Extended Abstract

Sustainable Use of Post-Olympics Buildings

Four Case Studies in Beijing

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Architecture

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ABSTRACT
Sustainable architecture is a comprehensive and cross-discipline area, which comprise from architectural design to material selection, as well as its sustainable use along the construction’s time. Therefore, and reflecting the specific Chinese context, it was presented to the author the possibility to investigate the current use of Beijing 2008 Olympic Games’ buildings, after the event. With the purpose of identifying and tackling the main concerns regarding these spaces/constructions, it begins with collecting information from literature research of case studies. Consequently, it is gathered information of the current use by site visits and surveys, highlighting, subsequently, primary sustainable measure taken regarding design, material and technologies. As a consequence of fieldwork and interviews organised by the author, it was possible to obtain a general comprehension at the level of architectural decisions as well as the original intentions exposed by architects and progressive development within the post game’s alteration process. While together with developers, the aim was to get aware of not only concerns and respective countermeasures but also feedback from users that could illustrate the most authentic image of building's harnessing. Overall, always keeping an objective and critical sense was a key factor to analyse both positive and negative aspects of each Olympic building, ending up with a list of possible recommendations for improvements for future projects on the same subject. In short, the ultimate goal is to carry out a thorough study on a subject that is undoubtedly consistent and essential in today’s China, making use of case studies as a “breakthrough point”, from an architectural view, to understand the sustainable use in buildings of this great event in Beijing.

Keywords: Post-Olympic uses, Olympic buildings, Sustainable Architecture, 2008 Olympic Games; Beijing.

MOTIVATION AND OBJECTIVES
Today, China is one of the most rapid developing countries in this globalising world. On the one hand, its increasing construction significantly contributes to its development, and on the other hand, fast-growing brought less thinking in architecture and inappropriate utilisation of technologies. According to the fact that Olympic games just occurs shortly during 17 days, some venues' functions would inevitably be excessed, moreover, maintenance costs would expose the host city to a critical situation with enormous pressure. So that, the initial planning for Olympic venues is to make full use of existing sports facilities in the host city, trying to transform and to meet Olympic competitions requirements while minimising investment and reducing the pressure on the city’s development after the Olympics. In regards to this major international event which for the first time taking place in China, the city of Beijing constructed and remodelled up to 31 venues, in which 6 of them located in universities (ZHOU 2011). Intending to tackle and understand the primary concern of how to use those sports venues effectively after the event, making it produce social effect and economic benefit through logical operations. After the games, the buildings will enter an extended period of local service, so, how to manage these
different properties/buildings. Moreover, is that the current management correspond to its prior planning? What could be changed/improved?

Within the topic of Post-Olympics 2008, it was proposed four works as the "Case Studies", in which two of them are essential - as brand images of the Olympic Games 2008: "Bird's Nest" and "Water Cube". Since the other two were also built for host the performance of Olympic competitions, less prominent but equally significant due to its character by taken place in the universities of the city.

Last decades, it was published various experiences in the field of sustainable architecture, hopefully, this research would contribute to the necessary review / more general analysis regarding the architecture of Olympics, starting from the design process to the technology implemented, and comparison of effectiveness in its utilisation between selected case studies. In this way, favouring future projects in this same area.

RESEARCH METHODOLOGY

The research methodology comprises in two parts, firstly, understand the reason of previous design for the space during the post-Olympics period; secondly, draws out from the real image of its uses after the great event, together with encountered issues and difficulties. This research is based on the analysis of a significant amount of data from reference research, as well as referenced to the theory of sociology, urban planning and others disciplines. All the studies are objective and scientific, combining theoretical investigation, site visits, and consequent surveys with architects, developers, managers and users. All in all, the research methodology can be expressed in the following points:

1. Literature Research Method: Information collected from publications related to the topic;
2. Site visit and survey: First-hand data regarding the constructions and interview with the responsible architect, developer/manager and users;
3. Interdisciplinary Studies: Exploration of the harmony between the different disciplines that contribute to the buildings’ sustainable use (urban planning, management, sociology and so on);
4. Comparison Method: Vertical and horizontal comparative analysis – comparison between space uses of a Olympic building (before and post-games), and, comparing between case studies with similar characteristics.

