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Structural Expression in Architectural Creation of Sports Facilities

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Abstract

The architectural creation of the sports facility normally depends on spatial structural design which gives the fairly rational structural form. Some times, the structural form directly means the external image and the inner space of a sports facility [1]. Structural morphological design method is proved to be very useful to the architectural creation practice with the innovation of spatial structure. It relies on the concord and unification of architecture and structure, and joins the ideal and the reality together [2].

In this paper, the creating method to form the sports facilities with circular plan is summed up in three steps: generating the structural surface, forming the structural system and adjusting the structural model. And then, three architectural projects of sports facilities creating by the author with structural expression during the international design competition recently are presented.

Keywords: Architectural creation, structural expression, morphology, sports facility

1. Introduction

The architectural design of large spatial sports facilities has a distinctive feature, which is to depend on the structural morphology more than any other buildings, not only has the large-scale in size, but also includes a variety of functions. Sports facilities, such as the gymnasium or stadium, which are normally constructed for the sports match and training in the past, have the development trend of multifunction, such as entertainment and leisure. For being a large space, it is very easy to realize the multifunction in the sub-spaces. Characteristics of architectural creation to the modern large-scale sports facilities can be summarized as follows:

1.1 Unique form

The sports facility normally performs an important public role in a city. A unique external image is the embodiment of sports energy to the people, more attractive and widely recognized than any one else in a city. There must be an inevitable relationship between the appearance and connotation. The conceived forms can be derived from the geometrical

principle, from the natural morphology, from the technological requirement, from the functional demand, from the contemporary character or from the local civilization.

1.2 Multiple functions

The sports facility has to satisfy the multi-purpose requirements of the people nowadays. In this way, the larger-scale space will be designed for the sports match, training, musical performance and even the exhibition, adapting the transform between different roles, despite the demand to the architect is a one-time design. Here the architect must be based on the forward-looking concept to every detail of the demands on vision, acoustics, illumination, and environment and so on.

1.3 Technical dependence

The sports facility should provide the large space for the player and the spectators, which depend on spatial structure technology. As a large-span facility, its structural morphology determines the architectural form to a large extent, especially reflects the technical aesthetics through the rational combination of structural members and details. However, due to the uniqueness of the functional requirements, structural expression in the form has some limitations. The more complicated the functions require, the less free the structures express.

2. Structural Expression Practice

There are three practice examples provided as followings.

2.1. Foshan Gymnasium, China (designed in 2003)

Our company was invited to join the international architectural design competition for Foshan gymnasium in 2003. The match hall should have a multiple match field for basketball, tennis, and gymnastics, and 11,000 spectator seats were demanded during the sports game.

My plan was based on the principle of “Form follows function”. A unique and attractive regular form was getting perfect in my mind, and a bowl shape was created further to meet the seat-uprising [Fig1]. With the help of a model with the scale of 1:400 in studio, we imitated the mechanical status of the real structural form. The architectural form was expressed directly by structural morphology, not only from the outer view, but also from the inner view [Fig2].

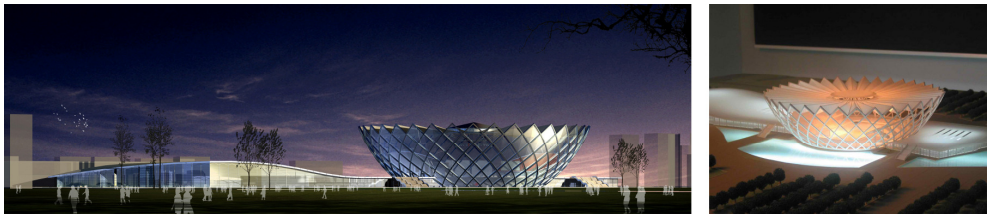
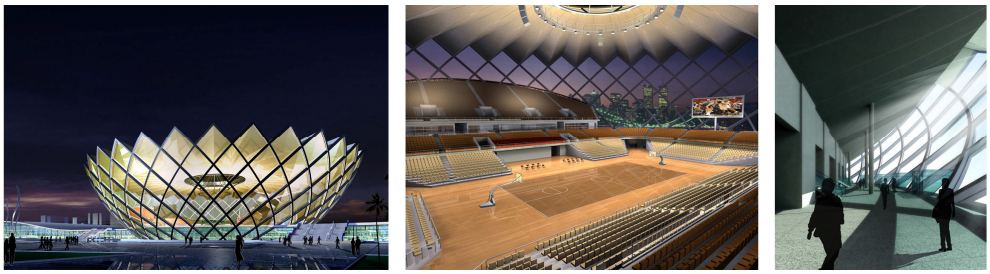


