

Discovering the Factor of the Bird's Nest Stadium as the Icon of Beijing City

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Abstract— The expression of architectural forms is currently remarkably diverse because technological advances influence it in materials and structures; this is understandable because public buildings compete to attract visitors' attention. The architectural work can also produce new structural works, which are expected to become a work of art that matches the spirit of the age at that time. The role of structural systems in the expression of architectural forms can produce phenomenal works of art so that the appearance of this building makes the icon for a city or even a country. This research methodology used qualitative analysis by examining architectural theory and structure as a basis for consideration to become an icon of the city of Beijing. The research aimed to study the role of structure and architecture to become a symbol or icon of a city. The conclusion of this study is establishing a harmonious relationship between architecture and building structures to produce a work of art. Thus, making the Bird's Nest stadium an icon of the city of Beijing by paying attention to local cultural values that have become an icon of the city of Beijing, sustainable buildings, metaphor concepts, and biomimicry. The findings of this study are that the Bird's Nest stadium building is a hollow steel structure with high-tech steel, which synergizes with the expression of architectural forms, not only making the symbol of the city of Beijing even making the icon of the country of China.

Keywords— Architecture; Beijing city; bird's nest stadium; icon; structure.

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I. INTRODUCTION

In recent years, the design of architectural expression forms is developing very fast. Advances in technology, especially structural technology, undoubtedly led to the development of architectural designs. The development of technological advancements is what can give expression to various forms of architecture. The development of architecture and structural technology can reflect the work of new technology in building at the time [1].

Public buildings generally develop the development of expressive and exciting forms of architectural expression because public buildings require visitors to be able to visit the building. The development of building expressions is not only in public buildings but also in the expression of sacred buildings to attract people to come to visit the house of God [2]. Advances in structural technology undoubtedly also supported the expression of this sacred form at that time.

The relationship between architecture and structural progress is a series that cannot be separated. No matter how great the expression of architectural forms is, it is impossible to realize if the development of structural technology does not

support it. Also, the reverse is good and spectacular structural technology if there is no expression of interesting architectural forms; of course, there is no benefit.

Architecture and structure will express beauty in the architecture itself. Marcus Vitruvius Pollio discussed architecture, structure, and beauty in 80-70 BC. Vitruvius was a Roman writer, architect, and engineer. Vitruvius wrote ten books on an architecture known as the trilogy concept, namely *Firmitas*, a sturdy structure, *Utilitas*, which is the function of buildings, and *Venustas*, the beauty of architecture [3]. Trilogy at the time of Vitruvius in the 80-70 century BC already showed the relationship between architecture and structure (*Venustas and Firmitas*).

At this time, the relationship between architecture and structure can produce beauty in the work of architecture itself to create works of art, and this will be the basis of consideration of architecture [4]. According to Otto Wagner, each expression of an architectural form will produce structural work. This work can be said to be successful if the building's expression makes a beautiful form and creates a work of art [5].

The relationship between architecture and structure is fascinating because artwork from architecture and structure can symbolize a city or country. The Eiffel Tower in France is a symbol of the building with the highest tower (325 M) in France in 1889-1930; it is an icon of the city of Paris because of the steel structure [6, 7, 8].

Based on the description above, Working Thesis can be made that there is a harmonious role between structure and architecture to make the icon of a city. Determination of this icon requires a long time to evaluate this building; the current condition of the Bird's Nest stadium has reached 12 years since the building was built or three times the Olympic period, held every four years. By looking for the role between architecture and structure separately, it will be more comfortable to know the basic concepts of building a Bird's Nest stadium so that it becomes an icon of a city.

Based on this issue, it is fascinating to study the role of structure and architecture so that this building will become an

architectural work of art and a symbol or icon of a city. Bird's Nest is an architectural and structural work used as the venue for the Beijing Olympics in 2008 with a capacity of 80,000-100,000 seats. The building was designed by Herzog and De Meuron and spent revised funds of 2.6 billion [9, 10]. The research aimed to study the role of structure and architecture to become a symbol or icon of a city.