STRUCTURE OF THE RESEARCH

The present dissertation is focusing on Beijing Olympics’ four building: the University of Science and Technology Beijing (USTB) Gymnasium, the China Agricultural University (CAU) Gymnasium, the National Aquatics Centre (Water Cube) and the National Stadium (Bird’s Nest). Those mentioned above are studied under the explained research method and the product is presented in six chapters:

1. Introduction - Background, Motivation, Scope and Objectives, Research Methodology and the Structure of this document. Explanation about the field of research and its framework;
2. Context – Context of the city of Beijing and main concerns of hosting the Olympic Games;
3. Case Studies – Information Collected. Data collected from fieldwork and systematic analysis;

4. Data Analysis – Horizontal comparison between case studies and identification of primary issues;

5. Design Recommendations – Recommendations for future projects on sustainability in architecture for Olympics;

6. Conclusion – Possible investigations that could contribute to sustainable architecture for Olympics.

**CONTEXT**

Throughout this chapter, it offers a general understanding of the city of Beijing and major preoccupations in order to host the XXIX Olympic games. Moreover, a brief review of past Olympics, relying on both negative and positive past experiences, attaining an objective and analytical perspective for the present investigation. This chapter is divided into three parts:

- Beijing: Geography; Climate, Resources and Environment and Air Quality;

- OG 2008: Summary of the main measures of being the host city, concerning of decisions taken regarding urban planning and venues, also, explanation of the Green Olympic concept, of how it was established and how it was implemented;

- A brief review of others Olympic Games: A quick review on the previous experience and results.

Taking advantage from the first part of this chapter, it was able to gain a general perception of Beijing. Moreover, it was also exposed policy study regarding measure taken in order to offer a appropriate air quality during the Olympic Games.

Since 1990s, in Beijing, the urban construction area has increased year by year, and the urban traffic has also increased rapidly- especially in the number of cars. By the end of 2009, Vehicle ownership has increased to about 400 million, motor vehicle exhaust gas emissions have become a source of PM2.5 (Institute of Urban Meteorology of Beijing 2007).

Table 1. PM2.5 concentration statistics of July-September (2006 to 2008), Beijing [Source: Author, adapted form BIMCMA]

<table>
<thead>
<tr>
<th>Rate of Concentration (µg/m3)</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Urban</td>
<td>Suburban</td>
<td>Urban</td>
</tr>
<tr>
<td>July</td>
<td>74.5</td>
<td>55.6</td>
<td>97.8</td>
</tr>
<tr>
<td>August</td>
<td>76.7</td>
<td>53.2</td>
<td>63</td>
</tr>
<tr>
<td>September</td>
<td>73.2</td>
<td>47</td>
<td>73.4</td>
</tr>
<tr>
<td>Aug. 8 - 24</td>
<td>78.9</td>
<td>54.5</td>
<td>65</td>
</tr>
</tbody>
</table>

Intending to tackle this issue, the Beijing Municipal Government, from 1999 to early 2008, promoted continuously the implementation of four stages (refer to table 1) of air pollution control measures before the Olympics, throughout a strict pollution control measures taken. Consequently, with the implementation of emission reduction measures, significantly reduced the concentration of particulate matter and effectively improving the urban air quality. So far, several measures are yet law in force in the city of Beijing, for instance, the limitation law for motor vehicles, differentiating by odd and even number of their plate number and, most companies have been changing their fundamental energy to less polluted resources, this is, the reduction in the use of coal.
CASE STUDIES – INFORMATION COLLECTED

In this chapter, all information obtained from case studies will be exposed organisationally. The fieldwork and interviews have been run during June 8 to July 19 of the present year, started from the USTB Gymnasium to the Bird’s Nest. Along this process, undoubtedly the result attained is product of collaboration from several parts, and, eventually, information obtained could be summarised in the following form:

- **UTSB GYMNASIUM:**
  One of the highlights in design is the optical lighting system on the roof, which could mostly meet up the pavilion’s indoor illumination requirement. While for the post-games revamp plan, the UTSB gymnasium had successfully constructed its swimming hall on its previous design. Regarding post games operation, it was established a management team, efficiently operating services that the building could offer, eventually, providing a great environment to all venue’s users;