Figure 1: Rendering image of Foshan Gymnasium and the model with scale of 1:400



a. Night view b. Interior view c. Resting hall

Figure 2: Rendering image of the match hall

The bowl was cut from a global surface, and formed a latticed shell by rolling method [Fig3]. By this way, the types of the structural members are limited within the number of seven. Here the latticed shell was used as the bearing structure, and the roof was designed as the spoke shape tensional cable structure with the diameter of 150m, combined with the latticed bowl. The membrane was arranged between the upper support cable and the lower balance cable. All the inner forces were transferred to the base by the latticed shell, which was proved to be a rational design according to the static and dynamic analyses of the structure [3].

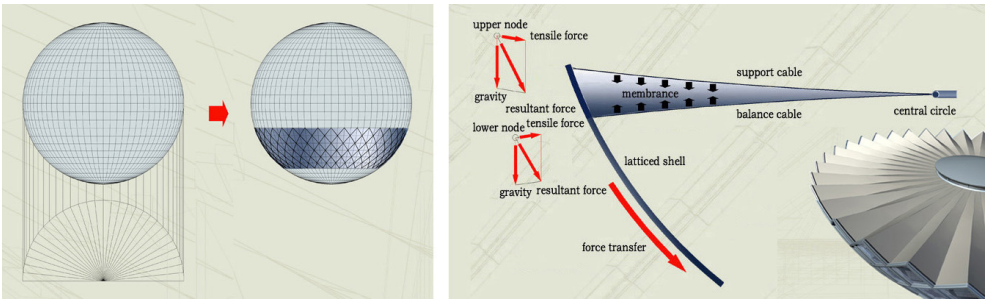


Figure 3: Structural mophology creation process and the interal force analysis

2.2. Dongguan Gymnasium, China (designed in 2006)

This plan was designed for the international architectural competition of Dongguan Gymnasium in 2006. The gymnasium was mainly for sports game, especially for the basketball, and had 15,000 seats for various spectators. The auxiliary functions were to host various performances, meetings and exhibitions. The rooms for the auxiliary functions would be designed, such as rooms for the relevant basketball club teams, management, media, sports organization and various business operations.

The structural expression meant the architectural appearance in this project [Fig4]. Pneumatic membrane structure was attempted to apply in the roof system. The circular roof of the match hall was designed as a cable supported latticed dome with the span of 120m,

covered by translucent ETFE membrane. The dome was sustained by a cable-mast system arranged in circularity with the height of 35m [Fig5].

Figure 4: Rendering image of Dongguan Gymnasium

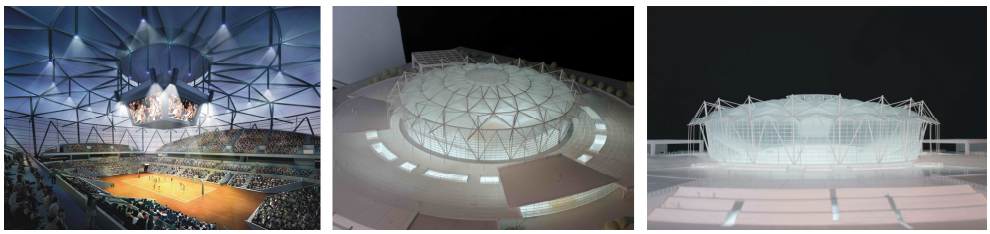
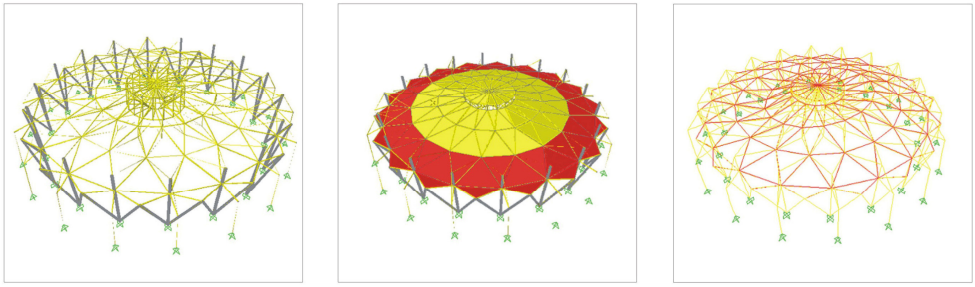


