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# A STUDY OF SHIGERU BAN'S ENVIRONMENTALLY SENSITIVE ARCHITECTURAL DESIGN APPROACH

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**Abstract**

Shigeru Ban is a Japanese architect who brought a new approach to contemporary modern architectural design with his material selection and techniques. Ban creates his designs with easily obtainable and affordable materials, and is appreciated for his ideology and his humanitarian aid projects. This research analyzes Ban's environmentally sensitive design approach and the natural materials used in the Japanese Pavilion in Germany, the Papertainer Museum in South Korea, the Centre Pompidou Metz in France and the Cardboard Cathedral in New Zealand. The paper tube technology that Ban developed and implemented is analyzed as a construction material and sustainable design. It also evaluates Ban's contribution to sustainable design.

## 1. INTRODUCTION

In a general sense, the environment, defined as organisms' living setting, is described as containing everything–alive or dead–related to ecology [1]. Green design, ecological design or environmentally sensitive design is an approach that advocates healthy environments in order to sustain healthy life forms. Yeang (2012) describes this design approach: "in accordance with ecological design principles and strategies, designing our built environment and lifestyles to integrate all life forms on earth in a coherent and faultless manner with the natural environment in which the biosphere is located" [2]. It is intended to make design compatible with the environment and nature as a whole. Green, ecological or environmentally sensitive design approaches require sustainability. In order to understand sustainable design, the concept of sustainability needs to be analyzed properly. According to the World Commission on Environment and Development (WCED), sustainability is: "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" [3]. Avcı (2016) defines sustainable architecture as a construction approach oriented by both humans and nature [4]. Green architecture, green design and sustainable design are intended to reduce harmful effects on human health and the environment [5]. Progress in contemporary green design has continuously increased the significance of sustainability [6].

As a prerequisite for sustainability, selecting materials from natural and local resources is one of the most important priorities for architecture. Ayaz (2002) describes the material selection process as producing and obtaining raw materials, and producing, using and recycling the design. [7]. These steps are interrelated and complementary. In this respect, choice of materials is an unavoidable consequence of environmentally conscious sustainable design, not just a choice. When choosing materials that emphasize the concept of locality, natural materials are desirable. Thus, the design can be produced with minimal

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problems in raw material supply, production and transportation. During the design process, choosing natural materials, recycled materials, self-renewing materials and materials that generate minimal waste has become a fundamental criterion of environmentally friendly design (URL1). Easy procurement and access to materials minimizes the use of energy. The reusability of raw materials at the end of their lifetime for recycling in nature or easily recyclable waste increases designs' sensitivity to the environment.

Climate change and the permanent damage of natural disasters, which have been the result of the ignorance of environment, have now forced designers to do new research in environmentally sensitive design. One of today's architects, Shigeru Ban, has developed a structural system that uses natural and recycled materials. The paper tube, which he developed by compressing recycled paper, has become prominent. Ban was awarded for the Pritzker Architecture Award for his designs and has become a guide to many designers, reminding them that the landscape should not be ignored.

## 2. MATERIALS AND METHOD: SHIGERU BAN'S ENVIRONMENTALLY SENSITIVE ARCHITECTURAL DESIGN APPROACH

Ban pays attention to environmental factors in his designs from the smallest to the largest scales, including infrastructure, natural sources, local materials and climate. The principle objective of Ban's design approach is satisfying the needs of current and future generations. Instead of the high-tech designs that are indispensable to today's architectural sensibility, he adopted an easily accessible, economical and environmentally sensitive design concept. The paper tube structure system has made his innovative material and design approach prominent. He was able to develop his system by taking the use of paper as a guide in Japanese architecture.

According to Shigeru Ban, a design should be as cost-effective and easy-to-use as it is durable. This is why he combines nature with architecture. The most prominent features of traditional Japanese architecture are based on this combination. Ban creates sustainable designs that are harmonious with nature. He has stated to those who define his architecture as sustainable that people did not pay attention to nature thirty years ago; however, he has improved his architectural approach by paying attention to low cost, local and recyclable materials [8]. Ban has also done important humanitarian aid projects, creating temporary shelters after natural disasters in Turkey, West India, Sri Lanka, Haiti Philippines and Ecuador (URL2). Using paper tube technology, he designed his projects to be easily demountable and movable. Some of Ban's designs have also been transformed into permanent structures such as the refugee camp in Rwanda.

The next section examines some of Ban's environmentally sensitive sustainable designs: the Japanese Pavilion, the Papertainer Museum, the Centre Pompidou Metz and the Cardboard Cathedral projects.