II. MATERIALS AND METHODS

A. State of the Art

A research search with the title "Searching for factors that cause Bird Nest stadium is the icon of Beijing city" needs to be done, with the aim of whether other researchers have ever done the same thing. With the hope that the value of the State of the art and Novelty of this research can be achieved. The keywords to explore this research are architecture, structure, and Bird's Nest stadium.

TABLE I
RESEARCH EXAMINED USING THE KEYWORDS ARCHITECTURE, STRUCTURE, AND BIRD'S NEST STADIUM

No	Title	Description	Source
1	The Present Situation and Constraints of Beijing' Forests for Holding 2008 "Green Olympic"	Urban forests will affect air quality in the area around the Beijing Olympics.	Journal of Forest Planning, 17-22. [11]
2	Numerical Study of The Effect of Traffic Restriction on Air Quality in Beijing	The results showed that a significant reduction of air pollutants occurred in Urban Beijing, where restrictions had been imposed. This study shows the efficiency of the size of traffic restrictions in improving air quality in Beijing.	SOLA, 17-20 [12]
3	Bird Nest Construction - Lessons for Building with Earth	Gas emission problems in the city of Beijing stadium must follow sustainable buildings. By analyzing building materials to create sustainable building materials.	WSEAS Transactions On Environment And Development, 83-92. [13]
4	Engineering aspects of nest building by birds	Bird's Nest concepts are real and significant ecological principles. Bird's Nest stadium is related to the microclimate environment from Nest's location, which can survive and protect from the surrounding nature and its predators. It shows many similarities with the principles followed by humans in building houses and other structures.	Endeavour Journal, 9-16 [14]
5	Case Study on Beijing National Stadium: Bird Nest Olympic Stadium	As part of this presentation, the effort holds the potential to become an architectural icon for the Olympics. Ahead of the 29th Olympics in Beijing 2008, to announce China's arrival as an economic superpower to the world. On the world stage. The Chinese aspire to build a sports venue with a new design.	International Research Journal of Engineering and Technology (IRJET) 3161-3163. [15]
6	The impact of the 2008 Beijing Olympic Games on China's destination brand: A.U.S.-Based Examination	This research provides input after the 2008 Beijing Olympics, social media factors, and exciting activities in this post-Olympic building. It can have a positive impact on international travelers visiting Beijing's Olympic buildings.	Journal of Hospitality & Tourism Research, 237-261. [16]
7	The relationship between symbolic images and recognition types of local assets - based on city parks within Busan Metropolitan City	The relationship of symbolic images as local assets is realized in a city plan.	Journal of Asian Architecture and Building Engineering, 98-103. [17]
8	Olympic Beijing: Reflections on Urban Space and Global Connectivity	This research focuses on art space, preservation of heritage, and infrastructure Beijing Olympics.	The International Journal of the History of Sport, 1011-1039. [18]
9	Spectacular Beijing: The Conspicuous Construction of an Olympic Metropolis	An analysis of the city's image affects social, economic, and political aspects - a critical review of the construction of the Beijing Olympics.	Journal of Urban Affairs, 383-399 [19]
10	Architecture and Nation Building in the Age of Globalization: Construction of the National Stadium of Beijing for the 2008 Olympics	This study examines the relationship of the architecture of the 2008 Olympics in Beijing to the era of globalization and cultural ideology. It was encouraging the production of leading architectural projects in China.	Journal of Urban Affairs, 175-190 [20]
11	The Beijing National Stadium as Media-space	This research draws on ethnographic method, media studies, and design studies at the Beijing Olympics.	Design and Culture, 145-163. [21]

Based on the description of Table I, it can be concluded that the research with the title “Searching for factors that cause Bird Nest stadium is an icon of Beijing city” has never been examined. So, with this research, it is expected to fill the void of existing research so that the novelty value of this research can be sought.

B. Theoretical Review

Theoretical research wants to examine the Olympics three times; first in the city of Beijing in 2008; second in the city of London in 2012; third in the city of Rio de Janeiro (Brazil) in 2016, why the Bird’s Nest stadium has become an icon of Beijing. Besides, the Bird’s Nest Stadium is more famous than the Aquatics Center building, in that the building is designed together and opposite the Bird’s Nest stadium in 2008 at the Beijing Olympics. So, in analyzing this theory, it is described separately from the architectural and structural aspects. The theory analysis in groups there is two parts, namely, (1) Architectural aspects included in the urban concept and building concept; (2) Structural aspect.