- **CAU GYMNASIUM:**
  Emphasising points in this building reveal in the natural illumination and ventilation, relying on over 400 gaps (some windows) created by designed staggered roof. Regarding post-games alteration, it was not carried out the initial planning (construction of swimming pool), due to financial difficulties. Moreover, the sunken design of this pavilion caused sometimes rainwater flood and poured into the building, together with the problem of non-defined function in parts of the building after games period, representing the most critical situation of this case study. Also, some drawbacks revealed in users feedback, up to 30% of interviewees feel dissatisfied with the space design, the reason behind was raised up by the issue of constructed spaces being unused;

- **THE NATIONAL AQUATICS CENTRE:**
  Surely, the Water Cube differentiates itself with unique façade skin, which possesses excellent behaviour regarding thermal insulation, ventilation and natural lighting. However, according to the manager, indoor acoustic environment demonstrated a lack of quality; consequently, several measures had been taken. Concerning post-games conversion plan, it has successfully implemented (removal of temporary seats and construction of the south and north building), and, all spaces designed are having designated uses, from where revenue comes and ensuring the water cube’s daily operation. According to the general manager, most of the issues were tackled by appropriate measures, and, highlighted the flexibility in main spaces, which undoubtedly ensured the success of post-games operation more sustainable;

- **THE NATIONAL STADIUM:**
  The remarkable structure of the Bird’s Nest assured its representative characteristic among others Olympic’s buildings. Additionally, through its double (ETFE and PTFE) membrane structure and Rainwater recycling system could generate the building more sustainable. Regarding its post-games’ uses, removal process of temporary seats and construction of new functional areas were effectively completed. However, previous conversion plans such as
hotel and commercial centre did not carry out due to bureaucratic process and security concerns. Furthermore, besides the largest contribution to the stadium’s revenue – tourism, others activities have been increasingly affording to the construction’s daily operation, likewise new development plans in establishing glass vending box in the guest’s entrance area (first floor), promoting the space with new businesses and more dynamic environment;

All in all, throughout information obtained from these four case studies, an authentic image was drawn up, relying on literature research, interviews and site visits could attain a thorough understanding of current situations of these case studies, moreover, by information collected from different people, diverse but precise perceptions could provide the author with an objective perspective and trustworthy interpretation regarding the above four post-Olympics buildings.

**DATA ANALYSIS**

In this chapter, information collected will be analysed dedicatedly. Being stated, despite vertical analysis (investigation and comparison) between the previous planning and current situation of each case study, also, comparing horizontally case studies with similar characteristics. This is, UTSB gymnasium and CAU gymnasium, Water Cube and Bird’s Nest, according to their localisation, dimension and others leading features. Therefore, with the objective of identifying main strengths and possible drawbacks, eventually, favouring future project for the Olympics by giving design recommendations.

**UTSB GYMNASIUM VS. CAU GYMNASIUM**

The UTSB gymnasium and the CAU gymnasium situated both in the university area, sharing similar geographical context and users in the post-Olympic period. Therefore, it is worth comparing one to each other, in term of original information of the building to the post-game uses, as well as management and users feedback.

Through the data in table 2, it is clear that both of these venues possess similar features construction area and a number of seats for spectators. However, while UTSB gymnasium had successfully implemented post-games revamp plans, the CAU gymnasium was not able to afford construction of its
previous planning, specifically, the swimming pool. During the site visits, the author obtained information such as number facts of how many users were hosted by the UTSB gymnasium, this undoubtedly shows that the venue has a comprehensive management team and efficient managing system. In contrast, it was not given from the CAU gymnasium, relying on the fact of no rigorous daily registration.

