The Analysis and Application of BIM Technology in Design of Steel Structure Joints

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Abstract: Building Information Model (BIM) is the future trend of the building industry. By studying the BIM technology, it could control and manage Life Cycle Cost of building in the Steel Structure Project. Besides, BIM highly integrates the programming, the design, the construction quantity&execution and all the relevant information of operational maintenance after completion. What's more, BIM is beneficial to improve the quality of design&construction and reduce the cost of project，and BIM also will benefit its application and popularization of Building Industry and contribute to raise the productivity of Building Industry continuously. This article firstly analyzes characteristics of BIM, then it describes modeling system of steel structure joints on the base of BIM, finally it presents the BIM application of steel structure joints.

Introduction

BIM，called Building Information Modeling，was first proposed by Autodesk Company in 2002. Based on the three-dimensional digital technology with the integration of all kinds of information of the Life Cycle of building project. BIM is an engineering database model and it is the expression of the related digital information of the project [1].As early as 1982, the Garphisoft Company proposed the concept "Virtual Building" and applied it into ArchiCAD in the first place. As the development of information technology, this kind of product is mainly made by foreign companies such as Autodesk, Bentley, Grahisoft, Dassault, Tekla and so on [2].

The Joints Design, as the most important link in the design process of steel structures, is extremely important to the stability of overall structures in the project, because these joints which bear concentrated forces of structures.In recent years, as the need for national production, the steel structure project scale is more and more larger and complex, and the joints are formed completely[3]. The software,CATIA vs,developed by France Dassualt has deep integration of CAD, CAE and CAM (drawing/analysis/manufacturing). CATIA vs has strong ability in the parametric model, and it supports the design of large and complex project. Most of detailed design can be done by using the 3d parametric modeling system. At present, the main BIM application for steel structure joints is Tekla Structures developed by Tekle Company. The Tekla structures has powerful ability to create larger entities buildings and provide a very powerful database of joint template which contains thousands of joints templates, but it does not support B-spline and NURBS(Non-Uniform Rational B-Spline) curving surface [4].

This paper researches the application of joints in the BIM which created by Tekla Structures for the steel structures with an example of Zhoukou City Radio and Television Tower.

The Application Of BIM For Steel Structure Joint

The overview of 3-dimensional modeling of steel structures joints. Tekla Structures can be used for building the 3D Model or importing the existing Model. The 3D Model Building Process includes the following steps: Axis Net Building, Views Building, Main Structures Building and Secondary Structures Building. Checking the formed structures data in real time is necessary, so that the Joints Assembly Model can be formed. However, for irregular structures with complicated joints, it is difficult to build the Model by Tekla Structures directly. So, prior to locate the Key Control Points and the Reference Lines in the drawing by AutoCAD is necessary, then save them as dwg and dxf block files, finally importing them in Tekla Structures. as shown in Figure1. This process can ensure the precision of completed joints model building [5].

