Research and Exploration of Steel Structure Deepening Design Based on Multi User Mode

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Abstract. Steel structure with its high strength, light weight, good seismic performance, high degree of industrialization, short construction period, strong plasticity, energy conservation and environmental protection and other comprehensive advantages, has been widely used in machinery, construction and many other fields. But because of its huge scale, increasingly complex structure, project management is facing many problems. Based on the multi-user mode of steel structure in-depth design, the technology of product modelling, structural analysis, in-depth design, engineering calculation, processing and manufacturing and cost control are studied, especially the advantages in model creation and component manufacturing bring more possibilities for the mechanical industry. Based on the multi-user mode, the steel structure deepening design technology integrates the technical requirements of the project, provides clear information for the owner, designer, raw material supplier, manufacturer, construction party, etc., promotes the implementation of the project, improves the achievement degree of the project, and improves the control ability of the engineering personnel. A number of foreign large-scale bulk material conveying systems have obtained good benefits by using the steel structure deepening design technology based on the multi-user mode, which improves the industrialization degree of steel structure component design and manufacturing, so that the research results have good practicability and operability. The research results have positive guiding significance for the practice of steel structure deepening design.

Key Words: Multi User; Node Library; Parametric Design; Part Atlas; Sheet Nesting; Detailed Design.

1. Introduction

Steel structure is an important part of large bulk material conveying system, accounting for more than 40% of EPC projects.

The steel structure is the skeleton of the equipment body in the large bulk material conveying system, which is responsible for carrying structure, supporting equipment and transferring materials, and occupies an indispensable and irreplaceable position in the project.

Steel structure with its own light weight, good seismic capacity, good overall performance, high material strength, short construction period and other significant advantages, is widely used in industrial
transportation system and other engineering construction. It is developing rapidly in the direction of lightweight, large span and high-rise structure.

From the perspective of steel structure construction process, steel structure usually integrates design, manufacturing, installation and maintenance. Due to the high technical requirements of steel structure construction, no matter which link has quality problems, it will affect the quality of the whole project. Therefore, it is very important to strengthen the quality control of steel structure design.

2. Research Contents of Steel Structure Deepening Design

2.1. Implementation steps and main practices
The detailed design of steel structure based on multi-user mode is designed, modified and analyzed intuitively in the form of three-dimensional visualization, and forms the documents that can be used in the whole life cycle of project design, construction, operation management, etc.

According to the characteristics of steel structure engineering such as huge scale, increasingly complex structure and long-term project management, we carried out the application research and practical exploration of steel structure deepening design to ensure the efficient implementation of steel structure construction process.

Based on the multi-user mode, through improving the structure system, the design optimization is carried out in the aspects of user-defined parametric nodes, reasonable classification of part drawings, docking of NC machining plate nesting and so on. So as to shorten the R & D and design cycle, improve labor productivity, improve the utilization rate of raw materials, reduce production and manufacturing costs, and achieve significant economic benefits.

2.2. Key technology design
Based on the research and application of steel structure deepening design of multi-user mode, the characteristics and design points of steel structure are deeply studied and analyzed. The existing design ideas are referred, and the digital modern design method is adopted. The main technical features and methods are as follows:

2.2.1. Strictly control the project duration and make the schedule in advance. Project software is applied to compile the project schedule, reasonably arrange the schedule of transfer station structure and auxiliary professional drawing, bidding procurement, production assembly, delivery site, installation and commissioning of external parts. Track project progress, optimize workflow, plan management efficiency, monitor plan implementation.

2.2.2. ANSYS finite element analysis. ANSYS finite element analysis is used to check the strength, stiffness and stability of the whole structure of the transfer station. According to the existing structure and load, the foundation reaction required by the structure is calculated, which provides the basis for the civil foundation design. According to the requirements of the project, formulate the design basis. The load combination factors are listed according to different working conditions. The geometric model of the structure is established, and the load is applied to solve the problem. Verify whether the load combination meets the design strength requirements, and investigate whether the structural deformation meets the design stiffness requirements. Select the dangerous area of the structure, as well as individual members with large slenderness ratio to judge whether the stability is up to the standard. If the calculation results do not meet the requirements of any of the above three points, the structure shall be modified and recalculated until the specification requirements are met.
2.2.3. **Structural design and connection calculation of steel structure joint.** The design of connection node is an important link in the overall design of steel structure, which has a direct impact on the integrity and reliability of steel structure, the quality and progress of manufacturing and installation, and the overall cycle and cost.

Due to the continuous development of welding technology and the popularization of high-strength bolt application, the design of H-section beam/column splicing connection, hinged connection between beam and column, rigid connection between beam and column, and rigid fixed exposed column base node in transfer room are checked and calculated. Developed a rich node Library (including 2D and 3D), which provides convenient conditions for subsequent projects.

2.2.4. **The steel structure design in multi-user mode is realized.** Multi user mode of steel structure design allows multiple users to access the same model at the same time. Multiple users can participate in the construction of the same project together and understand each other's progress. This avoids the trouble of copying and merging models. Multi user division of work, respectively responsible for the foundation, column, beam, facade diagonal bracing, plane cable-stayed, roof construction, as well as the connection node lap. Complementary interference, simultaneous. Multi user mode can be used in the whole process of steel structure detailed design from the creation of three-dimensional model to the transformation of two-dimensional drawings and the generation of production list. This kind of pattern saves time and efficiency. It is the development trend of large-scale steel structure engineering in-depth design.