1) Architectural Aspect

Urban concept: An overview of the concept of urban planning in a building, especially buildings with excellent Olympic levels, is needed. Urban contacts need to pay attention to a concept that gives specific meaning related to the city itself. Norberg-Schulz said, “The concept of place, thus, has two meanings: point of departure and place of action” [22]. It indicates the design of a place in urban contact, paying attention to the axis as a starting point and subsequently towards an endpoint.

The building axis binds the value of historic buildings as the core of the city’s culture [23]. Because historic buildings have become the core and culture of a city, it becomes symbol or icon meaning in a city [24].

This axis is expected to make the Olympic building follow its example and blend with historic buildings’ cultural heritage. Pierce’s semiotic view of the meaning of symbols is something that has become a sign, has been recognized and known by the public in general. The purpose of the icon is a sign that has been represented [25]. Therefore, in the urban context, the researcher must think about the axis of historic buildings’ axis as the symbols and icons of the city to become a cultural heritage.

Building concept: The building concept talks about the relationship between the form and function of the building; the building must follow what it wants to express so that the observer can understand and interpret it. The relationship between form follows function, or function follows form, and the function and form of each runs on its own [4]. This relationship is essential because in the design of buildings to determine the starting point of the architect’s concept to organize the expression of the building.

The metaphor form concept and also influence the relationship between function and form; the relationship between the form and the concept of metaphor will reflect the architectural expression following the building function [26]. The concept of metaphor can produce tangible, intangible, and or can be combined [27]. The metaphor concept is a concept that takes ideas from an imagined form that is adapted to the architect’s concept. The metaphor can also be made

from cultural forms or traditional house forms hybridized with today’s technology [28].

Because the concept of metaphor comes from the imagination of the form (according to the architect’s concept), then the imagination of this form should not be ambiguous. Architects are supposed to socialize the concept of this metaphor idea to the public. The concept of this metaphor design concept can be understood, it can also be designed using this metaphor form realized in the form of a model so that the public knows about it. It is to avoid misinterpretation from the public regarding the form of metaphors [29]. Therefore, building concept analysis aims to look for any factors that influence the expression of the shape of this Bird’s Nest stadium.

2) Structural Aspect

Building structures for Olympic buildings generally use a wide span using steel structures. Structural technology will enhance new ideas and produce new-generation products that can be passed on to the next generation. It is an essential thing for the concept of sustainable development [30]. The choice of the structure must be following the concept of architectural form so that the architectural form is following the function (*utilitas*) and structure (*firmitas*), so that beauty can be achieved to the maximum (*Venustas*). Of course, this building is also expected to become a work of art [3].

The relationship between structure and architecture is a relationship from function to the form of architectural buildings; in this case, the Olympic building with a wide-span structure. The building’s function is very closely related to the structure [31]. It increases strength in external loading and the distance between supports. The skeletal structure is formed to create space into a skeletal structure, further enhancing strength and stiffness. The skeletal structural system combines spatial structural systems that can cover large areas and free columns in the middle (wide span structure) [32]. It agrees with Robert Krier’s view that form, function, and structure are inseparable [33]. Arrangement of the construction of the column and beam system and positively affects building users toe utilized optimally [34].

The used structure is adjusted to the material and technology at the time. The used structure must be honest in accordance with the function of the use structure itself, not just the building’s deceptive appearance. For example, a column wants to function as a structural column, not only a form display [26].

Structural construction is a building structure method that takes into account loading from the roof, including the load of the floor plate to the column and then forwarded to the foundation. Structural construction methods should produce new form expressions. Architects always develop expressions of form with works of art that originate from building structures [5].

Paying attention to the basic principles of a building structure system can be an exciting variety of forms, but still paying attention to the regulations and comfort of safety standards for building users [35]. The purpose of structural system analysis is to look for the concept of structure used by buildings, so that it has a high value of the artwork and becomes an icon of a country.

C. Method

The method used in this research is qualitative with a theoretical study of the concept of building the Olympic Beijing or Bird's Nest. The method for analyzing Bird's Nest associated with the theoretical research, architectural and structural aspect.

