# Research on Economic Optimization Scheme of Pratt Truss Bridge

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**Abstract.** Economy is an important factor in bridge construction. The economic optimization of truss bridge is of great significance to improving the economic benefit of bridge construction. However, the safety and stability in bridge construction are often valued in traditional truss Bridges, and its economy is often ignored. The purpose of this paper is to study the economic optimization of Pratt truss bridge with 120 m span, 8m and node length of 6m, 10m and 12m respectively. The study of establishing two-dimensional model using structural mechanics solver shows that when the total length of the Pratt truss node is 12m, the total volume of the truss is the smallest, that is, the least materials are used, and the linear relationship between the bridge span and the node length is established to a certain extent. The results of this study provide an effective reference for the economic optimization of similar truss bridge structures.

**Keywords:** Pratt truss, economic, optimization of bridge, structural mechanics solver.

## 1. Introduction

With technological progress and the expanding global population, China's investment in infrastructure will pay more and more emphasis on [1]. The application of economy, practicability and other aspects of bridge design need to be considered in detail. While ensuring the function of the bridge, minimize the investment cost, implement the principles of economic economy, efficiency and practicality, so as to improve the level of the bridge design and meet the needs of transportation and people's travel [2]. The construction of bridge will enter a new era, at the same time, economic related issues will be more and more attention. Talking about economic-related issues cannot bypass engineering optimization design. Engineering optimization design refers to the process of selecting the optimal scheme by comparing many possible schemes under certain constraints, so as to maximize the structural performance and reduce the cost and reduce the dosage of [3]. The comparison of bridge design scheme has an important influence on the preliminary design and construction drawing design [4]. Truss bridge plays an important role in the development of modern bridge learning due to its advantages of simple structure, high bearing capacity, large longitudinal and transverse stiffness, and short construction period [5]. This paper discusses the economic problems related to the truss bridge. According to the different shapes of the grid between nodes, the truss bridge can be divided into two types of triangular grid and quadrangle grid: (1) Triangle grid triangular truss structure is a triangular grid system composed of several straight rods and nodes, and these nodes are connected by straight rods. Good stability, strong rigidity and light weight are the characteristics of this structure, which is suitable for large-span buildings. (2) The quadrangle grids the quadrangle truss structure is a quadrangle grid system composed of several straight rods and nodes, which are connected to each other by the straight bars. Good stability, strong rigidity and light weight are also the characteristics of this structure, which is suitable for large-span buildings. In this paper, the pratt truss is discuss in triangular grid triangular truss structure. As a widely used form of circular steel pipe truss structure, the Pratt truss has inclined belly rods, which are all tilted towards the center of the span. Thanks to this design, the shorter longitudinal is less affected by the flexion force and mainly by the compressive load [6]. At the same time, Pratt truss bridge has the advantages of light weight, strong crossing ability, welding and assembly in the automatic factory, and direct assembly to the site, which effectively shortens the construction period. This study decided to use a structural mechanics solver. Structural mechanics solver is a computer-aided analytical computing software dedicated to handle the problem of two-dimensional plane structure. The user enters the relevant data, and the software builds a two-dimensional structure model [7] that meets the setting conditions. It is used to solve some classical structural mechanical problems, such as geometric composition, static determination, internal force, elastic stability and limit load, which are very convenient and effective [8]. Although the current domestic research on truss bridge has had more innovative development compared with foreign countries, but there is still a lack of in-depth research in the optimization of truss bridge [9, 10]. In this paper, the structural mechanics solver will be used to study the truss bridge classification-pratt truss bridge, and explore the linear relationship between the node length and the amount of the bridge steel under a certain limit, so as to obtain the minimum value of truss material consumption.

## 2. Research Technique

### 2.1. The Pratt Truss Bridge Design

The design requirements include: bridge span 120m, tension 100 Mpa, pressure 30 Mpa, load 150 kn / m, on this basis to optimize the amount of truss materials. According to this design requirement, the pratt truss bridge is obtained as shown in Fig. 1.