On the green measures, both of these had attained to the object of sustainable uses during the post-games period. Moreover, according to research and site visit, it could be concluded that in both gymnasiums, badminton is the most popular sport, once the main competition halls were all converted to ensure badminton practise and training. By questionnaire carried out by the author at China Agricultural University (CAU), part of the users were not satisfied with no construction of the swimming pool and space designed.

| Table 3. Comparison between UTSB and CAU Gymnasiums 2 [Source: Author] |
|-------------------------------|-------------------------------|
| **Operation Mode**            | **UTSB Gymnasium**            | **CAU Gymnasium**            |
| Large scale events           | Yes                           | Yes                           |
| Rent to outside (long duration) | Yes                           | No                            |
| Construction Issue           | Occasional Leakage; Material degradation | Rainwater flood due to suken design; Cold wave flows into the building during winter |
| Cost/Revenue (year)          | Balanced with profit          | Balanced                      |
| Main Revenue Factor          | Badminton; Swimming           | Badminton                     |
| Initial Investment (euros)   | 26.7M                         | 21.4M                         |

Regarding post-games operation, according to the particular situation of these two venues of taking place in universities, the Beijing Olympic Organising Committee delivered the operation right of these two venues to host universities (Hou et al. 2012). Subsequently, universities attributed respective management team dedicated to the building’s daily operation, being an independent entity of the University. Intending enhance its income, the UTSB management team decided to rent some empty rooms to outside companies, whiles this policy was not implemented. On construction quality, several issues were exposed in the CAU gymnasium – flood into the construction and coldness during winter, evoking dissatisfaction from the current operation team. In contrast, in the UTSB gymnasium, occasional leakage and material degradation revealed relatively lesser disagreement between the design and reality.

Relying on revenue of providing badminton and swimming sports service at USTB, annually, the income surpasses its operation cost, while with only badminton as primary revenue factor, CAU gymnasium could merely afford its operation costs. As the current manager of the CAU gymnasium affirmed, the construction was the lowest investment among others university venues, with only 150 million yuan (approximately 21.4M euros), almost 25% less than the same of UTSB gymnasium.
To sum up, regarding the implementation of previous architectural design for post-Olympics, UTSB gymnasium had ultimately achieved the original objective, additionally, with a reasonable operation of the current management team, raising the revenue and popularity of the venue. For the case of CAU gymnasium, due to lack of funds and economic support, the original revamp plan was not carried out, and careless management team, consequently, affecting its post-games operation and own revenues.

**WATER CUBE VS. BIRD’S NEST**

Similar to the above two case studies, the National Aquatics Centre and the National Stadium also share several common points. Being located in the Olympic Park and “face to face”, these two building, regarding architecture, have been considered complementary to each other.

<p>| Table 4. Comparison between the Water Cube and the Bird’s Nest 1 [Source: Author] |</p>
<table>
<thead>
<tr>
<th>Water Cube</th>
<th>Bird's Nest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area (m²)</td>
<td>79,533</td>
</tr>
<tr>
<td>Nr. Seats</td>
<td>17,000 (During game); 6,000 (Post-games)</td>
</tr>
<tr>
<td>Post-games Alteration Plan</td>
<td>Well executed</td>
</tr>
<tr>
<td>Type of Venue</td>
<td>Indoor</td>
</tr>
<tr>
<td>Highlights Green Measure</td>
<td>Natural lighting; Thermal Insulation</td>
</tr>
<tr>
<td>Most Frequent Space</td>
<td>Main Swimming Hall; Warm-up Pool; Leisure Park</td>
</tr>
<tr>
<td>Function during Olympics</td>
<td>Swimming &amp; Diving</td>
</tr>
<tr>
<td>Users feedback</td>
<td>N/D</td>
</tr>
</tbody>
</table>

Relying on data from the above table, the Bird’s Nest is almost three times larger than the Water Cube regarding seats for spectators. As the main stadium to host the opening and closing ceremonies, the Bird’s Nest had up to 91,000 seats during games while the Water Cube possessed 17,000. Consequently, an equal number of seats were demolished in both venues. Regarding post-games alterations plan, the Water Cube undertook the entire previous design while in the Bird’s nest, the two principal plans – hotel and commercial centre were denied due to security policies for this iconic construction. Currently, the national stadium has been developing its tourism services, which corresponded its original objective of being a social space (Zheng 2014).

