Application of BIM technology in fine design in steel structure bridges

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Abstract: This paper elaborates the necessity of the fine application of BIM technology in steel bridge, and also describes the fine design of BIM technology in steel bridge node, oblique cable and anchor box node, bridge tower wall plate and rib plate node, steel box beam node, and introduces the application of the building concept in steel structure bridge without margin.

1. Introduction
Building Information Model (BIM, Building Information Modeling) as a new modeling concept and technology, has infiltrated the domestic and foreign construction projects in the design, construction, cost accounting and other stages, to create value for the project [1]. At this stage, the application and research of BIM is mostly concentrated in construction projects, but there are relatively few applications and research in infrastructure such as bridge engineering, and it is of great engineering significance to use BIM technology to carry out the fine design of steel structure bridges.

2. Analysis of the necessity of fine design
The traditional steel structure bridge node design only gives the standard node design method and can not meet the needs of actual processing and site installation, therefore, it is necessary to fine design the steel structure bridge, change the design status of the steel structure bridge, resulting in unnecessary duplication of labor and waste of material resources [2].

3. Node Fine Design
The essence of the fine design of BIM steel structure node is a new design mode based on digital technology. For example, in the Miso system double-rope single tower pull bridge, the bridge tower and steel box beam nodes and detail models are processed in the design stage, so that the design model and the actual maximum match, for the output of processing and installation requirements of high-quality detailed drawings to lay the foundation, while the fine design and BIM model includes the structural structure of the bridge geometry information and non-material properties information,
can provide the construction and operation of the various aspects of the relevant personnel to provide the data base for application management\textsuperscript{[3]}. This paper will take the Miso system double-rope single-tower leaning bridge as an example, and elaborate the fine application of BIM technology in steel structure bridge.

3.1 Prosteel Steel Bridge Node Fine Design

The detailed model based on BIM technology can be transferred directly from the design stage to the manufacturing, construction, installation and even operational management, and is of great practical value for design-to-manufacturing and integration project delivery, saving human, material and financial resources. At present, some design and construction units have used BIM technology to build detailed building models, and also developed relevant standards. BIM technology has broad application prospects in steel structure bridges with parametric modeling and visualization features.

(1) Parametric node library and custom batch operation to improve design efficiency

Prosteel steel structure detailing software usually contains a wealth of material libraries and node libraries, the basic idea of its node function is parametric design, that is, the user only needs to select the desired node form, and manually enter the relevant parameters, Prosteel detail software can be selected by the user of the node form and parameters, intelligently generate specific nodes, greatly improve the accuracy and speed of node design.

For some surface parts, special structure, and complex structure parts, the node library generally does not contain such zero components, the user can choose custom zero components, welded steel and combined steel form for batch operation. Visual node design, no dead ends, easy welding.

(2) Visual node design

BIM building information model has the characteristics of WYSIWYG, can visually simulate, show all the parts of the proposed project, to provide designers with the most intuitive and convenient design path and work platform, easy for designers in the design process to communicate, discuss and make decisions. Compared with the traditional 2D graphic design, node design in BIM software can be based on 3D model, based on network collaboration platform, automatic ally of various professional design changes and related data information in real time, quickly switch design views, make full use of the visual advantages of BIM technology, facilitate designers to visually observe the nodes in a visual and all-round way, find and correct the unreasonable points in node design in a timely manner, such as obvious collisions and welding dead ends.

3.2 Fine design of oblique cable and anchor box nodes

As the main force member of the oblique pull bridge, the accuracy of anchoring point positioning is very important to the force of the bridge, and the influence of the bridge tower and steel box beam related node is great, in order to improve the accuracy of anchoring point positioning, before the fine design of the oblique pull bridge node, the positioning coordinates, inclination and other relevant data of the anchoring point in the steel bridge BIM3D model should be reviewed, and the subsequent locking will be subject to error. After the completion of node fine design, basing on the model output two-dimensional picture and 3D graphic view combined with the structure details, BIM technology provides the technical assurance for the steel structure manufacturing processing plant and construction unit work smoothly.
Fig. 3.2 Coordinates of cable stayed cables of cable-stayed bridges with twin cable planes and single towers in the cable system

As shown in Figure 3.2, the double-cable single-stayed cable-stayed bridge in the development zone’s dense cable system uses dynamic point plus coordinate programs to mark the coordinates of the two end points of each cable-stayed cable in the BIM model. Once qualified, the design of the cable and anchor box joints can be carried out. There are many solid collisions in the original anchor cable standard nodes of steel bridges in the background of this thesis. Therefore, the author changed the anchor cable nodes on the steel bridge tower and steel box girder here. The changed node form is shown in Figure 3.4

Fig. 3.3 Standard node of anchor cable on steel bridge tower

Fig. 3.4 Standard node of steel box girder anchor cable

3.3 Bridge tower siding and rib design

BiM-3D modeling of bridge tower siding and ribs with Prosteel software's lofting capabilities. And change the traditional design of the rib plate only give specifications and spacing information design, according to the bridge tower wire shape and structural changes to deal with the details of the rib plate. The width of the wall plate of this bridge tower is a straight line shape of gradient, the width of the bridge tower near the bridge surface position is large, in the layout of the ribs, some of the ribs should be disconnected according to certain layout principles. Practice has proved that the precise modeling and fine treatment of the siding slabs of the single-tower ramp bridge bridge are realized by using ProsteelBIM technology, and the modeling efficiency is high and has high practical value[4].

