Exploring Flexibility in Stadium Design

by

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ABSTRACT

The Olympic Games, World Cup and similar events often serve as catalysts for the regeneration of urban areas and for the construction of new infrastructure and sport facilities. These sport venues attract a variety of social and cultural activities; consequently, such venues, particularly the stadiums, have regained their importance as city icons.

In the past, Olympic Games have fostered the creation of “white elephants”—large numbers of elaborate stadiums and infrastructures, whose full capacity would not be utilized after the events and whose long-term maintenance costs were unjustified. Therefore, when planning sport venues, the post-event use of the facilities is of significant importance.

This thesis analyzes the stadium typology and existing case studies, in order to explore new spatial organizations that allow greater flexibility in stadium’s form and function. This flexibility support different scenarios of the stadium life. In the specific case of the Olympic Stadium for London 2012 Games, from 80,000 seats Olympic stadium to 35,000 seats athletic stadium; to soccer stadium; to various multifunction venues that can play an important role in the economic, social and cultural improvement of the specific urban area.

Thesis Supervisor: J. Meejin Yoon
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To my mother and sister, who always made possible for me to live my dreams.
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1 Introduction

1.1 Motivation

After years of professional and research work on stadiums, I came to the conclusion that flexibility in their design would give rise to great opportunities for the building typology. Therefore, my research focuses specifically at flexible stadiums and the design issues associated with them.

1.2 Background and problems

Due to their unique ability to create synergy among the political, financial and administrative forces of a city, the Olympic Games have always been a strong catalyst for urban development; they stimulate tourism and the employment rate for the host country. Given how Olympic stadiums and complexes pose huge influences over the development of a city, it is important for the local authorities and the organizing committees to consider their post-Olympic uses when they plan the venues. For the 2008 Olympics in Beijing, 40 new competition facilities will be built (15 large sport halls, 13 stadiums and 12 special sports facilities), altogether they will provide up to 800,000 seats. In terms of post-event use, even in densely populated areas, the figure represents a daunting challenge for the facility operators. Therefore, it is not surprising that "white elephant projects" are left as financial burdens for former Olympic cities. Grim prospects of long-term indebtedness, along with the ever-increasing maintenance costs cast dark shadows over the image of the events itself and over stadiums as a building type. It is important that these building complexes are designed in such a way that they will allow a flexible program of activities.
Although the Millennium Dome in London was not built for an Olympic event, it is still a good example of a building for which the city could not find an appropriate use. After the Millennium celebration, the mega building hosted few events and was closed in 2002. At that time, the construction cost amounted to 275 million pounds, operation cost to 103 million pounds and additional marketing and exhibition cost to 416 million pounds, what gave a total of 794 million pounds, of which 628 million was covered by national lottery grants and 166 million through ticket sales. Although the government enthusiastically supported this project, there was no possible use for the 104,581 square meter area. For the Olympic Games in London in 2012, the Millennium Dome will be converted into a 20,000 seats indoor arena and, after the Games, into a multipurpose arena. Another example is the Olympic venue built in the Sydney Homebush Bay area, which is still being used as a multiple-purpose venue. However, other venues, such as the Entertainment Centre in Sydney’s Darling Harbor, have similar arenas and compete against each other for the same events. Consequently, 32 million dollars of tax money is spent every year to sustain these Olympic venues. Barcelona is still paying back a 1.4 billion-dollar debt, Salt Lake City 155 million, and Athens 2.5 billion.

These “white elephants” were the result of the fact that only the building authority and the architects were included in the design process and no future users were consulted. The architects considered the problems of design and construction, but almost never the life of the sport facilities or their uses and maintenance after the official opening.


This can be considered as an irresponsible oversight considering the fact that only 20% of the lifetime cost of the building lies in the construction cost, while the other 80% comes from annual operating cost, maintenance and renovation. Therefore, when planning Olympic venues, it is not only important to include the architect and building authorities but also engineers, facility managers, event managers, urban planners, the government and representatives from other groups.

Looking at the facts, the Olympic events can have positive and negative impacts over the future of the hosting city. On one hand they change the urban, social and economic structure of a city or region permanently. On the other hand, taxpayers have to pay for the large number of unused sport facilities and their high operating cost. The balance between the positive and negative impacts can make the event more or less successful.


1.3 From the Colosseum to today's stadium typology

When on the end of nineteen century Pierre de Coubertin initiated the modern Olympic movement, there was no thing such as athletic stadium nowhere in the world. The Greco-Roman model (amphitheatre and hippodrome) was initially adopted to modern sporting facilities.