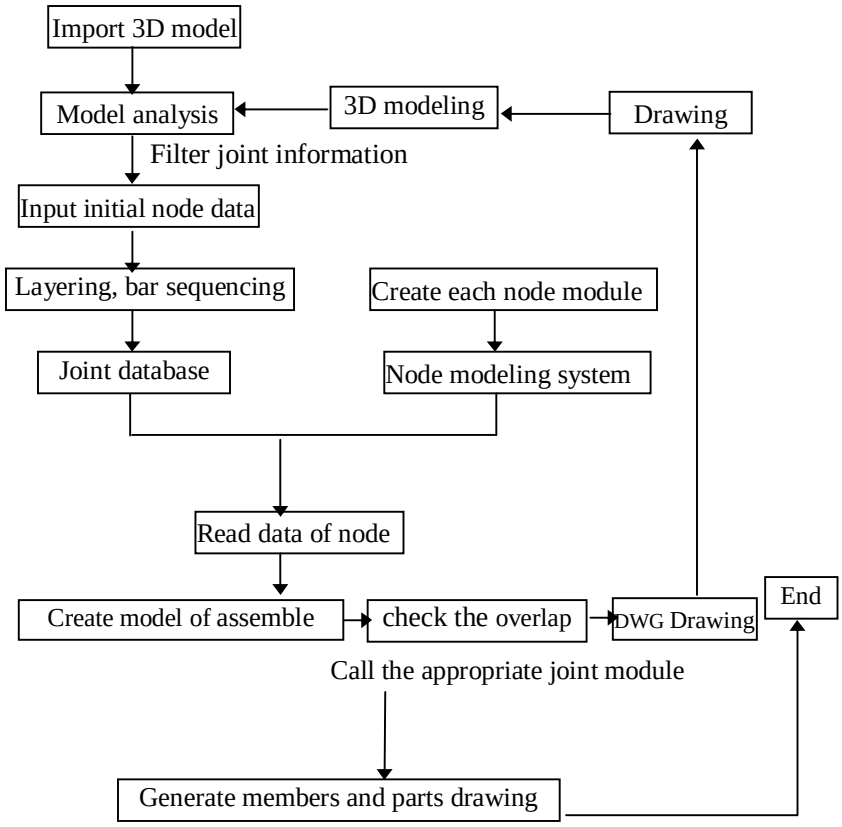

Figure1. The flow chart of overall program in Tekla Structures joints modeling

The connectivity and detail of the joint. For modeling processes of some softwares, the connecting detail of structures joints is defaulted which means that the connecting detail is invisible. But for Tekla Structure,
there are more than 600 built-in joints database and the parameters joints details what provide a con venient and humanized supporting for Joints Design. Besides, it also supports the Manual Input Joints Parameters and Intelligentized Generation Joints Parameters which make the Model Building Approach more convenient. After the dates reading, the automatic checking can calculate the subsequent installation issues of construction in advance. The details building of 3D Model will ensure the subsequent duration analysis and detailed design. It is more convenient for the process of modeling through generating intelligent joint parameter. After reading the data, automatic checking of joints can predict installed problems that may occur in the future of construction process. The

detail setting of 3d model is a guaranteed step upon which follow-up phase analysis and deep design will depend.

Calculation analysis and collision check of joints. The finite-element software is mainly to analyze the internal force of members, system architectures and the integral stability. And the calculation and the analysis are mainly to determine whether the joint meets the requirement of loading and construction conditions, so it has very practical applications. Collision check needs to be specific to joints, the object of inspection includes the place between different bolts at the joint, the place between bolts and flanges. Besides, easy installation and the collision check of large members are also necessary. By the collision checking in the phase of design model, the design defects and the potential troubles can be solved previously, and issues can be controlled successfully in advance[6].

The generation of 2-d drawings. In the current construction field, the submittal of final design result is still subject to 2D Drawing， so it is necessary to shift from 3D Model to 2D dates. Besides, the 2D Drawing can be thought of each view of 3D Model formed by lines and planes. For the functional module of Tekla Structures, it could conveniently shift from each view of 3D Model to the 2D Drawing. Nowadays, the architectural concept increasingly tends to the complicated architectural styles and spatial structures, but it would be difficult to describe Construction Plan Drawing, Elevation Drawing and Section Drawing with the traditional CAD Software. So, it is a revolution that automatically shifting from the established 3D Model to the 2D Drawing and improving the 2D Drawing to be the final Construction Drawing based on the design specifications. Additionally, Components Drawing, Components Detail and the complicated Joints Detail also can be described by BIM in the same way.

