Research on Standardized Structure and Construction Technology of Steel Truss Bridge with 40m Span

Chaofan Ma¹*, Pingming Huang¹ Zhigao Hao² and Hui Wei¹
¹ Highway Institute, Chang' an University, Xi'an, Shanxi, 710064, China
² The Chinese people's armed police force of Tibet, Lhasa, Tibet, 859700, China
*Corresponding author’s e-mail: 578881017@qq.com

Abstract. In recent years, China's steel production has been greatly increased, so the ministry of communications strongly encourages the development of steel structure bridges, and steel truss bridges are suitable for medium and small span. Under this background, this paper analyzes, studies and designs the standardized structure of medium and small span steel truss bridge. According to the basic structure, design requirements and design calculation theory of steel truss bridge, the corresponding finite element models are established respectively, and the standardized design sizes of steel truss bridge simply supported 40m and continuous 3 × 40m are given. At the same time, based on the domestic and foreign small span steel bridge erection and construction control technology, select the overall hoisting construction method to simulate the steel truss bridge construction process, so as to each construction stage structure static performance and construction control are systematically analyzed. This paper presents the key points of controlling the construction stage of 40m span steel truss bridge, which provides theoretical support for accelerating the construction period of the bridge and ensuring the construction safety of the bridge.

1. Introduction
In recent years, with the requirement of construction progress, steel bridges have been applied more and more widely. From the perspective of structural stress, steel bridge with medium and small span is mainly composed of steel plate beam and steel girder beam [1]. Steel truss is mainly composed of main girder, coupling, bridge deck, steel bridge design needs to achieve sufficient strength, stiffness and stability requirements. In the study of standardization of small and medium span steel truss structure, it should be noted into the bridge and in the process of construction must meet demands and linear, even and has good durability and applicability. In addition, the replaceable components of the same type of bridge should be satisfied, so as to minimize the cost of bridge construction and maintenance [2].

2. Standardization research and design of 40m steel truss bridge
The choice of the form of the main girder is related to the quality of the design of the truss, the selected the main truss form, should according to the topography, geology, meteorology, hydrology and choosing economic and reasonable transportation bridge site specific conditions, this requires the design of the truss bridge should not only meet the requirements of bridge crane and the clearance under the bridge will have to meet to save steel, easy to manufacture, transportation, installation and maintenance requirements.

2.1. Research and design of high standard structure of main truss
Truss is an important part of truss bridge, and the selection of main truss form is related to the design
quality of the whole truss bridge. This paper studies and designs the standardization of small and medium span steel truss bridge on highway based on the standardized design of the through bolted welded truss beam with spans of 46m, 64m and 80m on the railway. The determination of the height of the main truss depends mainly on the steel content and stiffness conditions. According to a large number of statistical data in the past and considering economy, the beam height of simply-supported and continuous truss Bridges can be selected according to the height-span ratio listed in table 1 and table 2.

Table 1. The range of choice for high span ratio of simply supported truss bridge

| Bridge type       | Railway bridge | Highway bridge |
|-------------------|----------------|----------------|
|                   | Parallel string truss | Polygonal truss | Parallel string truss | Polygonal truss |
| Under support     | \( \frac{1}{7} l \) | \( \frac{1}{10} \cdot \frac{1}{7} l \) | \( \frac{1}{8} \cdot \frac{1}{5.5} l \) |
| Upper support     | \( \frac{1}{8} \cdot \frac{1}{7} l \) | \( \frac{1}{10} \cdot \frac{1}{8} l \) | \( \frac{1}{10} \cdot \frac{1}{8} l \) |

Table 2. The range of choice for high span ratio of continuous truss bridge

| Bridge type       | Railway bridge | Highway bridge |
|-------------------|----------------|----------------|
|                   | Parallel string truss | Polygonal truss | Parallel string truss | Polygonal truss |
| Continuous steel girder | \( \frac{1}{6.5} l \) | \( \frac{1}{10} \cdot \frac{1}{8} l \) | \( \frac{1}{10} \cdot \frac{1}{8} l \) |

2.2. Finite element analysis of simply supported 40m steel truss bridge with different high span ratio

Figure 1. Axial stress of girder with high span ratio of 1/11

Figure 2. Axial stress of girder with high span ratio of 1/10

Figure 3. Axial stress of girder with high span ratio of 1/9

Figure 4. Axial stress of girder with high span ratio of 1/8
Can be seen from table 3, 40 m span steel truss, depth-span ratio from 1/8 to 1/11, namely the main truss girder height changes from 5.00 m to 3.64 m, the diagonal Angle changes from 63.6° to 53.5°, main girder axial tensile stress changes from 135.6 MPa to 176.3 MPa, main girder axial compressive stress changes from 110.9 MPa to 134.1 MPa, main girder overall moderate axial tensile and compressive stress, the largest mobile displacement are not overrun, standardized design centre sill high within the range of 3.64 ~ 5.00 m all meet the requirements.