![Figure 1. Structural strength stress nephogram of crushing station CH01 by finite element analysis.](image)

**Figure 1.** Structural strength stress nephogram of crushing station CH01 by finite element analysis.
2.2.5. Independent research and development of parametric design of steel structure. The steel structure modeling method based on Tekla uses conceptualized points and lines to form actual shape steel structure entities such as beams and columns by modifying section types. Then, the connection details between the steel structures are improved through the block nodes. However, the form of nodes in the system is limited, and there are some nodes suitable for our work, which need modularization and parameterization. In the past, the user-defined node can not be adjusted with the cross section, so its application is very limited and can only be applied to specific projects. After parameterization, parameters suitable for project application can be set, and the same parameterized node can be applied on different sizes of profiles in the same project by virtue of its adaptive ability. Password protection can also be set in the custom node. When external users get the model file, they can't see the relevant parameter settings in the node. Even if the node is forced to explode, the parameterized data in the node will be lost and the parameterization function will be lost. It is helpful for us to gradually accumulate and improve, and form our own unique modeling system.

2.2.6. Carrying out the mechanical structure analysis of purlin for steel roof. In the past, ANSYS finite element analysis was used to check the strength, stiffness and stability of the main structure of steel structure. For the purlin component of steel structure external decoration, because of its simple structure and convenient material selection, its mechanical structure analysis is often ignored. However, if the
wind speed and snowfall are large, it is imperative to carry out the calculation of purlin internal force, strength, stability and deflection. We have calculated various load combinations.

2.2.7. **It is convenient for the production site to classify and compile the parts.** According to the structure and function of parts, the type spectrum is divided. Taking the steel structure transfer station as an example, we divide the parts into beam ends, ring plate webs of tubular column frame beams, flange plate webs for vertical cable-stayed joints, plane cable-stayed gusset plates, beam flange cover plates, anchor parts, equipment base plates, ladder connecting plates, etc.

According to the classification, production on demand. Connect with production process smoothly, save working hours and simplify process steps.

2.2.8. **NC workpieces in ncl format can be generated accurately, and interface with machine tools.** After the model construction, detail design, collision detection and numbering of steel structure are completed, the drawing transformation can be carried out. Engineering details are suitable for production, installation and archiving. NC workpiece in NCL format and plate NC file in DXF format can be generated directly, which can be interfaced with machine tool to divide processing equipment according to profile. The process of outputting detail drawing of parts is saved.

![Figure 3. Notepad readable NC machining file in .ncl format.](image)

2.2.9. **Plate nesting, improve the utilization of materials and shorten the processing cycle.** Based on the nesting of plate in steel structure transfer station, the automatic nesting problem of two-dimensional irregular polygon is studied. Continuously strengthen the awareness of cost control, comprehensively consider the processing technology and surplus material management, so as to improve the utilization rate of materials.
3. Technological Innovation

To adapt to the characteristics of steel structure transfer station design, carry out transfer station process design. Prepare the schedule and carry out the detailed design in strict accordance with the steps.
Using the powerful calculation and analysis function of ANSYS, the rationality of transfer station structure is checked and optimized. PKPM software is used to check the strength and rigidity of purlin for steel structure transfer room. This is the part that is often omitted in the mechanical analysis of the main structure of the computer room by using ANSYS software in the past.

The connection node Library of steel structure is established to realize the serialization and generalization of nodes. The design atlas of steel structure joint is established, and the joint engineering drawing is developed. Due to the limited form of the existing joints, we build a parametric model of steel structure by using user-defined modular user element. The parameterized node is successfully developed, which has the characteristics of open parameter input settings and adaptability to the change of section size of the main structure.

Based on the development direction of large-scale steel transfer station, we have changed from a single user model to a multi-user model. That is, multiple users can access the same model at the same time, multiple users can participate in the construction of the same project together, and understand each other's progress. Multiple users cooperate with each other, and each performs its own responsibilities and complements each other. From beginning to end, all users participate in each stage of deepening design.

Make part drawing and classify in detail. According to the structure and function of parts, the type spectrum is divided. It provides convenient conditions for subsequent processing and production, saves working hours and simplifies process steps. Steel structure needs a large number of plates with different functions. The reasonable layout lofting of all the plate parts can directly generate the numerical control file, which is connected with the numerical control machine tool, so as to facilitate the numerical control cutting, replace the conventional mode of parts drawing, improve the utilization rate of materials and shorten the processing cycle.

Figure 6. Internal perspective of TT07 transfer station of an engineering project based on multi-user model.

4. Conclusion
In the development process of "research and exploration of steel structure deepening design based on multi-user mode", the conventional steel structure is fully optimized and improved. It is especially suitable for crushing station, loading building and other large steel structure transfer station with remarkable effect. The technology can be widely used in mining, metallurgy, coal, iron and steel, port, electric power, cement, chemical industry, building materials and many other industrial fields.
Parametric modeling design based on multi-user mode shortens the R & D cycle. The generation of numerical control files and nesting of plates improve the labor productivity, improve the utilization rate of raw materials, reduce the production cost, and obtain obvious economic benefits.

The process design of steel structure transfer room, at the same time, the idea of project management runs through the specific design, with new ideas and characteristics, greatly reducing the cost of product design and manufacturing.

Because it simplifies the process flow, reduces the error probability of equipment interface, reduces the capital construction and operation cost of equipment, and is favored by the majority of users. At the same time, its advanced design technology is conducive to the optimization of the enterprise's transmission line, which can greatly improve the work efficiency. So as to provide more benefits for the development of enterprises and help for industrial progress.

Figure 7. 3D rendering of TT07 transfer station of an engineering project based on multi user modeling.

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