Regarding green measures applied in these buildings, the Water Cube highlighted with the entire ETFE foil coating, providing excellent natural lighting and thermal insulation. While in the Bird’s Nest, it was also implemented a double membrane system (PTFE&ETFE), together with the character of being outdoor stadium, ventilation, illumination and acoustic were secured. Moreover, the rainwater recycling system in the stadium significantly contributed to its sustainable use and energy saving. After the Olympics and respective alteration plans, the three most important spaces of the water cube have constantly been using, hosting events, leisure and sports purpose. Likewise, for the national stadium, the main field have been receiving large-scale events and, the most applicable function is for tourism, contributing greatly to its revenue.
According to the following table, and with respect to the particular situation of these two buildings of their iconic meaning and massive initial investment (the bird’s nest cost up to three times more than the water cube), for the National Stadium, cooperation between the Beijing government and CITIC group corporation (a state-owned company) assured the fund for its construction. Consequently, a current operation team could be understood as a public entity (Wang & Liang 2012). In water cube, up to 90% of the initial fund was raised from overseas Chinese, as a result, current managers are associated to public entities. After conversion plans have been accomplished, the north and south buildings (two post-additional construction on the site of the prior temporary seat) are mainly rented to particular contractors, while in the Bird’s Nest, only one restaurant is managed by a private company.

Table 5. Comparison between the Water Cube and the Bird’s Nest 2  [Source: Author]

<table>
<thead>
<tr>
<th></th>
<th>Water Cube</th>
<th>Bird’s Nest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation Mode</td>
<td>Management Team</td>
<td>Management Team</td>
</tr>
<tr>
<td>(Public Entity)</td>
<td></td>
<td>(Public Entity)</td>
</tr>
<tr>
<td>Large scale events</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Rent to outside (long duration)</td>
<td>Yes</td>
<td>Partly (i.e.restaurant)</td>
</tr>
<tr>
<td>Construction Issue</td>
<td>Ventilation;</td>
<td>N/D</td>
</tr>
<tr>
<td>Acoustic environment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost/Revenue</td>
<td>Balanced with profit</td>
<td>Balanced</td>
</tr>
<tr>
<td>Main Revenue Factor</td>
<td>Hosting events; swimming pool</td>
<td>Tourism</td>
</tr>
<tr>
<td></td>
<td>146 M</td>
<td>471 M</td>
</tr>
</tbody>
</table>

On construction quality, in the Water Cube, indoor ventilation and acoustic insulation are not corresponding the previous design. However, contra measure has been developing and implemented, aiming to offer a great environment to users and eventually attract more clients and visitors. Therefore, by hosting events and rents spaces (commercial and leisure park), the national aquatics centre has successfully afforded all own expenses regarding operation and also, getting profits from these services’ revenue. And, tourism leads to the national stadium’s total income, in contrast with its neighbour, a sort of monotonous business format was not able to take the stadium’s revenue so long.

On the one hand, the Water Cube had completed previous architectural design for post-Olympics, moreover, with comprehensive operation and activities provided, allowing attain the objective of being profited and explore at most the venue’s potential. On the other hand, as a result of the monotonous business format in the National Stadium and several plans was not carried out, gradually, influencing its post-games operation and respective revenues.

DESIGN RECOMMENDATIONS

Relying on information collected during the site visit and interviews, together with analysis carried out by the author, some of the operation issue or disagreement between previous design and current situation were exposed. Considering all these problems identified, and, therefore, proposing some possible measures as design recommendation for future projects which share the similar backgrounds
as the four case studies. Recommendations are divided into two parts, bringing together buildings with identical features, specifically, University’s Olympic Buildings and Olympic Park Buildings.