2.3. Finite element analysis of continuous 3×40m steel truss bridge with different high span ratio

![Figure 5. Maximum displacement deformation with a high span ratio of 1/11](image1)

![Figure 6. Maximum displacement deformation with a high span ratio of 1/10](image2)

![Figure 7. Maximum displacement deformation with a high span ratio of 1/9](image3)
Figure 8. Maximum displacement deformation with a high span ratio of 1/8

Table 4. Stress and displacement of truss under different high span ratios of 3 × 40 m span

| High span ratio | Digit height (m) | Steel quantity (t) | Axial maximum tensile/compressive stress of main girder (MPa) | Maximum axial tensile stress of the upper horizontal joint (MPa) | Lower horizontal axial tensile/compressive stress (MPa) | Maximum displacement deflection (mm) | Inclination of web member (°) |
|-----------------|------------------|-------------------|-------------------------------------------------------------|-------------------------------------------------------------|--------------------------------------------------|-----------------------------------|-------------------------------|
| 1/11            | 3.64             | 420.2             | 141.7/174.3                                                 | 51.7                                                        | 16.7/15.9                                       | 22.9                              | 53.5                          |
| 1/10            | 4.00             | 421.3             | 134.8/174.5                                                 | 50.0                                                        | 15.3/14.3                                       | 20.7                              | 58.0                          |
| 1/9             | 4.44             | 432.8             | 126.4/170.3                                                 | 48.4                                                        | 13.7/12.7                                       | 18.6                              | 60.6                          |
| 1/8             | 5.00             | 435.7             | 126.8/164.2                                                 | 46.9                                                        | 12.2/11.0                                       | 16.8                              | 63.6                          |

Can be seen from table 4, 3 × 40 m span steel truss, depth-span ratio from 1/8 to 1/11, namely the main truss girder height changes from 5.00 m to 3.64 m, the diagonal Angle changes from 63.6° to 53.5°, main girder axial tensile stress changes from 126.8 MPa to 141.7 MPa, main girder axial compressive stress changes from 164.2 MPa to 174.3 MPa, the biggest mobile displacement are not overrun, standardized design centre sill high within the range of 3.64 ~ 5.00 m all meet the requirements.

3. Overall hoisting construction control of 40 m steel truss bridge

The application prospect of integral hoisting method is more and more broad, and more and more suitable for the development of modern bridge industry [3]. Two different lifting schemes are selected. The position of the lifting point of the first scheme is shown in figure 9, and that of the second scheme is shown in figure 10.

3.1. Stress control

For the two schemes in the lifting stage, axial stress force of the main girder is shown in figure 11 and 12 respectively.
According to the analysis and calculation results, the maximum tensile stress in scheme one occurs in the element 31 of the abdominal bar, with a maximum of 10.5MP, and the maximum compressive stress occurs in the element 30 of the abdominal bar, with a maximum of -8.7MP. In the second scheme, the maximum tensile stress appears in the element 23 of the abdominal bar, with a maximum of 11.7MP, and the maximum compressive stress appears in the element 12 of the abdominal bar, with a maximum of -10.9MP. The stress in the second scheme can meet the requirements in the lifting process.

3.2. Deformation control

During the lifting process, the deformation of the main beam of the two lifting schemes is shown in figure 13 and 14 respectively.

| Table 5. Scheme 1 Main Girder Joint Displacement |
|-----------------------------------------------|
| Node number | 1  | 2  | 3  | 4  | 5  | 10 | 11 | 12 | 13 | 14 |
| Displacement (mm) | -0.22 | -0.11 | -0.43 | -1.11 | -1.37 | -0.24 | -0.20 | 0.00 | -0.82 | -1.31 |

| Table 6. Scheme 2 Main Girder Joint Displacement |
|-----------------------------------------------|
| Node number | 1  | 2  | 3  | 4  | 5  | 10 | 11 | 12 | 13 | 14 |
| Displacement (mm) | -3.49 | -2.19 | -0.72 | 0.09 | 0.15 | -3.51 | -2.87 | -1.43 | 0  | -0.13 |

According to the calculation results, we can see from table 5 and table 6 in scheme 1, during the lifting process of the steel girder beam, the cantilever end deformation deflection is -0.22mm, the maximum deflection value is - 1.37mm; In scheme 2, during the lifting process of steel girder beam, the maximum downward flexural value of cantilever end deformation is -3.49mm, and the upper flexural value of mid-span is 0.15mm.

4. Conclusion

1. Introducing the concept of standardized rapid construction into the construction of steel truss bridge has great economic benefits.

2. In the standardized design of steel truss bridge with 40m span, it is recommended that the main
truss height is 3.64 ~ 5.00m, which is relatively economical and reasonable.

3. The overall hoisting of steel truss bridge with 40m span is feasible, and the axial force, stress and deformation during construction meet the requirements of the code.

The application of dynamic response and evaluation system for medium and small span steel truss bridge needs further research in the future.

References
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