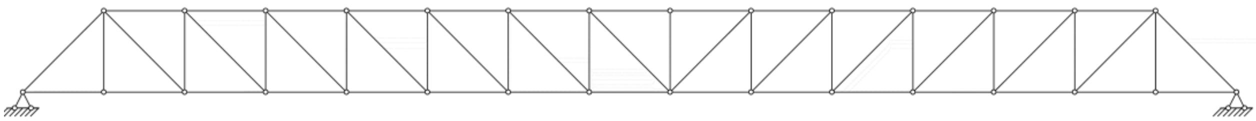

**Figure 1.** Initial model of the Pratt truss bridge

### 2.2. Optimization Method

(1) The node length is selected as the independent variable and the web rod length as the corresponding variable. Generally, the length of the bearing truss beam interjoint is 5.5~12m or 0.8~1.2 times of the truss height.8m is used in the standard design, and 4m, 6m and 12m are often used in the non-standard design. Based on the building code and design feasibility, the node length of 6m, 8m, 10m and 12m is discussed respectively.

(2) The inclination of the inclined bar is unchanged. Related to the truss height and internode length, the Angle between the oblique bar axis and the vertical line should be within the range of 30°~50°, thus selecting the oblique bar inclination within 45° as the determined value. The optimization scheme is shown in Table 1.

**Table 1.** Optimization scheme

| scheme | Bevel bar inclination of (°) | Node length (m) |
|---|---|---|
| Scheme 1 | 45 | 6 |
| Scheme 2 | 45 | 8 |
| Scheme 3 | 45 | 10 |
| Scheme 4 | 45 | 12 |

## 3. Results and Discussion

### 3.1. Scheme 1

Part of the results of scheme 1 calculated by structure solver is shown in Fig. 2. It is concluded that when the node length is 6m and the inclined bar inclination is 45°, the vertical web is 6 m, and the volume of the material is 181m³, as shown in Table 2. The volume of rod # 1 is large because of the large pressure, and the volume of rod # 5 is small because of the small tension.

