic zones.

## 3. OBJECTIVES

1. To understand the fundamental principles involved in the structural design and analysis of bridges.
2. To develop a digital model of a bridge using STAAD.Pro software, including key components such as deck slabs, girders, and supports.
3. To apply various types of loads such as dead loads, live loads, wind loads, and seismic loads on the bridge structure as per relevant design codes.
4. To analyse the structural behaviour of the bridge under different load combinations using STAAD.Pro.
5. To design structural elements of the bridge like beams, columns, and slabs to ensure safety, stability, and serviceability.
6. To compare results obtained from STAAD.Pro with manual calculations or standard design values for validation.
7. To optimize the design in terms of material usage, cost-efficiency, and performance using the analytical tools

available in STAAD.Pro

## 4. METHODOLOGY

The methodology describes the detailed procedure followed for the design and analysis of the bridge structure using STAAD.Pro software.

### 4.1 MODELING IN STAAD Pro

1. Data collection and preliminary study:
   - Collect relevant project data including span length, width, type of bridge (e.g., RC slab), materials (concrete grade, steel grade), and site conditions.
   - Review design codes such as IRC 6 for live loads, IS 456 for concrete design, IS 875 for wind load, and IS 1893 for seismic considerations.).
   - Determine the loading standards applicable, such as IRC Class A or AA for live load.

2. Bridge modeling in Staad.Pro:
   - Open STAAD.Pro and start a new project.
   - Define the geometry of the bridge by creating nodes at key points (supports, mid-span, etc.).
   - Connect nodes using beam elements to model the deck slab, girders, and other members.

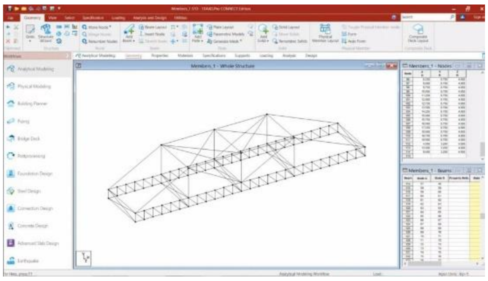

Fig 1: Selection of frame.

   - Assign cross-sectional properties (e.g., slab thickness, girder dimensions) and material properties (e.g., concrete grade M25, steel grade Fe415) to each element.
   - Define support conditions (fixed, pinned, roller) at the abutments and piers as per design requirements.

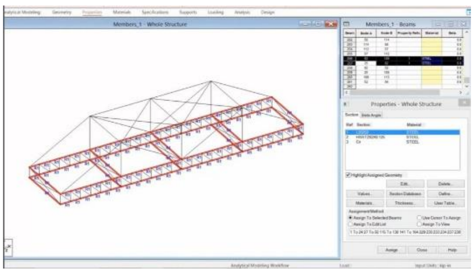

Fig 2: The Model of Structure with All Beams and Nodes.

3. Load defination:
   - Dead Load (DL): Self-weight of the slab and other bridge components, which can be automatically generated by the software.
   - Live Load (LL): IRC Class A loading representing vehicular traffic, applied as per IRC 6 guidelines.
   - Wind Load: Calculated based on IS 875 Part 3, applied laterally to the bridge structure.
   - Seismic Load (if applicable): Defined according to IS 1893, considering zone factors and importance factors.
   - Other Loads: Temperature effects or impact loads, if necessary.
   - Create load combinations as per relevant code requirements, for example:
     - 1.5(DL + LL)
     - 1.2(DL + LL + Wind)
     - 1.2(DL + LL + Seismic)

4. Structural analysis:
   - Perform static analysis in STAAD.Pro to evaluate the internal forces, moments, and deflections under the applied loads and combinations
   - Review analysis results such as:
     - Maximum bending moments at mid-span and supports.
     - Shear forces along the span.
     - Deflection of the deck slab.
     - Reactions at supports.
   - Verify whether the deflections and forces are within permissible limits defined by the codes.

5. Design of structural element:
   - Use the analysis output to design the reinforcement for the slab and beams:
     - Calculate required steel area based on maximum bending moments using IS 456 provisions.
     - Check shear capacity and design shear reinforcement.
     - Design supports (piers, abutments) for axial loads and bending moments.
   - Utilize STAAD.Pro integrated design modules or perform manual calculations for verification

6. Load Assignments:
   - Self-weight of the structure was included automatically.
   - Additional dead loads and live loads were applied at the top of the column.
   - In some cases, wind load was also applied according to IS 875 (Part 3).

