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Case Study on Beijing National Stadium: Bird Nest Olympic Stadium

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Abstract - *The modern day Olympic Games has been than just a sporting event where hundreds of athletes gather in a host country to compete against each other and challenge in becoming "faster, higher and stronger". With the advances in the mass media its also an excellent opportunity for the host country to showcase itself to the world. As, a part of this presentation effort it holds a potential to be architectural icon for the Games.*

In the run-up to the 29th Olympic Games in Beijing 2008, China wasted no time in announcing to the world the arrival of China as an economic superpower on the world stage. Old stadiums were refurbished and new ones built. The Chinese aspired to build bigger, better and more inspiring sport venues. And, among the new ones designs, the Beijing Stadium has been assets of the whole Beijing Olympic Games building boom.

Key Words: **Olympics, Architectural Icon, Economic Superpower**

1. INTRODUCTION

This brilliant sport stadium, referred to as the "bird's nest" from the tangle of twisted metal items that conjure its subject field structure, was built with the primary objective of being the main stage of the Olympic games, and some parties in the Olympic Football Tournament at the 2008 Beijing Olympics.

The Stadium, designed by Swiss Jacques Herzog and Pierre de Meuron in collaboration with ArupSport and China Architecture Design & Research Group, won the international convened in 2002 precisely because the original settlement proposal, impressed by the plot of a nest and created up a myriad of twigs and web, managed to impress a jury which included professional and impressive Koolhaas, Nouvel and Perrault. The project received a budget of $500 million dollars.

The Olympic sport Stadium in Beijing was the focus of the architects "brilliant aesthetic and structural challenges".
It is located in the Olympic Park, north of the city, the Stadium is only 1.5 km from the Olympic Village and 25 km from the airport in Beijing.

2. CONCEPT

The sport stadium design was evolved by the formation of nesting birds. The architects have succeeded in translating the thought, so that their work on the project soon gained the nickname "bird's nest" almost spontaneously among the Chinese population.

The design is revolving on the nests of birds, not solely aesthetically but also at a structural level. The entire structure, visible from the outside, mirrors the branches of the nests that working together with each other achieve unimaginable resistance to the elements.
At the center of the area that also houses other Olympic structures, the stadium seems to be perched like a spaceship, with a quiet majesty whose appeal is given by its slight undulation.

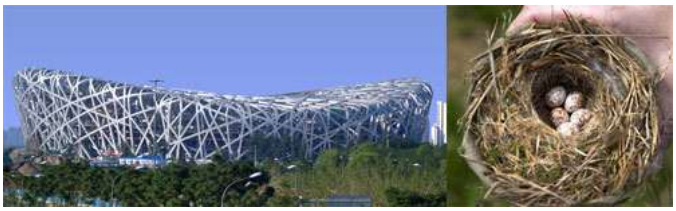

Fig 1 – Conceptual Idea

3. DESIGN

To achieve the optimum design, the team relied heavily on parametric design software. This helped to work out the sightlines, the bowl geometry, airflow to keep the grass in good condition, seismic studies and the design of the external envelope.

While the surface of the structure is simple, the geometry is complex – the calculations were so numerous and complicated that they could not be solved manually. Software was needed to make sure that the web of twisting steel sections fitted together, as they have to twist and bend to follow the surface accurately.

The main elements support each other and converge into a grid formation. The stand of the stadium is a seven-storey shear wall system with a concrete framework. The upper part of the stand and the stadium steel structure are actually separated from one another, but both of these are based on a joint foundation.

The "nest" structure, however random it might look, follows the rules of geometry and contains 36km of unwrapped steel. The shape of the roof was inspired by yin yang, the Chinese philosophy of balance and harmony.

4. CONSTRUCTION

4.1 Project Summary

The Beijing National Stadium aslo referred to as the Bird's Nest Stadium took five years to complete and was constructed using 42,000 tons of steel, making it the largest steel structure in the world.

The facts of the Bird's Nest Stadium

- Height: 69.2m (227 feet)
- Length: 330m (1082 feet)
- Width: 220m (721 feet)
- Steel Used to Construct the Outer Shell: ~42,000 tons
- Total Weight of Construction Materials (including concrete seating bowl): ~110,000 tons
- Seating Capacity: 80,000-91,000
- Design Life: 100 years
- Architecture Firm: Herzog & de Meuron

4.2 Construction Phase

Construction of the stadium proceeded in several distinct phases, the first phase involving the construction of a concrete supporting structure upon the concrete foundations laid for the construction site. This was followed by the phased installation of the curved steel frame surrounding the stadium, which is largely self-supporting. This phased installation involved the interconnection of sections of the curved steel frame that were constructed in Shanghai and transported to Beijing for assembly and welding. The entire structure of interconnected sections was welded together as the primary means of interconnection used to assemble the entire surrounding nest structure. Upon removal of the supporting columns used for the purpose of expediting the assembly of the interconnecting sections, the completed nest structure as a whole settled approximately 27 cm to attain full stability before the interior design and construction of the stadium could be installed and completed.