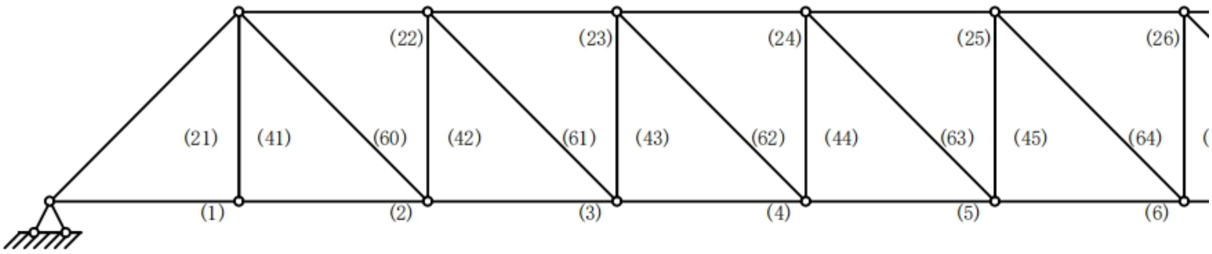


**Figure 2.** Part of the Pratt Truss Bridge Scheme 1 model

**Table 2.** Scheme 1 results of selected rod and the total volume

| Pole number | Axial force | Pull / pressure | Sectional area | Length | Volume | Total volume |
|---|---|---|---|---|---|---|
| 1 | -19980.00 | press | 0.67 | 6.00 | 4.00 | 181.69 |
| 2 | -19980.00 | press | 0.67 | 6.00 | 4.00 | |
| 3 | -12330.00 | press | 0.41 | 6.00 | 2.47 | |
| 4 | -5580.00 | press | 0.19 | 6.00 | 1.12 | |
| 5 | 270.00 | pull | 0.00 | 6.00 | 0.02 | |
| 6 | 5220.00 | pull | 0.05 | 6.00 | 0.31 | |
| 21 | -12091.00 | press | 0.40 | 8.00 | 3.22 | |
| 22 | -16200.00 | press | 0.54 | 6.00 | 3.24 | |
| 23 | -22950.00 | press | 0.77 | 6.00 | 4.59 | |
| 24 | -28800.00 | press | 0.96 | 6.00 | 5.76 | |
| 25 | -33750.00 | press | 1.13 | 6.00 | 6.75 | |
| 26 | -37800.00 | press | 1.26 | 6.00 | 7.56 | |
| 41 | 900.00 | pull | 0.01 | 6.00 | 0.05 | |
| 42 | -6750.00 | press | 0.23 | 6.00 | 1.35 | |
| 43 | -5850.00 | press | 0.20 | 6.00 | 1.17 | |
| 44 | -4950.00 | press | 0.17 | 6.00 | 0.99 | |
| 45 | -4050.00 | press | 0.14 | 6.00 | 0.81 | |
| 60 | 10818.73 | pull | 0.11 | 8.00 | 0.87 | |
| 61 | 9545.94 | pull | 0.10 | 8.00 | 0.76 | |
| 62 | 8273.14 | pull | 0.08 | 8.00 | 0.66 | |
| 63 | 7000.35 | pull | 0.07 | 8.00 | 0.56 | |
| 64 | 5727.56 | pull | 0.06 | 8.00 | 0.46 | |

### 3.2. Scheme 2

Part of the results of scheme 1 calculated by structure solver is shown in Fig. 3. When the node length is 8m and the inclined rod inclination is 45°, the vertical belly rod is 8m, and the volume of the material is 142m³, as shown in Table 3.

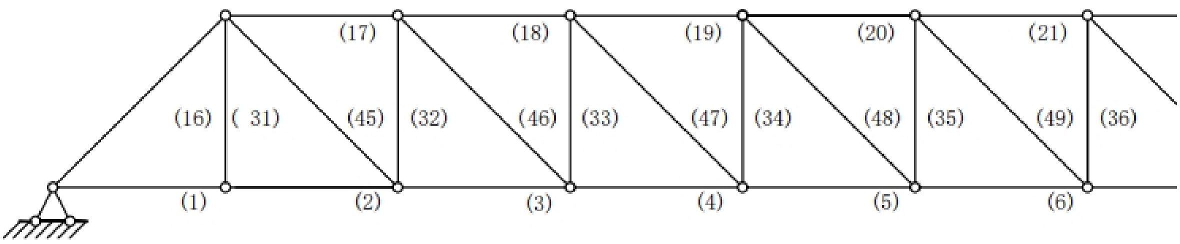


**Figure 3.** Part of the Pratt Truss Bridge Scheme 2 model

**Table 3.** Scheme 2 results of selected rod and the total volume

| Pole number | Axial force | Pull / pressure | Sectional area | Length | Volume | Total volume |
|---|---|---|---|---|---|---|
| 1 | -12880.00 | press | 0.43 | 8.00 | 3.43 | 142.22 |
| 2 | -12880.00 | press | 0.43 | 8.00 | 3.43 | |
| 3 | -5680.00 | press | 0.19 | 8.00 | 1.51 | |
| 4 | 320.00 | pull | 0.00 | 8.00 | 0.03 | |
| 5 | 5120.00 | pull | 0.05 | 8.00 | 0.41 | |
| 6 | 8720.00 | pull | 0.09 | 8.00 | 0.70 | |
| 16 | -11879.39 | press | 0.40 | 11.00 | 4.36 | |
| 17 | -15600.00 | press | 0.52 | 8.00 | 4.16 | |
| 18 | -21600.00 | press | 0.72 | 8.00 | 5.76 | |
| 19 | -26400.00 | press | 0.88 | 8.00 | 7.04 | |
| 20 | -30000.00 | press | 1.00 | 8.00 | 8.00 | |
| 21 | -32400.00 | press | 1.08 | 8.00 | 8.64 | |
| 31 | 1200.00 | pull | 0.01 | 8.00 | 0.10 | |
| 32 | -6000.00 | press | 0.20 | 8.00 | 1.60 | |
| 33 | -4800.00 | press | 0.16 | 8.00 | 1.28 | |
| 34 | -3600.00 | press | 0.12 | 8.00 | 0.96 | |
| 35 | -2400.00 | press | 0.08 | 8.00 | 0.64 | |
| 36 | -1200.00 | press | 0.04 | 8.00 | 0.32 | |
| 45 | 10182.33 | pull | 0.10 | 11.00 | 1.12 | |
| 46 | 8485.28 | pull | 0.08 | 11.00 | 0.93 | |
| 47 | 6788.22 | pull | 0.07 | 11.00 | 0.75 | |
| 48 | 5091.16 | pull | 0.05 | 11.00 | 0.56 | |
| 49 | 3394.11 | pull | 0.03 | 11.00 | 0.37 | |