7. Creating load combinations:
   - Load combinations such as (DL + LL), (DL + WL), etc., were defined as per IS code.

8. Saving and Analyzing the Model:

   - The model was saved and the **analysis was run** to check for axial force, bending moment, shear force, and displacement.

9. Checking Errors and Viewing Results:
   - The structure was checked for modeling or support errors.
   - All outputs were viewed in the post-processing mode for structural behavior and design forces.

## 5. DEAD LOAD

In structural engineering, a dead load (also known as a static or permanent load) refers to the constant load acting on a structure due to the self-weight of structural elements and all permanently attached components. This includes:

- The self-weight of primary structural elements such as beams, columns, slabs, and walls.
- The weight of non-structural elements like flooring materials, false ceilings, partitions, and cladding.
- The load from permanent fixtures and equipment, such as plumbing systems, HVAC units, and built-in machinery that are fixed in position.

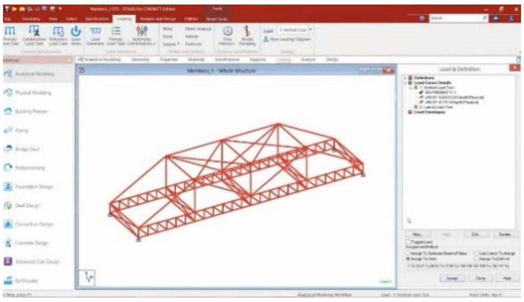

Fig 3: structure under dead load

## 6. LIVE LOAD

The second vertical load that is considered in plan of a structure is forced loads or live loads. Live loads are either portable or moving burdens with no quickening or effect. These heaps are thought to be delivered by the planned utilize or inhabitance of the building including weights of versatile parcels or furniture and so forth.

Live load continues changing now and again. These heaps are to be reasonably expected by the planner. It is one of the significant loads in the plan. The base estimations of live loads to be expected are given in IS 875 (section 2) – 1987. It relies on the expected utilization of the building.

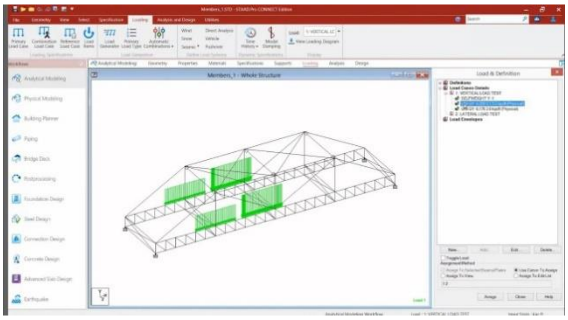

Fig4: structure under live load

## 7. WIND LOAD

Wind is a mass of air that moves in a mostly horizontal direction from an area of high pressure to an area with low pressure. The wind load is defined as the load on a structure due to the action of wind. High winds can be very destructive because they generate pressure against the surface of a structure. The effect of the wind is dependent upon the size and shape of the structure. Calculating wind load is necessary for the design and construction of safer, more wind-resistant buildings and placement of objects such as antennas on top of buildings. Wind data taken from IS 875 as follows.

| Parameter | Value |
|---|---|
| Exposure Type | Type C |
| Basic Wind Speed | 39 m/s |
| Importance Factor | 1.0 |
| Building Classification | Category II |
| Structure Type | Lattice Framework |
| Method Used | Normal Force Method |

## 8. CONCLUSION

This project deepened my understanding of how reinforced concrete columns behave under different loads, and I gained hands-on experience with STAAD.Pro and AutoCAD. By applying these tools, I was able to analyze and design a column that met Indian building standards, ensuring its stability and longevity. The project demonstrated the power of technology in streamlining the design process, allowing for precise calculations and efficient workflows. Overall, it was a valuable learning experience that combined theoretical foundations with practical skills.

## 9. FUTURE SCOPE

This project focuses on a single-column RC structure, but in the future, the study can be expanded to design buildings with several columns to support bigger and more complex structures. Additional factors like earthquake forces, temperature changes, and moving loads can be included to better understand how the structure behaves under real conditions. More advanced analysis methods, such as nonlinear and pushover analysis, can be used for detailed safety checks. Designing the foundation along with the column will give a complete picture of the structure’s stability. Integration with modern tools like Building Information Modelling (BIM) can improve planning and construction. Also, using newer materials like high-strength or fibre-reinforced concrete could make the structure stronger and longer-lasting.

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