Fig 2- Construction photo of Stadium

4.3 Structure & Material

The stadium is 330 meters long, 220 meters wide and 69 meters high.

The protagonist between the materials is the steel that constitutes the various branches of the nest, between one and another, a series of "cushions" of inflatable ETFE (ethylene-copolymer tetrafluoretileno) give the stadium a "quilted" image. The cost of this large area of material used for the cover was $8 million.

Besides the aesthetic value of this network, we must emphasize the role of the structural elements of metal, which are interlacing and are mutually supporting. Although it produces the impression of a casual and almost natural course, the meeting of the various elements and the direction we take in the nest, are the result of precise calculations.

Fig 3 – Detailing of the Trusses

The steel structure had to be supported by 176 hydraulic jacks during its construction while the structure was not capable of self-sustainment. Each crane was capable of holding 300 tons, each with an accuracy of one millimeter. Later, the hydraulic jacks were removed at once to check the stability of the structure of the stadium.

The special features of this stadium, which was the main stage of the 2008 Olympics, suggest it being completely closed. In fact, in correspondence with the central area, the ceiling is a transparent membrane, through which passes the light from outside. The remaining part of the structure is covered by a translucent layer that protects it from adverse weather and a second layer of acoustic insulation.

To the architecture of Herzog & de Meuron, attentive to the materials and implementing new solutions, this project has also become an opportunity for experimentation and research, both during the "creative" stage as during its work. The set of materials that form the structure of the complex exceed 44,000 tons.

Fig 4 – Detail of Exterior

4.4 Removal of Formwork

The building was standing on 78 supporting columns, evenly spaced below the structure and were subjected to 42000 tons of steel load.

To remove the columns from beneath the roof, hydraulic jacks were used. These jacks would first support the roof, the columns would be removed and the load would transfer to the jacks which would eventually lower, allowing the structure to support its own weight.

According to calculations, the roof had to settle up-to 30cm and it did so after the supports were removed. Still they had to wait to see any further sinking or cracking. If so, it would mean that serious damage would occur. In full 1 week all of the supports were removed. Still the structure was just a hollow steel structure. It had to be furnished and fabricated to be an Olympic stadium. Flouro-Carbon polymer transparent sheets were used to fill up the spaces between the steel structural members.

5. EARTHQUAKE RESISTANCE

As China is surrounded by some of the deadliest fault lines, the stadium had to be earthquake proof. The building structure of Beijing Olympics stadium had to pass vigorous seismic tests. Thus the responsibility of making the Bird's nest earthquake proof started. The immediate problem was that the stadium was so large that it would not shake uniformly altogether with the same frequency. So the solution was to construct concrete bow in parts, then surround it with metal bow.

Dividing the concrete building structure of Beijing stadium into 6 parts was the key to safety. Being isolated, each part could move flexibly and independently in earthquake so that it could absorb the energy by its free movement, instead of being broken into pieces by this energy. Then it was to be surrounded by metal bow. So that, if in the worst case concrete fails, the steel would be unaffected and would support the structure frame. The structural guidelines of the Olympic committee were also to be met accordingly i.e. the stadium should have giant screens, shops, restaurants, cafes, bars and above all spectacular views of the competitions. Every seat was designed to be as close to the action as possible. No seat was more than 142m from the center of the stadium.

6. GREEN FEATURES

Aside from the structural advantages provided by steel, it has the added benefit of being easily recyclable, and thus ties in with the Beijing Olympic organizers' focus on sustainable design, and the driving principles of biometric design. Beijing's Olympic Stadium draws directly from nature, as elements of the bird nest are exposed as its major aesthetic motif, with little material wasted to disguise the structure. In keeping with the bird's nest analogy, the façade is in-filled with translucent ETFE panels in much the same way that a nest is insulated by stuffing small pieces of material between the twigs that make up the structure. The ETFE panels serve to protect spectators from the elements and provide acoustic insulation, while allowing sunlight to filter through to feed the natural grass field (Lubow, 2006). Furthermore, the panels are lighter than either glass or aluminium panels would be, reducing the dead load supported by the roof. The panels are also self-cleaning and durable, reducing costly maintenance. Openings in the façade allow natural ventilation as air filters through the public concourse, into the stadium, and eventually vents through the central opening in the roof structure.

REFERENCES

[1] Slideshare / Bird Nest Stadium
[2] Benyus, Jane. Biomimicry: Inspired by Nature.
[3] En.wikipedia.org/wiki/Beijing Olympic Stadium
[4] "The National Stadium, Beijing." Architect's Journal. 219.15 (2004) : 52-55

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