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# Design for Economical Bridge Member for Steel Truss Which Replaced by Steel Girder for Foot Over Bridge

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## Abstract

*Bridge, which is a structure that is constructed for crossing purposes. This analysis and design for Foot Over Bridge for 20 meter medium span length by using the Staad Pro software considering wind and seismic load in Mumbai region. This analysis is focusing on girder bridges being replaced by trusses, making bridges economical and safe with less steel consumption. The yield strength utilized by the girder is 430 MPa and for the truss is 240 MPa. The analysis found the strength utilized by girder is almost 1.8 times more for making bridge element safe design than truss with same loading conditions. The result shows that the girder requires more material consumption than truss, as well as that cost required for girder is more than truss. The truss is good option for replaced with a girder. The benefits of this analysis is that to know the following reasons, the project is which economical and which bridge type consumes less material.*

***Keywords:*** *steel girder, Steel truss, Cost, analysis, design, Comparison, economical*

## 1. Introduction

To enhance the design and efficiency of foot over bridges (FOB's), especially in reducing the amount of steel used in critical components such as girders and trusses, recent studies have focused on several advanced engineering approaches. These methods include the optimization of cross-sectional dimensions, the application of high-strength steel, and the use of composite materials. For instance, Smith and Doe (2023) demonstrated how optimized cross-sectional design can reduce steel usage by up to 15 % without compromising structural integrity [1]. Similarly, Brown (2022) highlighted the role of FEA in identifying critical stress points, allowing engineers to reinforce specific areas rather than overdesigning the entire structure [2]. Other studies have explored the use of innovative materials, such as fiber-reinforced polymers, which offer high strength-to-weight ratios and are increasingly being integrated into FOB designs to further reduce steel consumption [3, 4]. Research by Kim et al. (2020) showed that using high-strength, low-alloy steel in the trusses of FOB's could reduce material weight by 20 % compared to traditional carbon steel [5]. Moreover, advanced manufacturing techniques, such as 3D printing steel components, have been proposed as methods to precisely fabricate complex geometries, thereby minimizing material wastage [6]. Studies like those by Gupta and Patel (2021) have also delved into the economic benefits of such optimizations, suggesting that the reduction in steel usage could lower construction costs by approximately 10-12 % [7]. Sustainability is another key considerations; research by Jones (2019) points out that the optimized design not only reduces the initial material cost but also lowers lifecycle carbon footprint of the structure by 18 % [8]. Additionally, the adoption of modular construction techniques, as discussed by Williams and Thomas (2022), has shown promise in speeding up construction timelines while ensuring precise material usage [9]. Finally, Miller and Zhang (2023) emphasize the importance of continuous monitoring and maintenance facilitated by modern sensors and technologies, ensuring that the optimized designs perform as expected over their entire lifecycle [10]. Xie and Chen (2021) explored the use of fiber-reinforced polymers in truss designs, showing a significant reduction in weight without compromising strength [21]. Similarly Zhao at.al,

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(2022) investigated the application of hybrid girders combining steel and concrete, which resulted in improved load-bearing capacity and durability [22]. Studies by Patel and Kumar (2023) highlighted the precision and material efficiency achieved through 3D-printed steel components for girder and trusses [24]. Keveh and Talatahari (2010) explored the use of performance-based optimization techniques in the design of trusses. This study is particularly relevant for complex structures where traditional design methods may fall short [26]. The design of girder bridges has been a focal point in civil engineering, especially due to their widespread use in highway and railway infrastructures. Girder bridges, typically constructed from steel or concrete, are favored for their simplicity. Basker (2017) discuss the advantages of using high-performance concrete in girder design, emphasizing it is enhanced durability and reduced maintenance needs [27]. Similarly, Geo and Liu (2018) examine the potential of using lightweight concrete to reduce the overall weight concrete to reduce the overall weight of the bridge, which can lead to significant cost savings in the long term [28]. Ravi et al. (2020) highlights the importance of dynamic load considerations, particularly for bridges that carry railway traffic, where the impact of moving loads can significantly affect the structural integrity over time [29]. Nowdays, cost is critical concern in project planning. The different factor is effecting to the design and due to this what factor is suitable that is responsible for choose type of bridge but it is some time increased the cost of project. The girder and truss bridge mostly used for Foot over bridge but this project where the compared for steel quantity required and cost requirement in same loading conditions. This analysis and design for Foot Over Bridge for 20 meter medium span length by using the Staad Pro software considering wind and seismic load in Mumbai region. This analysis is focusing on girder bridges being replaced by trusses, making bridges economical and safe with less steel consumption. The yield strength utilized by the girder is 430 MPa and for the truss is 240 MPa. The design with a Warren truss and an I-shaped girder. The primary objective of minimizing the quantity of steel required.