### 3.3. Scheme 3

As calculated by the structure solver, part results of scheme 3 is shown in Fig. 4. When the node length is 10m and the inclination of the inclined rod is 45°, the vertical belly rod is 10m, and the volume of steel is 119m³, as shown in Table 4.

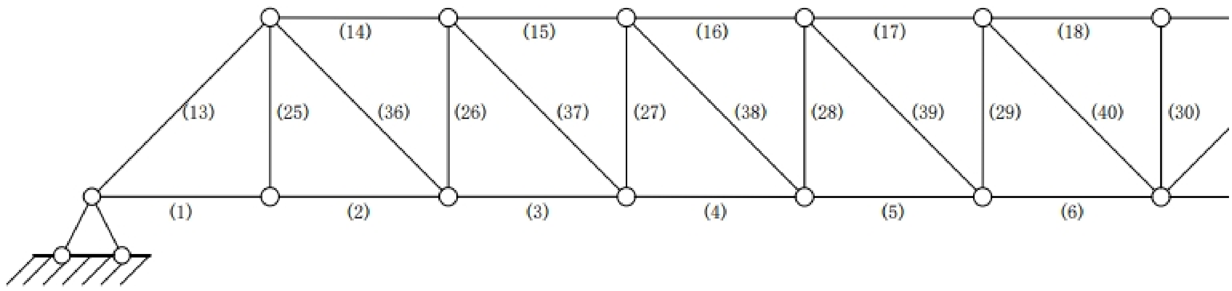


**Figure 4.** Part of the Pratt Truss Bridge Scheme 3 model

**Table 4.** Scheme 3 results of selected rod and the total volume

| Pole number | Axial force | Pull / pressure | Sectional area | Length | Volume | Total volume |
|---|---|---|---|---|---|---|
| 1 | -8750.00 | press | 0.29 | 10.00 | 2.90 | 119.14 |
| 2 | -8750.00 | press | 0.29 | 10.00 | 2.90 | |
| 3 | -2000.00 | pull | 0.07 | 10.00 | 0.70 | |
| 4 | 3250.00 | pull | 0.03 | 10.00 | 0.33 | |
| 5 | 7000.00 | pull | 0.07 | 10.00 | 0.70 | |
| 6 | 9250.00 | pull | 0.09 | 10.00 | 0.93 | |
| 13 | -11667.00 | press | 0.39 | 14.00 | 5.46 | |
| 14 | -15000.00 | press | 0.50 | 10.00 | 5.00 | |
| 15 | -20250.00 | press | 0.68 | 10.00 | 6.80 | |
| 16 | -24000.00 | press | 0.80 | 10.00 | 8.00 | |
| 17 | -26250.00 | press | 0.88 | 10.00 | 8.80 | |
| 18 | -27000 | press | 0.90 | 10.00 | 9.00 | |
| 25 | 1500.00 | pull | 0.02 | 10.00 | 0.15 | |
| 26 | -5250.00 | press | 0.18 | 10.00 | 1.80 | |
| 27 | -3750.00 | press | 0.13 | 10.00 | 1.30 | |
| 28 | -2250 | press | 0.08 | 10.00 | 0.80 | |
| 29 | -750.00 | press | 0.03 | 10.00 | 0.30 | |
| 30 | 0.00 | - | - | 10.00 | 0.00 | |
| 36 | 9545.00 | pull | 0.10 | 14.00 | 1.34 | |
| 37 | 7424.00 | pull | 0.07 | 14.00 | 1.04 | |
| 38 | 5303.00 | pull | 0.05 | 14.00 | 0.74 | |

### 3.4. Scheme 4

As calculated by the structure solver, part results of scheme 4 is shown in Fig. 5. When the node length is 12m and the inclination Angle of the inclined rod is 45°, the vertical belly rod is 12m, and the volume of steel is 101m³. As shown in Table 5.