Figure 5: Interior rendering image and the model with scale of 1:200

The architectural creating process was accompanied by the static and dynamic structural analyses [Fig6]. The results showed that the roof system had sufficient stiffness and good dynamic performance in the wind and seismic conditions, which gave us the confidence of structural feasibility.



a. Rod-system model b. Surface unit model c. vibration mode

Figure 6: Structural analysis figure

2.3. Huizhou Stadium, China (designed in 2006)

Huizhou Stadium was designed for the sports game and football match. As the local climate is very hot, a good ventilation condition is very important, any extra decoration is unnecessary to this stadium. Thus, to realize the concord and unification of architecture and

structure becomes a valuable theme to our creation. My project had a circular outline and an elliptical playground with the track and football field, surrounded by rounding spectator stands with 40,000 seats [Fig7].

We formed the roof according to the plane and elevation of the spectator stands, initializing an equal-width circular roof at first, changing the inner edge to an ellipse by shape of the playground secondly, and bending the plane roof into a saddle according to the height of the stands at last [Fig8].

Figure 7: Rendering image of Huizhou Stadium and the model with scale of 1:300

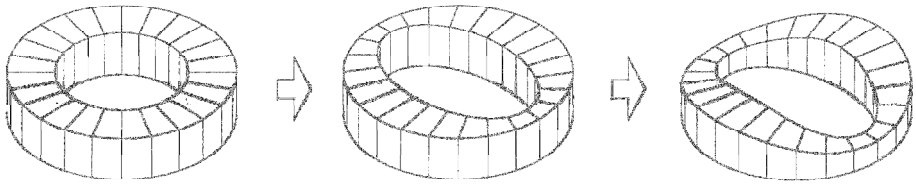
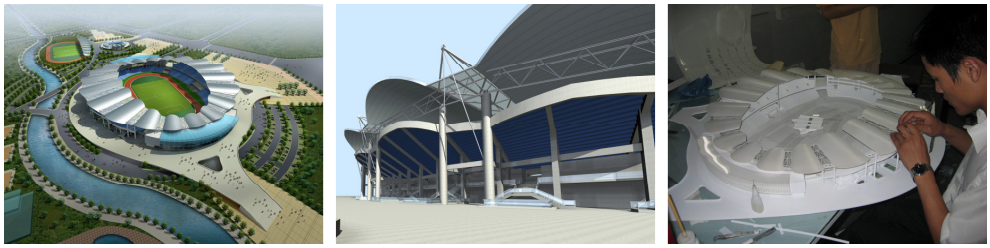


Figure 8: Process of the roof forming

The saddle roof was a twist surface. It was hard to realize by a whole surface. Thus, we separated the roof into 20 pieces, forming a petal-like roof. Every petal could be designed as a fairly regular unit surface. The roof structural system was made up by the combined cantilever trusses which composed the framework of the saddle. The support structure of the roof was designed as a cable-mast system, resting on the reinforced concrete frame stands [Fig9].



a. Bird's eye b. Details of structural support c. Model making

Figure 9: Image of the roof structure and photograph of model making

3. Conclusions

A rational structural expression for the architectural creation can be achieved with the help of form imaging, structural composition and scale model analysis. The creating method to form the sports facilities with circular plan is summed up as following:

3.1. Generating the structural surface

There are a variety of ways to generate the structural surface, such as geometrical creation, natural morphology and traditional architectural form etc. The form could be expressed by the mathematical method at last.

3.2. Forming a proper structural system

A structural form should be realized by choosing a proper structural system. For being a circular form, we can choose a logical structural system, such as latticed shell, tensional cable spoke, latticed dome or spatial truss, according to the appearance need, technological level and economic condition.

3.3. Adjusting the structural model

The original symmetric structural morphology may not meet the ultimately needs to the functional space or architectural form. The structural model has to be appropriately adjusted. In addition, the reasonable structural system must be maintained in this process.

The three sports facility examples which are presented above in this paper have not been implemented finally, while the active practices have already leaded us to success in many projects [2]. The creative practice has proved that the structural expression plays an important role of innovation indeed in architectural performance.

References

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