Research of section optimization design of steel structure main workshop of a large thermal power plant

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Abstract. In order to reduce the section size of column C and D column, to satisfy the needs of process engineering, this paper, by using the finite element analysis software STAAD model the stress of the main building, the main steel structure building carried on the thorough analysis, put forward two kinds of section optimization scheme, the comparative analysis shows: in the same section and the amount of steel case, the safety of the second scheme is higher than plan a, therefore, the scheme two is better than one. For scheme 1 and scheme 2, the safety of scheme 2 is 13.7% and 9.8% higher than that of scheme 1 when the same column section, the same load and the same parameters are used for column C and column D. The research results are applied to Hami Power Plant of State Grid Energy, with only columns C and D, and the actual value saves more than 500 tons of steel compared with the original value, and obtains good economic effect.

Keywords: Steel structure; main workshop; Section optimization; Seismic performance evaluation.

1. Introduction
At the end of 2012, our institute completed the preliminary design work of the 4×660MW project of State Grid Energy Hami Power Plant. Fig. 1 shows the section of a certain frame.

According to the calculation results of the preliminary design, the section of column C is H1700x850x48x56, that of column D is H1600x750x48x50, and that of the coal hopper support beam is H2300x600x48x48. Process professionals report that the section of column C and column D is too large, and the net distance between column CD is only 11.850m, which makes the layout of equipment and pipeline very difficult. It requires structural professionals to optimize the design, reduce the section of column C and column D, and ensure that the net distance between column CD is not less than 12m, so as to meet their requirements.

The research team has investigated several steel structure main workshops of the same type of unit engineering. India GSR project is 300MW unit, but due to the poor coal quality and heavy coal bucket load of this project, its value is 1000t, which is similar to the State Grid Hami project, so this project is taken as one of the comparative projects.

It can be seen from the above table that, compared with the same type of units, the frame column of the steel structure main workshop of State Grid Hami Project is obviously larger. After team members of careful analysis, we agree that this project column C and D column section is the main reason of the...
large coal bucket load is too big, its value is 1100 t, heavier than the same type unit coal scuttle 45 ~ 60%, the coal hopper support beam and frame column just answer, cause the frame column bending moment is larger, resulting in the larger frame column section here.

From the above analysis, we can see that in this topic, the coal bucket load is too large is the main reason for the larger section of the frame column, but the coal bucket load is determined by the coal quality, can not be changed, can change only the size of the bending moment of the frame column.

From the point of view of structural force analysis, the bending moment of the frame column can be reduced by changing the force system of the structure, and then the section size of the frame column can be reduced. Can be seen from the above analysis, its hami project preliminary design of column C and D column column of large pillar, and influenced the process equipment and piping layout, in order to meet the requirements of project and improve the level of our design, after much debate, team members, decided to confirm the event name as: to decrease the size of the steel structure of main factory building frame column section. It provides a strong basis for the optimization design and engineering application of the main building structure of large thermal power plant [1~5].

2. Optimization Objectives

In order to reduce the section size of column C and column D to meet the requirements of the technology profession, the objectives are set as follows:

| NO. | phase       | dimensions of Column C | dimensions of Column D | Clear distance (m) |
|-----|-------------|-------------------------|------------------------|--------------------|
| 1   | Original value | H1700X850X48X56         | H1600X750X48X50        | 11.85              |
| 2   | Target value  | H1400×800×44×50         | H1300×700×44×50        | 12.15              |

By using the finite element analysis software STAAD, the stress model of the main workshop is established, and the in-depth analysis of the steel structure of the main workshop is carried out. The checking results of the frame column in the preliminary design stage are shown in Figure 2.

As can be seen from Fig. 2, for column C, the stress ratio of the frame column at the coal hopper supporting beam is 0.90 (the code requirements shall not be greater than 1.0), and the maximum stress ratio at other parts is only 0.69. For column D, the stress ratio of the frame column at the coal hopper supporting beam is 0.83, and the maximum stress ratio at other parts is only 0.69. According to Staad's calculation results, the stress ratio of axial force and bending moment is shown in the table below:
From the above table analysis, it can be seen that the bending moment $M_x$ contributes the most to the overall stress. If measures can be taken to reduce the bending moment $M_x$ here, the stress here can be reduced, thus reducing the size of the entire section.