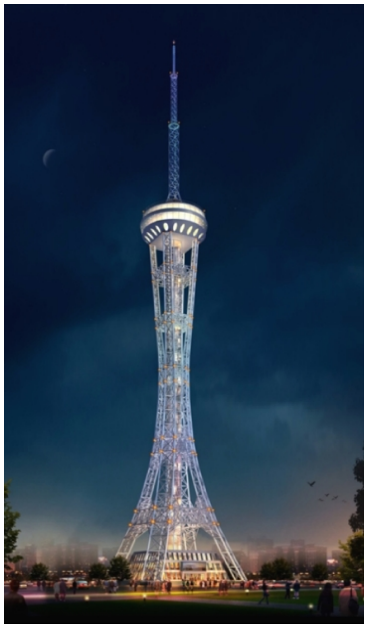

Figure2. Effect picture of the tower

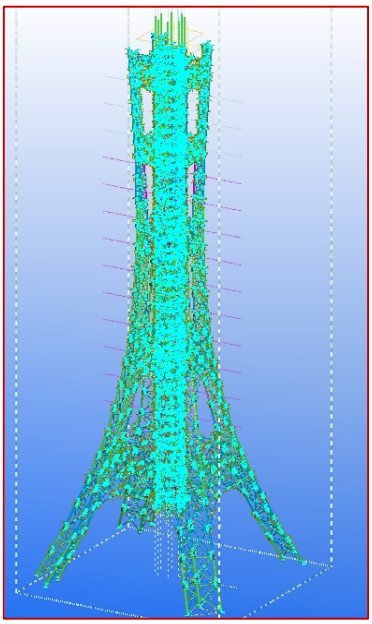

Figure3. 3-D model of the tower

The Applications Of Steel Structure Joint Modeling In Zhou Kou Television Tower

The project profile. Zhoukou Broadcasting TV Tower is located at the crossing of Qiyi Road and Zhoukou Avenue in Zhoukou City. It covers an area of 54.6 acres, and the gross area is 8376.8㎡, the quantity of steel structures is 5200t. The total project cost was estimated at appraisal to be 2 million YUAN. The overall height of the tower is 286.57m. The Zhoukou is Broadcasting TV

Tower is mainly composed of 5 parts including Tower Bedding, Tower Mast, Tower Shaft, Tower Loft and Antenna. It is a multi-functional building integrated with Radio and Television signal emission, sightseeing, repast and travel, and it will be the landmark after completion in Zhoukou City. [7]

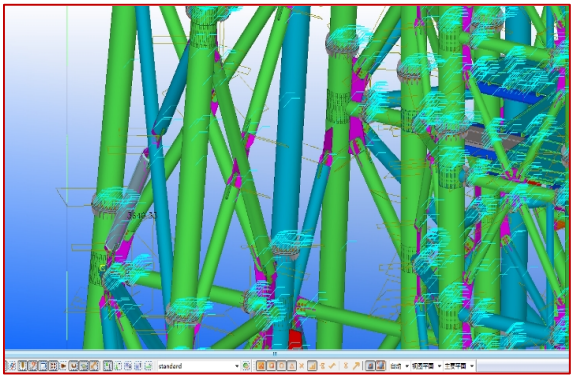

Figure4. The design of connection joints

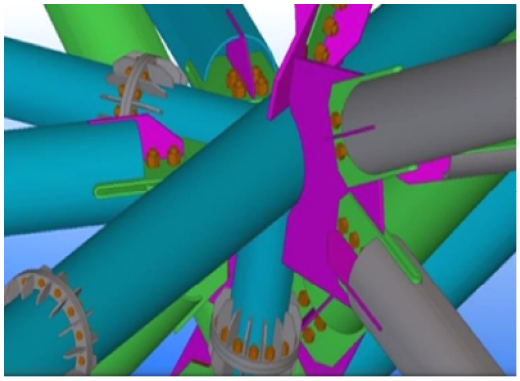

Figure5. The complex joints

Facade structure. The facade tower columns take the shape of Small Pretty Waist, the column limb is two-way bending designed from bottom to top with multi-angles and multi-sections, the key and difficult point is to ensure the tower's accuracy of curvature in the process of design and construction.