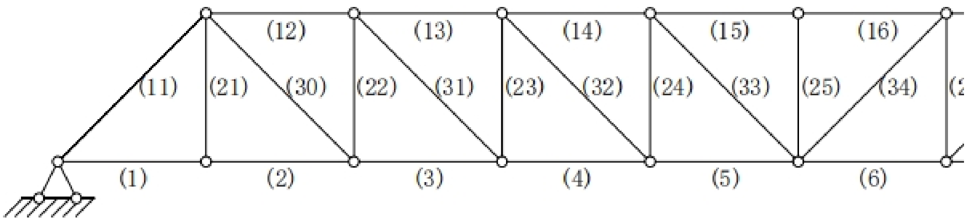


**Figure 5.** Part of the Pratt Truss Bridge Scheme 4 model

**Table 5.** Scheme 4 results of selected rod and the total volume

| Pole number | Axial force | Pull / pressure | Sectional area | Length | Volume | Total volume |
|---|---|---|---|---|---|---|
| 1 | -6120.00 | press | 0.20 | 12.00 | 2.44 | 101.50 |
| 2 | -6120.00 | press | 0.20 | 12.00 | 2.44 | |
| 3 | 180.00 | pull | 0.01 | 12.00 | 0.02 | |
| 4 | 4680.00 | pull | 0.04 | 12.00 | 0.56 | |
| 5 | 7380.00 | pull | 0.07 | 12.00 | 0.88 | |
| 6 | 7380.00 | pull | 0.07 | 12.00 | 0.88 | |
| 11 | -11455.00 | press | 0.38 | 17.00 | 6.47 | |
| 12 | -14400.00 | press | 0.48 | 12.00 | 5.76 | |
| 13 | -18900.00 | press | 0.63 | 12.00 | 7.56 | |
| 14 | -21600.00 | press | 0.72 | 12.00 | 8.64 | |
| 15 | -22500.00 | press | 0.75 | 12.00 | 9.00 | |
| 16 | -22500.00 | press | 0.75 | 12.00 | 9.00 | |
| 21 | 1800.00 | pull | 0.01 | 12.00 | 0.21 | |
| 22 | -4500.00 | press | 0.15 | 12.00 | 1.80 | |
| 23 | -2700.00 | press | 0.09 | 12.00 | 1.08 | |
| 24 | -900.00 | press | 0.03 | 12.00 | 0.36 | |
| 25 | 0.00 | | 0 | 12.00 | 0 | |
| 30 | 8909.00 | pull | 0.09 | 17.00 | 1.53 | |
| 31 | 6363.00 | pull | 0.06 | 17.00 | 1.08 | |
| 32 | 3818.00 | pull | 0.03 | 17.00 | 0.64 | |
| 33 | 1272.00 | pull | 0.01 | 17.00 | 0.22 | |
| 34 | 1272.00 | pull | 0.01 | 17.00 | 0.22 | |

### 3.5. Discussion

The results are obtained from four optimization schemes: in the pratt truss with 120m span and 45° inclined rod inclination, the 12m node length truss is the smallest overall volume. That is, when the node length is 6m, 8m, 10m, 12m, and the inclined rod inclination is unchanged, the truss engineering material of the truss structure bridge decreases with the increase of the node length.

## 4. Conclusion

This paper mainly studies the relationship between the node length of 6m, 8m, 10m, 12m respectively, and the inclination angle of the inclined bar is 45°, and obtains the following main conclusions:

(1) For the truss bridge with 120m span and inclined bar inclination of 45°, if the node length is 6m, 8m, 10m and 12m respectively, the truss engineering material of the truss structure bridge decreases with the increase of the node length.

(2) This paper only discusses the interval of 6m, 8m, 10m and 12m integer respectively. The value problem is that there are fewer samples, so the conclusions may be accidental. Appropriate addition of the optimization parameters can be considered later. In addition, this article only takes the volume of the truss rod as the optimization goal, considering its economy, which has some limitations.

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