| Table 2. Comparison table of STAAD calculation results |
|--------------------------------------------------------|
| Column | Column of C | Column of D | note |
|--------|-------------|-------------|------|
| Axial force | 11845 | 10191 | |
| Stress caused by axial force (N/mm$^2$) | 79 | 82 | |
| Ratio of stress due to axial force to total stress | 35% | 37% | |
| MX | | |
| Bending moment size (kN·m) | 11016 | 8863 | |
| The stress caused by bending moment (N/mm$^2$) | 128 | 135 | |
| Ratio of stress due to axial force to total stress | 57% | 62% | |
| MY | | |
| Bending moment size (kN·m) | 133 | 5.2 | |
| The stress caused by bending moment (N/mm$^2$) | 18 | 2 | |
| Ratio of stress due to axial force to total stress | 8% | 1% | |
| Total stress (N/mm$^2$) | 225 | 219 | |

3. Feasibility analysis
In the above four projects, the first phase of Wang Song power plant in Shanxi Province and Inner Mongolia white tone HuaJinShan pithead power plant new engineering and Togtoh power plant phase II project are the same steps: increase brace under coal scuttle bearing beam, through the brace coal bucket load by means of axial force to the pole, thus reducing the intersection point of beams bending moment, thus reducing the section size of the frame column. The preliminary design of the GMR project in India and the State Grid Hami project adopts the same measures: the force is transferred to the foundation mainly through the frame columns.

This research group has also considered changing the support under the coal scuttle beam to an inverted V-shaped support. However, after consultation with the process, the process professional does not agree to change the support form, because there are two pedestrian channels on both sides of the V-shaped support. If the support form is changed, the lower part of the coal scuttle beam will not be passable. Therefore, this scheme is not feasible.

4. Determine the optimization scheme
After careful analysis, repeated discussions, and full communication with various technical professionals, team members proposed two solutions, as shown in Fig. 3~4. According to the information obtained by the research team, there is no precedent for the application of these two structural systems in the main steel structure workshop of thermal power plant in China.

After the scheme was proposed, the finite element analysis software STADD was used to build the calculation model respectively, and the two schemes were compared and analyzed.

As can be seen from the above, under the condition of the same section and steel amount, the safety of Plan 2 is higher than that of Plan 1. Therefore, Plan 2 is better than Plan 1. For scheme 1 and scheme 2, the safety of scheme 2 is 13.7% and 9.8% higher than that of scheme 1 when the same column section, the same load and the same parameters are used for column C and column D. Therefore, the research team chose Plan II as the best plan.
5. Cross section optimization
Using the finite element analysis software STAAD to establish the calculation model, as shown in Fig. 5 and Fig. 6:

After repeated debugging by team members, the section of column C is determined as H1400×800×40×48, and that of column D is determined as H1300×700×40×48. As can be seen, the maximum stress ratio of column C is 0.80<1.0, and that of column D is 0.82<1.0, meeting the requirements of the specification.

6. Conclusion
In order to reduce the section size of column column C and D column column, to satisfy the needs of process engineering, this paper, by using the finite element analysis software STAAD model the stress of the main building, the main steel structure building carried on the thorough analysis, put forward two kinds of section optimization scheme, the comparative analysis shows: in the same section and the
amount of steel case, the safety of the second scheme is higher than plan a, therefore, the scheme two is better than one. For scheme 1 and scheme 2, the safety of scheme 2 is 13.7% and 9.8% higher than that of scheme 1 when the same column section, the same load and the same parameters are used for column C and column D. The research results are applied to Hami Power Plant of State Grid Energy, with only columns C and D, and the actual value saves more than 500 tons of steel compared with the original value, and obtains good economic effect.

**Table 3.** Table of completion of project objectives

| NO. | phase       | dimensions of Column C | mass (kg/m) | dimensions of Column C | mass (kg/m) | Clear distance (m) |
|-----|-------------|------------------------|-------------|------------------------|-------------|-------------------|
| 1   | Original value | H1700X850X48X56       | 1346        | H1600X750X48X50       | 1154        | 11.85             |
| 2   | Target value  | H1400×800×44×50       | 1077        | H1300×700×44×50       | 964         | 12.15             |
| 3   | Ture value   | H1400×800×40×48       | 1012        | H1300×700×40×48       | 906         | 12.15             |

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