

# The Development of Green Architecture Based on the Study of EXPO Architecture

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## Abstract:

World Expo architecture represents the most advanced architectural development direction of the era. This paper analyzes the development of green buildings in World Expo based on the representative cases of green buildings in Milan Expo, and tries to analyze the development trend of green buildings combined with green buildings in the same period.

## Keywords:

World Expo, Green Building, Development

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## 1. Unique Representation of Expo Buildings

The World Expo is a grand occasion for countries from all over the world to display their best culture and the most advanced science and technology. For designers, the World Expo is a stage to show the spiritual outlook of the country and personal talents. Here, architecture is the carrier, carrying the culture and personality of the country. Architectural works also express the design concept of architects. The Crystal Palace, the main building of the first World Expo held in London in 1851, represents the bold attempt of architects to combine new materials such as glass and steel with new architectural structures after the Industrial Revolution. The Eiffel Tower, which commemorates the 100th anniversary of the French revolution at the Paris World Expo in 1900, represents the architect's perfect attempt to combine technology and art. The German pavilion of the 1929 World Expo Barcelona breaks through the existing architectural form and presents a new architectural space. At the Japan Pavilion at the 1992 World Expo in Seville, architects used modern technology to express traditional architectural culture. The Seed Cathedral of the UK Pavilion at the 2010 world expo in Shanghai reflects contemporary designers' exploration of future architectural forms. The architecture of the Expo represents the latest and cutting-edge architectural styles and technological development level of the same period. These works bearing the most advanced architectural technologies of the time and become the most directional architectural development direction, which has a profound impact on the future of architectural design. The Milan Expo also presents the cultural and economic strength of participating countries in the latest technology and style. The self-cleaning materials on the exterior walls of the Italian Pavilion, the interactive design of the

German Pavilion, the thermal insulation materials of the UAE Pavilion, the open construction system of the China Pavilion and the low-tech green structure of the French Pavilion all has a typical representative on green building and sustainable development.

Focusing on the conservation and utilization of resources, emphasizing the relationship between human and nature, and exploring eco-city issues, the ecological theme of the Expo has been constantly expanded and deepened, and the ecological characteristics of the Expo buildings have also been strengthened. From the wooden roof of the landmark building in Hannover, Germany in 2000, to the solar long-term handicap venue of the Japan Aichi Expo Japan Pavilion in 2005, and to the exhibition of low-carbon materials and energy-saving technologies including the China Pavilion at the 2010 Shanghai World Expo, all show that the ecological concepts and related technologies have been, and will still be the focus of the Expo building in the future a certain period of time.

## 2. Green Building at the Milan Expo

### 2.1. Italian Pavilion

As the host country of Milan Expo in 2015, Italy pavilion (Figure 1) has the largest architectural volume of the Expo, and its shape is derived from the natural architecture of the Italian artist Giulia Maori. The design theme of the Italian Pavilion is “deep forest in the city”. The elevated pillars on the ground floor, combined with the abstract facade of growing branches, wrap the pavilion. The white building is like a huge plant rooted in the city. The Italian pavilion used parametric design in the construction process, and the custom-made skin system achieved a continuous façade pattern effect. In terms of sustainability, the Italian Pavilion's active technologies for energy efficiency include: photovoltaic panel glass is installed on the roof to improve the energy efficiency of the building; passive technologies include: natural ventilation on the ground floor is installed to optimize the indoor thermal environment of the building. The Italian Pavilion is innovative in the choice of materials. The photocatalytic concrete on the facade can neutralize organic and inorganic pollutants in the air, which makes the building have the function of directly optimizing the external environment of the building.



**Figure 1.** Facade of Milano pavilion 2015.



**Figure 2.** Facade of The United Arab Emirates pavilion 2015.

### 2.2. UAE Pavilion

The UAE attaches great importance to sustainable design and is LEED platinum certified national pavilion building. The UAE Pavilion (Figure 2) is designed with the