**FOR UNIVERSITIES’ OLYMPIC BUILDING**

- On the design part, architects should be acutely aware of climate situation of the location/city/province, despite the fact that great building behaviours (thermal, ventilation, illumination) in an individual season, likewise, in the rest of the year, it is also important to provide similar behaviours. Most of the time, regionalism could limit the view of an architect, focusing in the most concerned design part while paying less attention to the area’s particular climate and extreme situations (e.g. torrential rain);

- Considering the material applied in each space that will be requested for post games alteration, with different functions could the requirement vary, preventing material degradation due to huge difference between before and after (e.g. conversion of seating are to basketball court in UTSB gymnasium);

- Utilisation of natural lighting devices (on roof) could be improved by considering in its post-Olympics behaviour, this is, at the early stage of design, simulating post-game uses of these devices, once these devices are permanent and hard to alternate its positions and projection area;

- The most relevant is to respect the previous design for post-games, to be stated, each space design has its own characteristic and requirement for hosting different activities;

- To avoid situations of no implementation of post-games conversion plan (e.g. CAU gymnasium), it is indispensable studying the financial viability of each particular case, and design project should be appropriate to the real situation of constructions, preventing “considerate projects” but no suitable to the site;

- The quality of operation could be improved through management team, and this was clearly revealed within the comparison of these two case studies. A comprehensive management team and being flexible to current demands could surely bring more activities to the building, eventually, raising in its income and being self-balanced;

- By taking place in universities, the primary function of gymnasiums is to serve students and school staffs. Therefore, revenues could only come from outsiders. Despite temporary space renting for practising sports, rooms with no defined function could always be rented, relying on its localisation and university environment, companies with profile research or I&D are suitable to university constructions;

- Providing an extensive variety of sport or courses could also contribute to reinforcing the gymnasium’s profile, this typically requires investments in purchasing sports materials or recruiting trainers. However, through thorough viability investigation carried out by management team (as UTSB did), could precisely identify appropriate demands that the venue could offer or add with minimum investment (e.g. besides the existing Ping-Pong hall, extra Ping-Pong tables were added in the tennis court area, according to increasing demand for this sport at UTSB).

**FOR OLYMPIC PARK BUILDINGS:**

- With the utilisation of innovative materials and technics in a construction of the principal public buildings, it is relevant being aware of its behaviour of its daily functionality (Sha 2011). As the case of Water Cube, the Department of Building Energy Efficiency of School of Architecture of Tsinghua
University was assigned to provide constant follow-up regarding the ETFE foil structure’s functional behaviour, as well as tackling possible difficulties encountered during its functions;

- Regarding architectural design for the post-game period, it is recommended to design the space with maximal flexibility. Due to the unique status of being large public buildings with a particular context and meaning, policies or management team changes could influence its post-games alteration plan (e.g. the National Stadium). Therefore, alterable spaces could provide more development opportunities;

- According to the requirement of hosting Olympic Games, each building should provide a significant number of functional spaces. Consequently, these areas are likely to lose their uses after games. Therefore, for post-games operation of large-scale construction, one of the prospect development direction is to host large activities/events, taking advantage of existent spaces;

- As reinforcement to the post-Olympics management team for large Olympics buildings (public entity), it could be established partnerships with private companies, this is, renting part of the building and contract for exploration. As the case study reveals, part (Leisure Park) of the Water Cube contracted to a private entity, with which a significant part of revenue for the venue’s operation comes;

- Aiming to improve post-games utilisation, large scale Olympics venues should focus on diversifying their services provided. Reviewing most of past Olympic games, the main stadium was majorly converted to sport, cultural and public centre (Fu 2007). So that, the water cube has been adapting demands by varying the function of spaces, thus obtaining high income, while a monotonous business format in the Bird’s Nest should be improved by exploring others areas of business;

- Under public entities controls, most of decisions or measures were taken by the management team could be time-consuming due to a complex structure and bureaucracy in government entities. As we are aware of, part of collaboration opportunities relies on exact timing, so that bureaucratic process could be a “counterforce” to the development. Thus, a simplified management system could facilitate its short-long term development and, giving more uses to the venue;

- In general, for large public buildings, legal policies could significantly contribute for its sustainable post-games utilisation. For instance, tax reduction in some services offered (e.g. visit ticket, energy consumption, etc.). On the one hand, by providing cheaper access ticket could bring more visitors; on the other hand, through a reasonable reduction in energy tax, the venue could invest more in other areas such as implementation of alteration projects. Eventually, captivating more clients and raising the venue’s revenue (e.g. large-scale events, commercial services).
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