Analysis of Engineering Structure Design and Management Mode of Lihuayi Group Media Center

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Abstract. Engineering project management is a new thing in the field of engineering construction. It is a management model strongly advocated by the state. It conforms to the objective requirements of the socialist market economy and is conducive to optimizing the allocation of resources and achieving the minimum investment and maximum output of the project. But any management model can only play its role if it is used effectively in practice. This article takes the Lihuayi Group Media Center as an example, and introduces the main contents of the theater structure designing, including structural selection, floor designing, roofing beam designing, cantilevered building designing, stage craft designing and other design points. Combined with the above design points, the design analysis method and conclusion are proposed for typical components of the theater structure, research on the organizational structure design problem under the management mode which can provide practical reference for similar engineering design.

1. Project overview
Lihuayi Group Media Center is located within the Lihuayi Group, at the west of Jinwu Road, south of Liyi Road, Lijin County, Dongying City. As required by Party A, the designed theater should be able to undertake national high-level cultural and artistic performances. The total construction area is 16,091 m², 11,503 m² of which is the above-ground construction area and 4,588 m² the underground construction area. The total height of the building is 21.65 m, which is mainly composed of 1,200 theaters, exhibition halls, training centers, reading centers and related ancillary houses. The structure plane is rectangular with a length and width of 73x63 meters. The architectural renderings and plan are shown in Figure 1, and the building section is shown in Figure 2.

Figure 1. Architectural renderings.  Figure 2. Building section.
The Lihuayi Group Media Center has a design life of 50 years, a structural importance coefficient of 1.0, and a seismic fortification category of Category B. The seismic fortification intensity is 7 degrees (0.10g), the third group of seismic design is adopted, and the site category is III.

2. Structure selection
The structure employs a concrete frame-shear wall structure, and the large-span exhibition hall on the west side is made of steel-reinforced concrete beams. The shear walls are arranged at the four corners of the auditorium, both sides of the platform beam, and the periphery of the building. According to the requirements of the architectural plan, the exterior of the building is designed in the form of dense vertical bars, and the outer wall of the building chooses the form of a coupled wall combined with facade. What's more, the floor above the auditorium is built in the form of steel grid, and the stage is covered with concrete floor. The overall model of the structure is demonstrated in Figure 3. Parameters of the main component are listed in Table 1.

![Figure 3. The overall model of the structure.](image)

| Structure type               | CSA (mm)           | Material |
|------------------------------|--------------------|----------|
| Frame column                 | 600x600            | C35      |
|                              | 800x800            |          |
| Shear wall                   | 300                | C35      |
| frame beam                   | 300x700            | C35      |
|                              | 400x750            |          |
| section steel - concrete beam| 400x1250           | C35      |
| Cantilever beam              | H: 900x200x11x17   | Q235B    |
| bracket                      | 500x900            | C35      |
| floor                        | 150mm              | C35      |

3. Design points

3.1. Floor designing
Due to the existence of the stage, balcony, side light rooms, plenty staggered floor plans, and more than 50% of the floor openings, the structural designing had applied the elastic plate to simulate the floor slab, and analyze the stress of the slab. According to the value of the stress nephogram of basic double-layer two-way reinforcing bars, the steel bar is added, in order to further ensure the force transmission stability of the slab under vertical working and seismic conditions. Figure 4 gives the stress nephograms of floorslab under vertical working condition and seismic load condition.
3.2. Roof abutment beam designing

According to the designing needs, the span of platform beam is set as 18m. It supports the top truss of the auditorium at the 20.75 m, and the top roof of the performance hall at the 23.8 m elevation. In addition, the load is large due to the processing set-ups on the stage. To meet the demands of the building function, concrete truss is installed with lower chord at 20.75 m and upper chord at 23.80 m, between which are the straight rods and oblique web members. The truss is drawn in Figure 5.

Through structural calculations, the upper and lower chords are all of 400x1200, and the corresponding deflection is less than the demanding value in related specification and for the installation of stage equipment. Also, the designing parameters has a good economic effect.