theme of “Food for the Spirit”. The building is shaped with a wavy interior defining a long and narrow walkway, which combines the sandy landscape with the oasis image at the end to present the desert landscape. The UAE Pavilion effectively controls building energy efficiency and emission reduction by following active and passive technologies under sustainable principles, such as rainwater recycling and photovoltaic panels. As the host of expo 2020, the UAE Pavilion showcases the technology of how buildings adapt to different climatic conditions. In order to return the venue to the country after the end of the Milan Expo, the architect needs to solve the energy efficiency problem of the building in two extreme climates. The UAE has a tropical desert climate that is hot and dry all year round. The building is exposed to sunlight for a long time and needs good thermal insulation properties, while Italy has a Mediterranean climate. The architects chose a new material, GRC - glass fiber reinforced concrete, with a steel frame structure suspended from the exterior wall of the building. Glass fiber reinforced concrete has high blocking, high elongation and bending strength. On the one hand, it plays an insulating role in the internal space of the building; on the other hand, it is easy to install and disassemble. At the 2010 Shanghai World Expo, the French pavilion (Figure 3) also used glass fiber concrete. The façade of the French pavilion is interspersed with the line to create a high degree of elongation due to the high elongation of the glass fiber concrete. In addition, the French Pavilion also adopts vertical greening in the atrium of the building, which not only optimizes the air quality of the atrium, but also provides energy-saving skin for the building.



**Figure 3.** *Facade of French pavilion 2010.*



**Figure 4.** *Facade of China pavilion 2015.*

*Figure 3 source: <http://www.nipic.com/index.html>*

### **2.3. Introduction to China Pavilion**

The theme of the China Pavilion (Figure 4) is “The Field of Hope, the Source of Life”. The overall design is a traditional beam-type wooden frame, and an innovative open construction system is adopted: The structural system with plywood as the main material and the supporting system which penetrates the waterproof layer and connects the shading bamboo board on the structural beam. The wavy roof also adopts the parameterized customized skin, through the traditional Chinese material bamboo board, combined with the flexible shape to express the cultural flavor of Chinese characteristics. The shading bamboo board system of the roof has the effect of energy-saving lighting, which not only improves the indoor lighting efficiency, but also increases the air circulation speed inside the building to reduce energy waste. The China Pavilion also adheres to the concept of sustainable design in the selection of indoor materials: from the OSB finish on the wall, the metal punching plate on the top

surface, to the polished concrete and resin paint on the floor, all of which embody the concept of sustainable design.

#### 2.4. Wood Application

More than 90% of the wood structure buildings in this Expo have adopted a wood frame structure system, indicating that it has strong vitality and broad application prospects. (Figure 5)

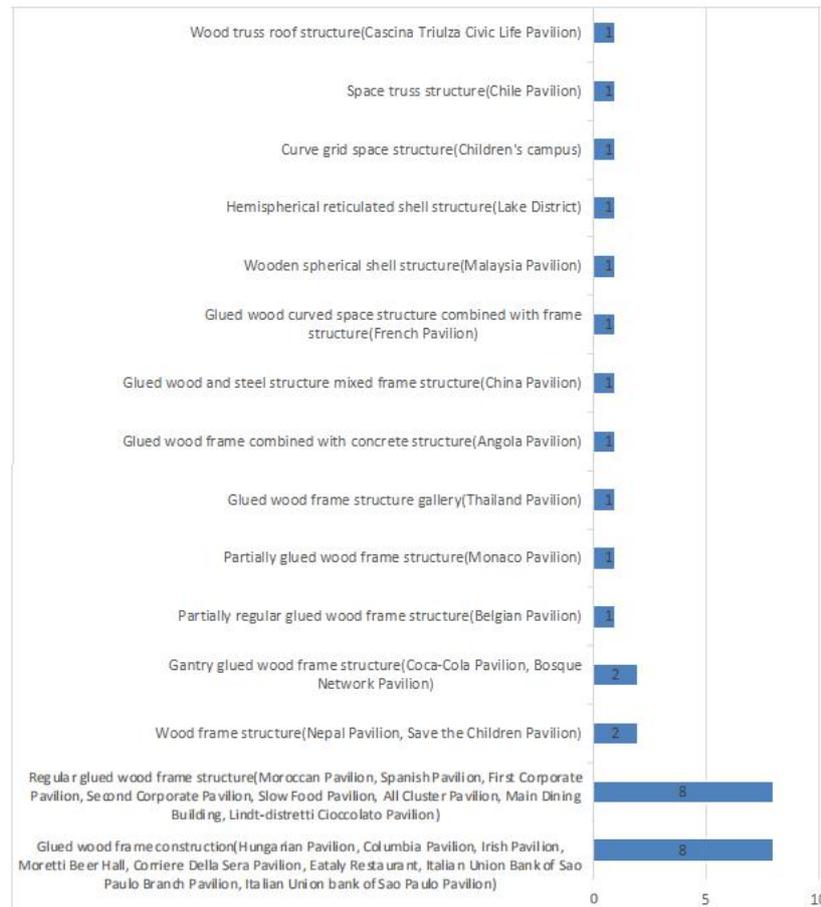


Figure 5. Wood application on Milan EXPO.