III. RESULTS AND DISCUSSION

A. Architectural Aspect

This architectural aspect analysis is divided into two groups: urban concept and building concept. These concepts have a very close relationship with the expressions on the building form of Bird's Nest because every appearance of the building form must be integrated with the urban environment.

1) Urban Concept

The concept of urban design takes what has become the cultural heritage of the city of Beijing, the urban concept of the Beijing Olympics is *Hutong*. *Hutong* is the road between *Si-he-yuan*, *Si-he-yuan* is a type of floor plan that has an open roof space towards the sky, which now called the air well, Tian-Jing [36].

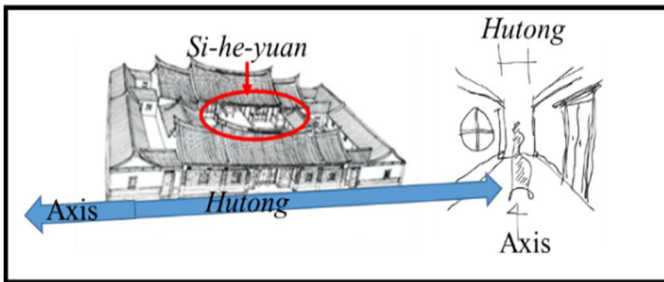


Fig. 1 Si-He-Yuan. Source: "The origin of Green Dragon (青龙) and White Tiger (白虎) icons as architectural elements at traditional Chinese temple (庙, 廟) entrance (at Java island) [37]"

Hutong is a concept of continuous roads that already existed in the *Yuan* dynasty (1206-1368), *Ming* (1368-1644), and *Qing* (1644-1911). Since the Republic of the *Hutong* era, the use of *Hutong* is no longer used. To revive the old cultural heritage, the *Hutong* concept was used again. The *Hutong* concept is used as a road Axis by taking the *Tien A Men* axis line in the South with the Forbidden City in the North. In the South to North movement, this was used for the Beijing Olympics building period [24]. Then from this extension, the axis is called the cultural axis [38] (Fig. 2).



Fig. 2 Culture Axis: *Tien A Men*, Forbidden City, and Beijing Olympic Source: "https://www.google.co.id/maps/@39.9929431,116.3943225,17z," 29 January 2020.

There are two forms of building for the Olympics: the rectangular shape symbolizes the world, and the round shape symbolizes heaven. The rectangular shape is the Water Cube building (Beijing National Aquatic Center), while the round building is the Bird's Nest [20, 39].

The city of Beijing's problem was air pollution, which was so high that urban forests were needed to overcome the problem of air pollution. Urban forests are expected to overcome urban pollution, as is known by the lack of green open space, which will cause an increase in the microclimate in a location [40].

Extend the Axis culture to the end of the urban forest, which is the endpoint of the Beijing Olympic building and is also expected to be the starting point for the next building [41]. The urban forest concept is an embodiment of sustainable development, which can achieve the Beijing Olympic project's potential and innovation to benefit in the form of an environmentally friendly design concept, efficiency, and effectiveness. Finally, this building has been designed safer for the surrounding environment (Fig. 3) [42].



Fig. 3 Culture Axis and Olympic Forest Park. Source: "https://www.google.co.id/maps/@39.9929431,116.3943225,17z," 29 January 2020

2) Building Concept

Swiss architects designed the design of this building, Herzog and de Meuron, in collaboration with Chinese architect Ai Weiwei; Ai Weiwei expressed the expressive structure of a bird's nest. Herzog and de Meuron express the form of the Bird's Nest with a bowl concept because the bowl is often used in daily life in China [23]. Based on these two concepts produce the final work at the expression form of Bird's Nest, which is a metaphor concept of Bird's Nest and bowl, which is a combination of tangible and intangible (Fig. 4) [27].