After the first Olympic Games in Athens in 1892, the stadium developed from a basic stand to “sports parks” as a subgroup of the park. The modern Olympic Park was created as a response to the need to modernize classical stadiums and to open the sports parks to the mass. But, the large scale stadium was still not ready to fulfill its function. There was large number of trial-and-error design attempts in the beginning. These attempts were extremely interesting for my research because their failures were caused by their attempts to combine different sport activities in one stadium building. One example is the Amsterdam Olympic stadium from 1928, where the cycling track was inside the athletic stadium. Because of the steeply banked corners of the cycling track, the stand was cut back, thereby reducing the stadium's seating capacity and lengthening its sight lines.

This and many other modern cases show that adopting the Greco-Roman model and not developing new typology or sub-typology of Olympic stadiums was one of the biggest errors in the development of stadium design. The classical typology has been proved to be too static for the dynamic life of Olympic stadiums. And the reason why Olympic stadiums have a different life cycle from normal stadiums is because they are build for a function that has a lifespan of 17 days, after that, the Olympic stadiums needs to accommodate to different daily scenarios.

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5 Van Winkel, The stadium: The architecture of Mass Sport, 22.
Euro Stadium, Salzburg

Before 2007

2007

2008

After the Olympic Games

18,000 spectators

30,000 spectators

2008 European Championship (2014 Winter Olympics)

Stadium Australia, Sydney

1999

2003

110,000 spectators

2000 Olympic Games

Construction cost: 80 million

81,500 spectators (for oval field)

Australia football, Cricket

83,500 spectators (for rectangular field)

the lower seating rings in the east and west side are movable

A > B A

Atlanta, Georgia

1996

1997

85,000 spectators

1996 Olympic Games

Construction cost: 167 million

Reconfiguration from athletic to baseball stadium

Reconfiguration costs: 40 million

50,000 spectators

Braves baseball stadium

Reconfiguration costs: 40 million

A > B

Sapporo, Japan

Ground arrangement for soccer matches

The ground is rotated

The ground is moved

The ground is moved and converted to baseball game arrangement

A > B
2 References

2.1 Second life of stadiums – Case studies

In the recent years, there have been arguably successful attempts to design stadiums with a second life. All of them are venues that were built for events such as the Olympic Games, the Commonwealth Games or World Cup, which proves one more time that a stadium’s ability to transform itself is necessary.

For the Atlanta Olympics in 1996, an athletic stadium for 85,000 people was planned to be partially demolished after the event in order to create a baseball stadium for the Atlanta Braves with a capacity of 50,000 seats. Most of the facilities and equipment were temporary and portable and had post-games owners. The negative effect of this kind of solution was that the economic and the ‘image’ effects do not last as long and as much as they should. Considering that the Olympics are catalyst for urban development, the “the circus came in town” setting is not satisfactory.

In the case of Sapporo Dome in Japan built for the World Cup 2002, mobile elements were planned to be used such that the playfield can transform itself from a soccer field to a baseball field, and vice versa. The sequence of the transformations goes as follows: the artificial turf of the baseball field is first rolled up. Then the moving wall opens towards right and left. At the same time, the outfield seats are retracted. When the hovering soccer stage starts to move, the revolving banks of seats also begin to move in parallel with the soccer stage; after the stage has arrived in the closed arena, it rotates 90 degrees along with the revolving banks of seats.

Is it possible to create higher level of transformability?
2.2 Structure in the Nature

In the process of exploring how maximum transformability can be achieved, it became very clear that both the general scheme and every part of the lower-level entities need to be subordinated. In that way the system with all its components can accommodate changes without experiencing errors. Considering the notion of physical as well as design flexibility, it is important that the system is able to accommodate changes and stay robust. Similar structural systems can be found in nature. These structural systems are complex adaptive systems that entail processes of self-organization and growth.

When I began to look at the nature and its structures, I did not have bio-mimicry or ornament in mind. An essay I read, Conceptuality of Fundamental Structures from Buckminster Fuller, provoked me to think about structures not as a “thing”, but as a pattern. Structures in nature can be defined as inherent patterns which affect each other in varying degrees and are continuously reproducing themselves in unique local configurations.

| MIT's Department of Mathematics' self definition in 1953 was: "Mathematics, which most people think of as the science of numbers, is, in fact, the science of structure and pattern in general". Therefore, "structure" refers to an ordered arrangement of components that is different from "construction" that carries implies something physical being put together.

The approach that I took in looking the patterns in the nature was not to look for the visible modules, but to search for the sub-visible modular structures. These sub-visible structures produce internal balance, order and symmetry in level of sub-assembly and grand-assembly.

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8 Fuller, Structure in Art and Science, 68.
2.2.1 Waterlilies, Sponges and Dragonflies

The engineering principles of biological systems are characterized by a high level of redundancy and complex differentiation in the material hierarchy. It is exactly the redundancy and differentiation, rather than optimization and standardization, that creates robust systems that successfully respond and adapt to different stresses and dynamic loads. The patterns or the structures of biological systems such as waterlilies, sponges and dragonflies inform how the organisms behave and perform under a specific range of environmental conditions.