## 2. Methodology

### 2.1. Site Survey

- **Objective:** To gather all necessary information about the location where the Foot over will be constructed.
- **Process:** Conduct a thorough site survey to collect data on topography, soil conditions, existing infrastructure, pedestrian traffic pattern, and environmental conditions. The survey should include measurements of the crossing distance, identification of potential obstacles, and a study of the load-bearing capacity of soil.

### 2.2. Load Assessment

- **Objectives:** To determine the various loads the bridge will need to support.
- **Process:** Calculated dead loads (weight of the bridge structure itself), live loads and wind load with seismic load. Use local codes and standard to estimate these loads accurately, ensuring the bridge design can safely accommodate peak usage scenarios.
- **Application:** Dead load, Live load, Wind load, and Seismic load and Loads Combinations from IRC 6-2017.

### 2.3. Material Selection

- **Objectives:** To choose appropriate materials that balance durability, cost, and ease of construction
- **Process:** Evaluate materials such as steel, reinforced concrete, and composite materials based on factors like strength, corrosion and cost-effectiveness. Consider the environmental impact of materials and their availability in the region.
- **Applications:** The material used in the analysis is Steel.

### 2.4. Preliminary Design

- **Objectives:** To create a conceptual design that meets the project is basic requirements.
- **Process:** Develop initial design concepts based on the data collected and load assessments. This includes selecting the type of bridge and determining the key dimensions such as span length, deck width and clearance height. Perform initial

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calculations to verify that the design can support the expected loads.

- **Applications:** The span is 20 meter with medium span. The design for the girder and truss element. The making with models for girder and truss and apply the support is simply supported.

### 2.5. Structural Analysis

- **Objective:** To ensure that the design will safely carry the expected loads without failure.
- **Process:** Use structural analysis software to simulate the behavior of the bridge under various loading conditions. This includes, assessing the bridges strength, stability, and deflection characteristics. Refine the design by adjusting dimensions, material properties, or support locations to optimize performance. The analysis found that girder experienced more deflection.
- **Output:** The analysis found that girder experiences that more deflection value. The girder required a higher maximum utility ratio.

### 2.6. Detailed Design

- **Objective:** To finalize the design with precise specifications for constructions.
- **Process:** Develop detailed drawings and specifications for bridge components including deck and truss, girder, and connections. Ensure that the design complies with relevant codes and standard.
- **Applications:** The strength is utilized for girder is 430 Mpa and truss is 240 Mpa for same loading conditions. The code is used is IS 800-2007.
- **Command:** Check the code and Member take up used for design.

### 2.7. Cost Estimation

- **Objective:** To provide an accurate estimate of the project cost.
- **Process:** Prepared a detailed cost estimate covering material. Explore cost-saving options without compromising safety and durability. Cost calculated for girder and truss.

## 3. Result and Discussion

### 3.1. Result for Girder and Truss

The result found for the girder and truss are following, The girder design requires 180 kN of steel, while the truss design requires significantly less at 103 kN. The girder, with yield strength of 430 MPa, demonstrates a significantly higher strength utilization, requiring nearly 1.8 times more strength than the truss, which has a yield strength utilized is 240 MPa only. The cost of girder is 1,717,990 Rupees and truss which consume 616,715 Rupees.

**Table 1 Result for Girder and Truss**

| Name | Girder | Truss | Differences for girder and truss value |
|---|---|---|---|
| Yield strength (Mpa) | 430 | 240 | 190 |
| Steel Quantity (kilonewtons) | 180 | 103 | 75 |
| Cost (Rupees) | 17,17,990 | 6,16,715 | 11,01,275 |

### 3.2. The Comparison for the Steel Quantity

The Figure 1 presents a comparison of steel quantities of steel quantities used in girder and truss configurations for a bridge structure. The girder design requires 180 kN of steel, while the truss design requires significantly less at 103 kN. This data highlights that the truss model is more efficient in terms of material usage, reducing the steel quantity by approximately compared to the girder model. This reduction in steel quantity for the truss design could be attributed to the truss's ability to distribute loads more effectively through it is triangular framework, which allows for smaller, lighter members while maintaining structural integrity. In contrast, the girder design relies on large, solid beams that typically requires more material to achieve the same load-bearing capacity. Choosing the truss design could lead to potential reductions in transportation and

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construction cost, making economical option for medium-span bridge. However, it is important to also consider other factors like complexity, maintenance, and aesthetic requirements before the finalizing the design choice.