3.3. Overhang seats designing Stage craftsmanship designing

The cantilevered building is a typical component of a theater-like structure. The cantilever span of the project is 7.95 m. At the early designing phase, there are three structural schemes: concrete cantilever beam, concrete beam plus diagonal bracing cantilever and section steel reinforced concrete cantilever and the results are as follows: 1. The concrete beam cantilever structure is simple and convenient for construction, but the size is large, and it is not easy to control the deflection and the amenity of the floor.
It is only suitable for the structure where the floor cantilever is small. 2. concrete beam plus diagonal bracing cantilever is more complicated for construction, the diagonal bracing and cantilever beam need to be demolished together, and the diagonal bracing can occupy part of the space under the balcony. The beam is small however, and the deflection and amenity of the floor are relatively easy to control; 3. The section steel reinforced concrete cantilever structure is complex, and the section steel is needed to added in the cantilever beam and frame column, which leads to high cost. Nevertheless, it does not take up the space and has less deflection. This project combines the design of the building plan and selects plan of the concrete beam and the diagonal bracing cantilever, which is also currently the mainstream design for the building of overhang seats. The structure layout scheme is depicted as Figure 6. In order to balance the horizontal force transmitted from the diagonal bracing to the column bar, a horizontal beam is placed at the position of the bracing in the column.

As calculation results show, the size of the cantilever beam is selected for 500x900, the reinforcement ratio is only 0.85, and the deflection is 26 mm, which totally meet the demands of the specifications and have significant economic effectiveness. Figure 7 shows the displacement nephogram.

3.4. Stage craftsmanship designing
The stage design includes the design of pulley beam layer structure, grid top layer structure, and the steel structure horse track. Each component is briefly described as follows: 1. The pulley beam layer is connected with the stage roof frame beam by embedded parts, which is made of Q235 steel. The structure is mainly designed for the pulleys to carry out the lifting and lowering of stage equipment such as curtains and lights. 2. The top layer of the grid is connected with the steel beam in the pulley beam layer through the steel hanger, on the top of which fits the steel plank. The main function of this layer is the installation and maintenance of the pulley beam equipment. As the profile layer shown in Figure 8, the horse track has three layers, which is connected by the steel ox legs. The steel ox legs are connected to the frame column to enable the installation and maintenance of the stage equipment.

![Figure 6. Cantilever structure plan.](image1)
![Figure 7. Displacement nephogram of the cantilever structure.](image2)

![Figure 8. Section drawing of the steel structure of stage.](image3)
The structural designing load is provided by the relevant equipment manufacturers. And the force transmission route is:

Based on the structural force calculation and slenderness ratio construction requirements, the steel structure dimensions of this project are: steel beams: HM300x200, HW200X200, steel hangers: HW100X100 (tension members), roof embedded parts: nine 12 mm anchor bars.

4. Conclusions
The Lihuayi Group Cultural Center is a typical theater structure with features of complex functions, multiple floor slabs, large floor openings and large cantilevered balcony. Through the analysis of the project designing, following conclusions can be drawn, which can provide reference for the designing of similar structures:

(1) It is recommended that the structure selection adopt the frame-shear wall scheme, and the wall limbs should be arranged reasonably by adjusting the layouts of the side light rooms and the wall around the auditorium.

(2) The large opening of the slab weakens the contact in the plane, which is unfavorable to the earthquake loads. In the designing process, the thickness of the slab can be appropriately increased and application of double-layer bi-directional reinforcement should be taken into consideration. Also, it is necessary to analyze the plane stress of the slab.

(3) The structural plan should be based on the size of the cantilever of the overhang seats, and give comprehensive consideration to the requirements of the plan, construction difficulty and economic indicators. Conventional practice generally involves the concrete cantilever beams plus bracing. Attention should be paid to the flexibility of the composite overhang building and the amenity of the floor.

(4) The stage craftsmanship is relatively constant. The design should be cooperated with the equipment manufacturer to determine the equipment load and should consider the increase of load caused by equipment upgrade in the future.

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