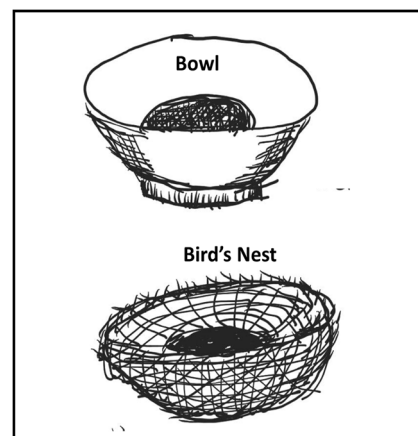


Fig. 4 Bowl and Bird's Nest

The building is designed to consider sustainability factors, including green buildings, clean water, and all materials and workers from China. The concept of greening and using clean water is taken and processed from the concept of urban contact in the form of a forest park, which is expected to overcome pollution, water catchment, and temperature rise. Based on the building period associated with the concept of sustainability and the concept of the metaphor, the concept of expression of the Bird's Nest stadium can be seen in Fig. 5.

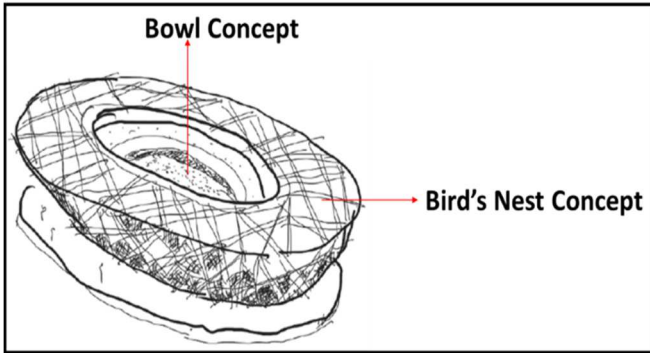


Fig. 5 Bird's Nest Concept

B. Structural Aspect

In this structural aspect analysis, the stadium's main structure assumes a group of humans who stand in a circular position and hold hands. Holding each other in a circular shape can withstand loads both vertically and horizontally. The vertical purpose here is the load of the roof and concrete floor. In contrast, there is a shear force in the horizontal load that can be assumed to be the force due to an earthquake (Fig. 6).

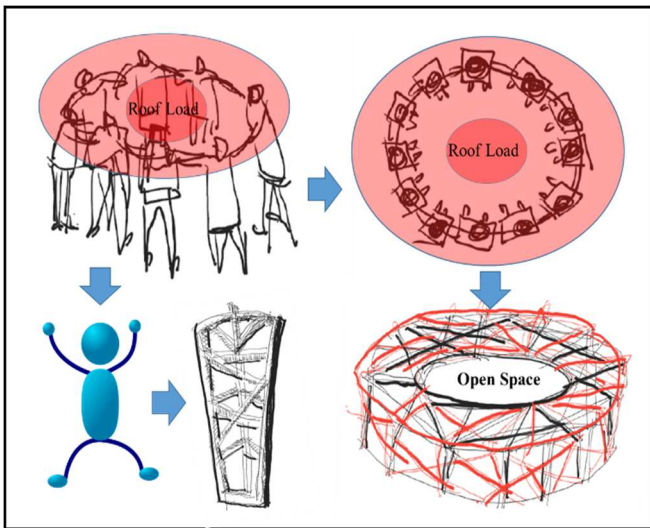


Fig. 6 Structure Concept

The stadium building structure system that resembles a Bird's Nest looks irregular. However, if examined closely, it seems that the frameworks still follow the skeletal structure system's rules, namely the presence of beams that continuously form the main portals (see Fig. 7).

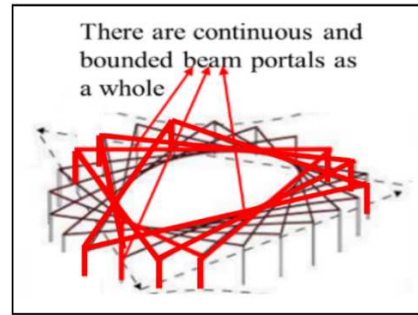


Fig. 7 The Primary Structural System of the Bird's Nest Stadium

The trunks of the skeletal structure in balance Pull and press are made to vary in location as if forming the concept of "interwoven" bird nests that look irregular [35]. This series of trunks become a unified whole, resulting in perfect rigidity [32]. The series of intersecting rods will add rigidity in all directions.