3.4 Fine design of steel box beam node

Miso system double rope surface single-tower pull bridge steel box beam zero components more, at the same time there are vertical and cross slope and has a certain degree of arc, the strength of the ribs mainly have U-shaped ribs and slat ribs two, its change of bridge wire shape, partition specifications and strength rib form makes each partition is unique, need to be for each partition U-shaped rib over the welding hole and slab rib over the solder ingesting hole processing requirements. As shown in Figure 3.5-3.6, In the BIM-3D model, the U-rib is first arranged and then cut in the standard over-weldhole form at the appropriate position. In addition, in order to the needs of the later operation and maintenance phase, the steel box beam internal needs to set up manhole, and the same, the
position of the human hole due to the change of the bridge wire shape will also be slightly different, need to be arranged in accordance with the design standard style Rui each man hole, while the visual characteristics of BIM can assist the controller to check the consistency of the man hole, to avoid the emergence of maintenance dead end.

Fig.3.5 Standard Cross Section of Steel Main Beam at Cable Crossing

Fig.3.6 Fine Design of Steel Box Girder Nodes

4. Application of the no-residual construction concept in steel bridge design

In the actual steel structure bridge processing operation, in order to make up for the welding shrinkage, the conventional use of reserved margin, that is, in the deepening design stage deepening personnel will consider the reserve on the basis of the zero components of the steel bridge to deepen, therefore, the site installation often needs secondary positioning line, cutting to achieve the required accuracy requirements, The working mode consumes more manpower and time, and there is a two-cut, the economic benefits are poor[5]. The principle of steel structure bridge processing and hull segment construction is consistent, such as if the concept and method of hull segmenting no margin construction are introduced into the steel structure bridge processing and production, coupled with BIM technology as a technical support, it will be possible to change the traditional manufacturing process of steel structure bridge, accelerate the manufacturing accuracy and efficiency of steel bridge zero component factory, Save on construction costs.

Because the construction accuracy of the steel structure bridge is slightly lower than the hull, and the top, bottom, abdominal plate parts shrinkage are not the same, it is difficult to achieve in strict accordance with the specifications of the unit type precisely add welding shrinkage, so there is no need to measure the amount of shrinkage compensation, the completed works of data can be processed, obtain coarse precision value or according to empirical value to determine the approximation value. After completing the segmented segmentation of the steel bridge tower and steel box beam, the designer can, on the basis of this value, use the no margin concept, based on the precision modeling function of BIM technology, to deal with the model accordingly, such as the top plate of the steel box
beam, the bottom plate and the abdominal plate part in the length direction and width direction to give welding compensation. At the same time, at both ends of the bridge close section to give a certain amount of reserved margin, construction installation in the form of inlay section to be connected, can effectively avoid the existence of the two-tangent situation, to ensure accuracy.

After the detailed design steps of the above nodes are completed by the single-tower pull bridge, the relevant part of the steel structure bridge design can be implemented without margin. Because the top, bottom and abdominal plate parts shrink are not the same, it is difficult to achieve in strict accordance with the unit type specifications accurately add welding shrinkage. For the application of no margin manufacturing technology and concept in steel structure bridges, in order to control the precision of the top plate, bottom plate and abdominal plate unit welding within the specified range, the top plate of the ordinary steel box beam, The base plate and abdominal plate parts in the length direction of each end plus 2.5mm welding compensation amount, width direction without welding compensation amount for no margin manufacturing, and in the bridge close section at both ends of the 50mm of reserved margin, site installation according to the actual situation of the cut, to control the installation accuracy of the entire bridge. After determining the compensation and margin, the BIM model needs to be processed accordingly to lay the foundation for accurate mapping and calculation of engineering volume. See Figure 4.1 for details.

(a) Bridge Tower Section
(b) Steel box girder section

Fig. 4.1 Bridge tower and steel box girder section

5. Summary
Taking the Miso system double-rope single-tower ramp bridge as an example, this paper elaborates the fine design of BIM technology in steel structure bridge, explains the necessity of the fine design of steel structure bridge, and gives a detailed description to the steel structure bridge node.

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