#### 2.5. Site Selection of the World Expo and the Development of the Post-Expo Site

Under the sustainable design evaluation system, green building not only refers to the structural materials of the construction process itself, but also refers to the energy consumption and management cost of the building from the site selection to the use period of the building. More importantly, it refers to the redevelopment of the base after the demolition of the building and the harmonious coexistence of the regional environment. With the continuous expansion of the scale of the Expo, the land resources occupied by the Expo are also surging, and the subsequent use of the pavilions by the host cities is not the same. Taking the Shanghai World Expo as an example, the core green park Houtan Park of the World Expo is located on the Huangpu River in the core area of the Expo site. The Houtan Park was completed in 2009 and will be retained after the Expo. With the design concept of “the Return of Huangpu River Beach”, Houtan park allows nature to do its work, so as to restore the natural vegetation of the base and retain the special culture of the base. Reserved venues for the Shanghai World Expo: The China Pavilion, the Expo Center, the

Performing Arts Center, and the Expo Theme Pavilion will be used for follow-up after the closing of the Expo, becoming a new landmark for Shanghai conferences, exhibitions, and cultural entertainment. The later development of Puxi of the expo park includes two functional areas. One is the cultural exposition area relying on the original Puxi enterprise pavilion area. The second is the urban best practice area retained as a whole. After the closing of the Milan Expo, the Italian Pavilion became a reserved building. The temporary pavilions on the north-south axis were all demolished, and the planning and use of the post-Expo venue was not clear. The government intended to transform it into a scientific information center and university.

### **3. The Development of Green Architecture**

#### ***3.1. Development of the World Green Architecture Evaluation System***

In 1990, the British government issued the first environmental assessment system BREEAM -- Building Research Establishment Environmental Assessment Method. In 2006, the British government proposed a more comprehensive “Sustainable Housing Standard” than the system. Mandatory assessment of all new residential buildings was implemented from 1 May 2008. Germany’s green building assessment system DGNB - “German Building Sustainable Quality” requires that green buildings should meet the requirements of resource protection, sustainability and climate protection. In 2003, American green building association proposed LEEDTM - “green building assessment system”, which is used to evaluate green buildings, including sustainable site selection, energy and atmosphere, indoor air quality, water resource efficiency, materials and recycling, concept education and innovative design. Sustainable architecture has also developed rapidly in China. In 2006, the government has issued the “Green Building Evaluation Standards” for reporting green building evaluation and star rating. The “Green Building Evaluation Standard” (GB/T50378-2014), which was officially launched in 2015, has added construction and operation management, reflecting China’s emphasis on sustainability in the life cycle of buildings and also reflecting the continuous improvement of the green building evaluation system on a global scale.

#### ***3.2. The Development Trend of Green Architecture***

With the continuous improvement and refinement of green architecture evaluation system, the development of green architecture also shows the trend of comprehensive and scientific development. Green architecture design has gradually changed from the isolated pursuit of architectural space, structure and material. Starting from the site selection of buildings, controlling the disorderly spread and development, sustainable development: renovating and redeveloping the developed land. The use efficiency of water resources on the base and in the building, while the building pursues energy efficiency, it makes full and reasonable use of active technology and passive technology. The innovation and breakthrough of building materials will also bring about the upgrading of indoor and outdoor environmental quality of buildings. When the whole life cycle of buildings ends, the secondary development will start again. Since the beginning of the design and planning of buildings, the task of green design has also started, which is the comprehensive development trend of green buildings. On the other hand, the improvement of building technology depends on the development of science and technology. The development of green building brings

new materials, the application of renewable energy, and the development of green building will be fuller of science and technology.

#### 4. Conclusions

It has been 165 years since the first World Expo. In all the recorded World Expo buildings, we have witnessed the rapid progress and evolution of the materials, technology and style of the building. With the more and more common display of green buildings at the World Expo, more architects are practicing green building design. With the continuous improvement of green building evaluation standards and the continuous leap of building science and technology, the development direction of green building design will become a conventional building code. Finally, green building saves us from the shortage of natural resources, and green building becomes the best tool to adjust the contradiction between human and land.

#### Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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