Another type of system that is commonly used in biology and architecture is polymorphism. Polymorphism describes systems that are made of different elements, forms or individuals. In architecture, polymorphic systems implies complex interrelations of form, materials and structure in the design, which is in turn materialized by deploying the logic of manufacturing processes.

2.2.1.1 Victoria Amazonica (Waterlily)

In the process of searching for subvisible modular structure in the Waterlily, I did not follow the L-System (Lindenmayer system) of modeling growth patterns of simple molecular organisms. The method that was used was form finding with force diagrams.

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2.2.1.2 Venus Flower Basket and Dragonfly

The two examples in the following - fiberglass structure of the sponge known as Venus Flower Basket and the structure of the wing of the Dragonfly, are interesting not only because of the diamond and polygonal grid, but also because of how these grids are using a minimum amount of materials to achieve maximum performance in very versatile and aggressive environments.

Looking at all these patterns and how their structural logic overlaps give rise to interesting possibilities in assembling layers of data and pattern. Balmond calls this template of ideas informal, because there is no hierarchy - only interdependence in the natural patterns. 12

Figure 5.
Extracting the rules of the branching structure of Victoria Amazonica

Figure 6.
Diagrid structure of the Venus Flower Basket (Euplecella Aspergillum)
Figure 7.
The structure of the Dragonfly wing
Exploring two-dimensional patterns in three-dimensional assembles.

Figure 8.
In overlaying the patterns new 2D frameworks emerges. It is not a process of simple replication, but of morphogenesis. Although these 2D patterns on one level are fixed, they give an opportunity to be viewed as a projection of more complex 3D networks which led to the investigations that follow.

The 3D networks begin to represent not just overlaying patterns, but also compositional field, connectivity, geometry, system, proportion, form and structure.

Figure 9.

Making visible modular structure out of subvisible modular structure by overlaying the logic of branching structure and hexagonal grid.

_The pattern turns into structure, which becomes architectural devices._
Figure 10.
Explorations in complex use of patterns
Figure 11. Creating the Grid

- Seat grid
- Section grid
- Diamond grid
- Soft grid
2.3 Creating the Stadium Module

In the process of developing the stadium module, the main drivers are the multiple overplayed grids. They start from the basic seats configuration and continue with first a sectional grid that divides the volume into planar sections, then a diamond grid that connect points within the pattern, the seats and the sectional grid. Finally a soft grid that tightly follows the diamond grid is introduced.

Having created a system that could be developed three-dimensionally and can accommodate transformations without losing the robustness of the system, the next step was to test it in a real stadium design.
3 London Olympic Games 2012

3.1 The Olympic Park

The London Olympic Park is located in new development area Stratford City, which includes new office and retail space, hotel and conference facilities, as well as health, education and communication facilities.

Olympic Stadium

The current design for the Olympic Stadium done by Foreign Office Architect and HOK, has a demountable concept with the purpose the stadium to be reduced after the Games from 80,000 to a capacity of 25,000, serving as the home of British athletics. The top two tiers of the steel and concrete structure will be dismantled leaving the lowest tier. Most likely, the grandstand will remain, retaining the state of the media, changing rooms, conferencing and banqueting facilities. The roof will simply be lowered to fit over the reduced structure. This demountable stadium concept was developed in response to an International Olympic Committee commissioned report (Olympic Movement’s Agenda 21: Sport for sustainable development) that recommends that Olympic venues should be designed such that they leave a better legacy for future use.

Aquatic Centre

The Aquatic Centre, designed by Zaha Hadid, has capacity of 20,000 that will be reduced on 3,500 post-Games. The temporary grandstands will be dismantled and the water-polo pool lifted out and relocated.

Multi-Sport Arenas

After the Games one of the arenas will remain as a training and competition venue for indoor sport. Two others will be dismantled and reconstructed in another location in the United Kingdom.
Figure 14. Connectivity diagram
3.2 New Concept for Olympic Stadium

How to create higher level of transformability in stadium design, considering the notion of physical as well as design flexibility?

1. Breaking the massive volume of the stadium in multiple segments
2. Using modular structure that assures transformability in level of sub-assembly and grand assembly.
3. Using mobility to create different arrangements of the stadium pitch.

Figure 15.
New Concept for Olympic Stadium
Figure 16.
Applying the grid
3.3 The Process

Figure 1.
Extracted Geometry

Figure 17.
Form finding
Figure 18.
Athletic arrangement
Figure 19.

Soccer arrangement
Figure 20.
Applying the grid
Figure 21.
Extraction Geometry
Figure 22.
Olympic stadium with 80,000 seats
Figure 23.

Explorations - Construction
Figure 24.
Explorations - Construction
Figure 25.

Explorations - Construction - Assembly
This research resulted with some principal ideas of how we as architect can start breaking the stereotype of a stadium and create new topology of multi-functional-multi-transformable stadium. The research did not aimed to give solutions, but to give a first step in a future discussions on the topic of transformable stadiums.