Establishing the 3D Model by Tekla Structures firstly, and then describing the secondary deepen design of structures. Finally, optimizing the size and the location and the carving bending of structures during the tower body modeling period.

The joint connection. The steel structures joints are designed to be connected by flanges and high strength bolts. The fit of flange alignment should be larger than 70%, and the connection gap should be less than or equal to 0.3mm, and 100% connection bolts penetrating are necessary. When establishing the detail by Tekla Structures, applying the templates of flanges and bolts, and directly describing the detail of structures components, the assembly drawing, the layout and elevation in order to ensure the accurate positioning during the components manufacturing, fabricating and installation [8].

Complex joint. For the completed joints issues, the Connecting Detail Simulation formed by multi-angles and multi-spaces can solve the structures overlap issue, as displayed in Figure5, installation blind angle issue, wrong size issue, etc. Tower and mast structure use the flange connection, ultra high altitude and suspended installation. The model of component center line should be defined coordinates as the basis of measurement of the positioning component structure installation so as to install and connect the complex set of components in space. According to the virtual assembly connection, it is clear that 52 components can not be installed, 64 joint positioning is not right [9], as shown in Figure6.

Prior to the construction, integrating the models of all sections in order to check the overlap detection is necessary, then submitting Design the overlap points as the information of solving the real issues on site, and trying to reduce the overlap issues between components and conduits and avoid reworking. It achieved that make potential problems solved during the design phase.

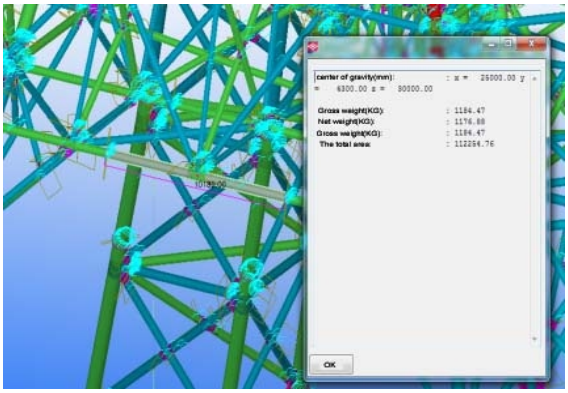

Figure6. The connection and collision check

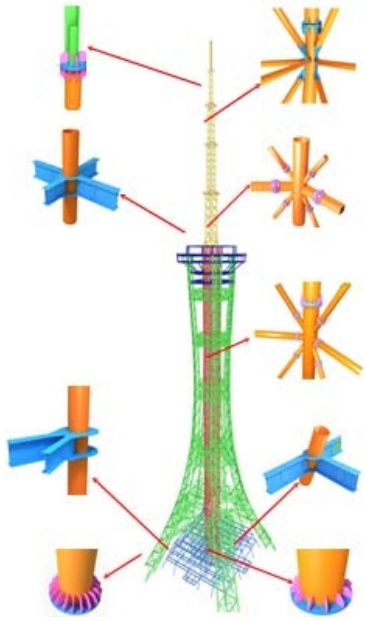

Figure7. The virtual assembly

Joint type. Figure7 demonstrates the types of joints: The tower body is mainly made of structures penetration by rounded steel pipes, and a part of it also adopts the H-channel connection on the extension arm, the connection between H-Channel and rounded steel pipes, the connection of variable cross sections and the connection of rectangular steel tubes. The joints of tower mast are mainly several following types, Penetrated Joint, Spheric Bedding Joint, Rigging Joint and Shifting Bearing Joint[10].

Conclusion

This paper explores the BIM technology of steel structures positively with the living example of a steel structure project, and establishing the joints model by BIM software, Tekla, for solving completed joints issues in the simulated visual construction model by Collision Check and other methods. It is an attempt to the BIM concept, and I believe that the 3D Building Information Model will be more great extent to apply to the overall of the project by various ways and the Building BIM concept will have wider development in the future.

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