The structure used is a steel frame, the emphasis of construction of this stadium on the concept of green building and advanced technology. The stadium with a metaphor bowl concept with the inside, there is a concrete seat. The front view is wrapped in bent steel shaped like a Bird's Nest (Fig. 5). The volume of the shape of stadium buildings, such as ellipses with a broad breakdown of approximately 333 M X 284 M with a height of 69 M. Stadium building is called biomimicry. Biomimicry is a new science that studies models sourced from nature and then takes inspiration to solve humans' problems. Emphasis on building construction issues includes green building and advanced technology [9].

Using a hollow steel plate structure is a sustainable building concept; besides that, the remnants of unused steel can be recycled. The metaphor bowl and bird's nest concept's biomimicry provide natural air circulation into the stadium space, reducing the stadium's electrical load (Fig. 6). Dimensions of high-level carbon steel with box form/box adapted to the need to shade a wide span with a non-geometric shape require high accuracy, both in design and implementation. The form resulting from this skeletal structural system allows natural ventilation compared to the massive structure, so the stadium building is in the category of sustainable green building. The Bird's Nest stadium observes natural light in the corridor, and this corridor surrounds the building by using glass material on the walls of the building (Fig. 8).

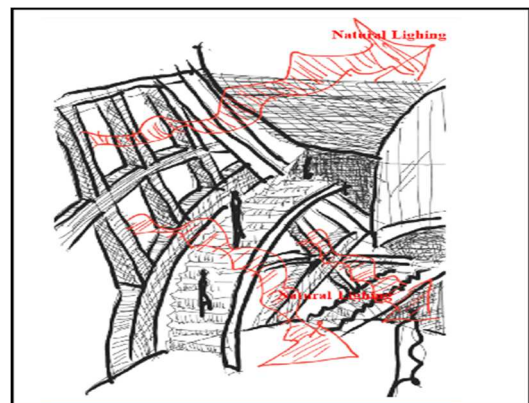


Fig. 8 Structure with Bowl and Bird's Nest Metaphor Concept

Natural lighting will affect the atmosphere in the building [2]. This natural lighting during the day will reduce electricity expenditure because there is no need to increase the artificial electricity load. At night this Bird's Nest stadium uses artificial lighting using LED lights. So, this building's effect will have two lighting images, daytime, and night-time, to provide a different atmosphere.

IV. CONCLUSIONS

There is a harmonious role between structure and architecture to make the icon of a city. This role can be seen from the architectural and structural aspects so that this relationship can be concluded as a harmonious relationship in the building of the Bird's Nest Stadium; thus, this building can become an icon of the city of Beijing, as for the following description: *Architectural aspects*: Architecture which includes urban concept and building concept with due regard; (1) Sustainable building, especially on air pollution; (2) The Bird's Nest Stadium pays attention to local culture by reviving the concept of historic buildings as symbols in the past such as *Hutong*, *Tien A Men*, and *Forbidden City*; (3) The stadium concept takes the concept of the metaphor; bowl and bird's nest; (4) The stadium building is examined from Pierce's semiotic theory with its first concept, only a symbol of the city of Beijing. The Bird's Nest stadium is an icon of the city of Beijing and can even be known as the country's icon of China.

Structural aspects: Structure of the Bird's Nest Stadium; (1) Using hollow steel plate construction with high technology; (2) The use of structures and materials pay attention to the concept of green and sustainable buildings; (3) The use of material and structure with the concept of metaphor bowl and Bird's Nest as a system that is modeled on biological entities and processes, the use of material and structure is called the concept of biomimicry.

The structural system's role is crucial in supporting architectural forms and adjusting to each other, especially in unusual forms such as building the Bird's Nest Stadium. Material technology is needed, especially for wide-span structural systems, so that the functions and shapes of buildings can be realized properly. The system structure's basic rules still apply to realize the architectural forms that designers dream of and become certain icons. The building structure system is visible from the outside (not hidden), united, and at the same time becomes an integral part of the expression of its architectural form.

The findings of this study are that the Bird's Nest stadium building is a building with a hollow steel plate structure with high technology, which synergizes with the expression of architectural forms, making the symbol of the city of Beijing even make the icon of the country of China.

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