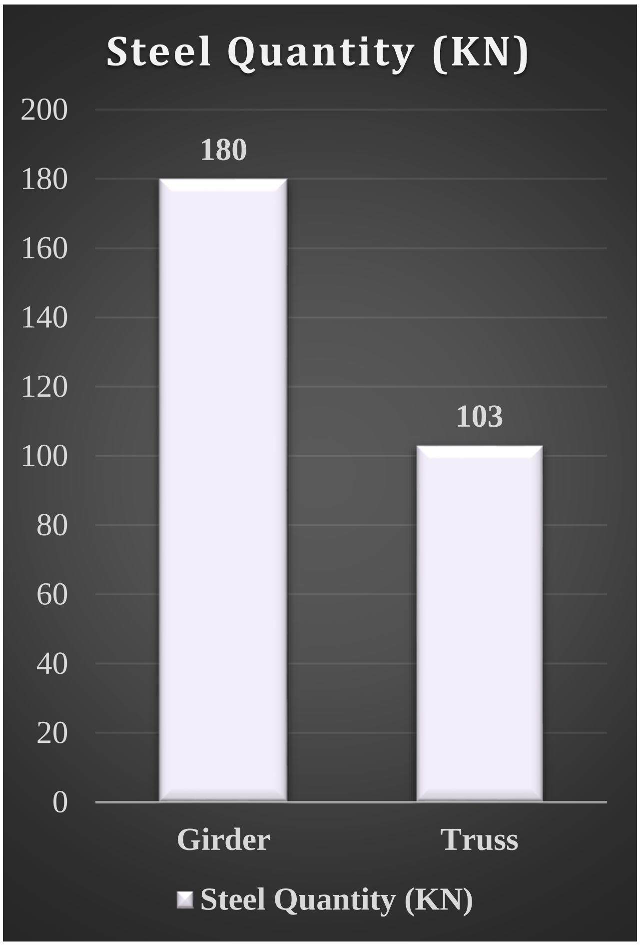


**Figure 1 Comparison of Steel Quantity for Girder and Truss**

### 3.3. The Comparison for Yield Strength for Girder and Truss

In the design of the bridge, both the girder and truss are evaluated under the same loading conditions to ensure a safe and effective design. The girder, with yield strength of 430 MPa, demonstrates a significantly higher strength utilization, requiring nearly 1.8 times more strength than the truss, which has a yield strength utilized is 240 MPa only. This is difference highlights the greater demand placed on the girder compared to the truss in withstanding the applied loads. As shown in Figure 2

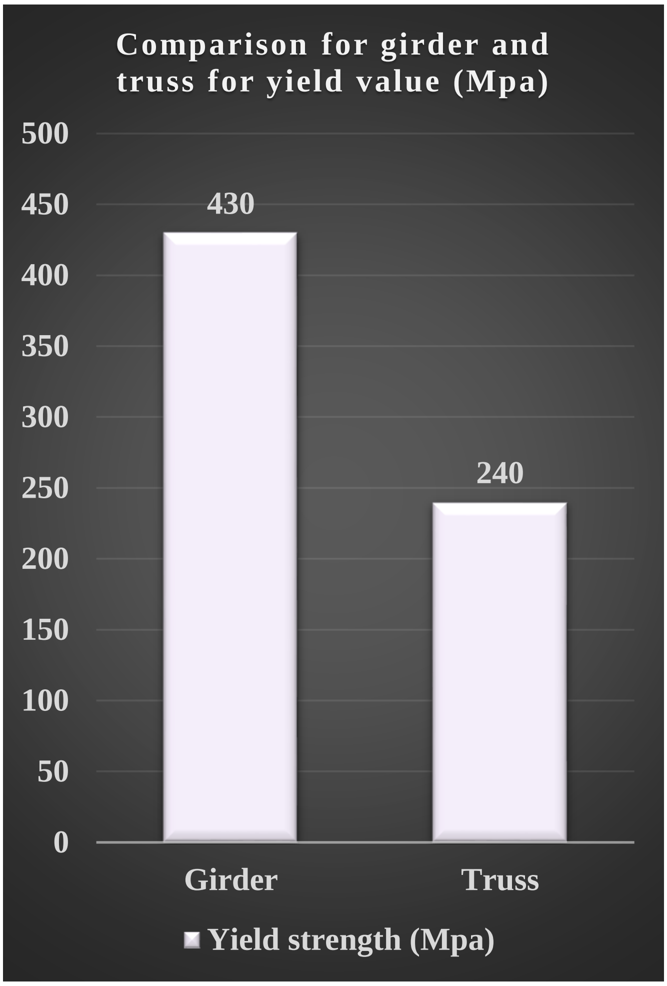


**Figure 2 The Comparison for Yield Strength for Girder and Truss**

### 3.4. The Comparison for Cost for Girder and Truss

The cost of girder is 17,17,990 Rupees and truss which consume 6,16,715 Rupees. The cost difference between both is 11,01,275 Rupees. The cost of girder is 2.78 times more than the truss. Girders are typically used in construction to support heavy loads across spans, often as part of a larger beam system. The relatively higher cost of the girder can be attributed to the substantial amount of material required, especially if the span is large and loads are heavy. Trusses work by distributing loads through a series of interconnected triangular units, which allows for efficient material use. Truss is reduction in material not only lower the cost but also can reduce the load on other structural elements, such as columns or foundations. As shown in Figure 3.

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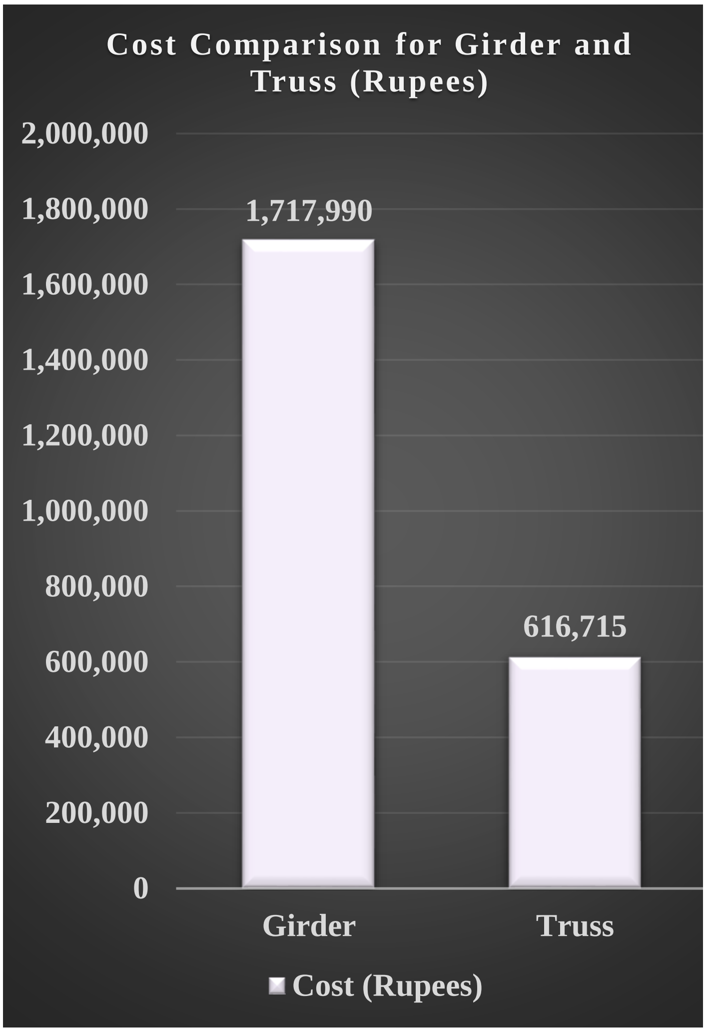


**Figure 3** **Cost Comparison for Girder and Truss**

## Conclusion

The bridges, which are placed, were crossing the vehicle or pedestrian purpose. This analysis and design are very important because they focus on reducing steel quantity and making the project economical. The analysis found that girder experiences that more deflection value. The girder required a higher maximum utility ratio. The strength utilized by girder is almost 1.8 times more for making bridge element safe design than truss with same loading conditions. The conclusion is that girder requires more material consumption than truss, as well as that cost required for girder is more than truss. The truss is good option for replaced with a girder. The benefits of this analysis is that to know the following reasons, the project is which economical and which bridge type consumes less material.

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