### 2.1. The Japanese Pavilion: Hannover, Germany, 2000

**Figure 1.** The Japanese Pavilion at Expo 2000 (URL3)

The Japanese Pavilion in Hannover, Germany was Shigeru Ban's first design that used paper tubing in very long dimensions (Figure 1). For the environment-oriented expo, Ban was asked to create a design

that would exemplify Japanese culture. The pavilion's tunnel arch is approximately 73.8 m long, 25 m wide and 15.9 m high, with an area of 3,015 m2 (URL4). Ban collaborated with Frei Otto and Buro Hapold to develop the roof's grid shell system instead of the paper dome design he had previously used (Figure 2).

**Figure 2.** The Japanese Pavilion's grid shell system (URL3)

Paper tubes, 40 m in length with a radius of 12 m, and used in the tunnel arch and connected by laminated wood and polyester fabric tape (URL4) (Figure 3).

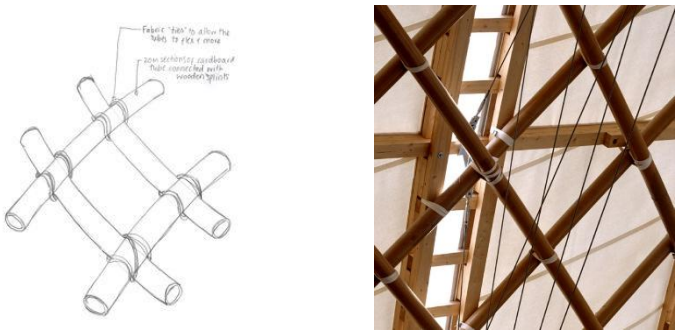

**Figure 3.** Laminated wood, paper tubes and polyester fabric tape (URL3)

In Ban's design approach for the Japanese Pavilion:

- At the base of the construction, reusable steel boxes filled with sand were used instead of concrete in an attempt to reduce construction waste.
- The pavilion is made up of floor texture and top covering. Ban disassembled the structure of his system without using vertical conveyor elements. The outer shell and top covering are easily removable and reusable.
- The use of the grid shell system developed by Ban, Otto and Hapold reduced costs by minimizing the use of wooden joints.
- The roof was made of a fire and water resistant, translucent membrane. Along with ecological materials, Ban used the traditional Japanese architectural understanding of shoji, or roof system, to benefit from natural light and save energy (Figure 4).

**Figure 4.** Shoji in traditional Japanese architecture and the Japanese Pavilion's grid shell system (URL5 and URL6)

- The structure's simplicity and freedom of vanity, simple spatial design and use of ecological materials that can easily be integrated with nature make pavilion exemplify its main theme, Japanese culture and tradition. Hard surface materials were used in the pedestrian areas around it. A different choice of outdoor flooring material and green spaces would better reflect its theme.
- The Japanese Pavilion is seen by many designers as a fundamental step in paper architecture's resolution of structural and fire resilience problems [9].

### 2.2. The Papertainer Museum: Seoul, South Korea, 2006

**Figure 5.** The Papertainer Museum (URL2)

The Papertainer Museum was built at the Seoul Olympic Park as a temporary exhibition hall to celebrate the thirtieth anniversary of the South Korean publishing company, Design House (Figure 5). Its area is 3,455 m2. It was built with paper tubes and shipping containers [10]. The structure has three main parts: two exhibition halls in the masses where the containers and paper columns are. In the middle, there is an open space that is its focal point. By arranging the shipping containers side by side and on top of one another, a straight line with a height of 10 m was obtained. The Paper Gallery section of the structure was built with a semicircular array of paper tubes. The columns were constructed from paper tubes with a diameter of 75 cm, and the roof was constructed from paper tubes with a diameter of 30 cm. Ban's design used 353 paper tubes and 166 containers (URL7) (Figure 6).

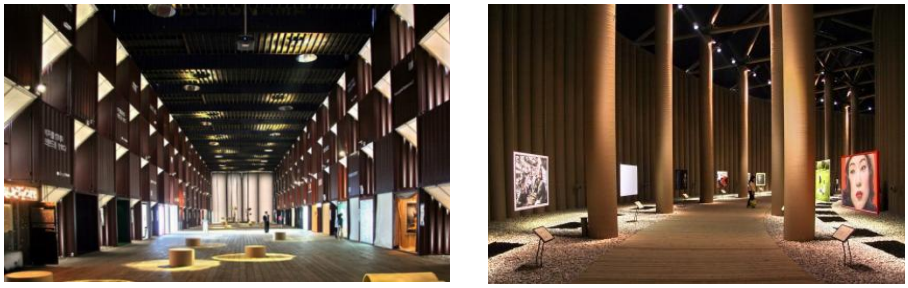

**Figure 6.** The Papertainer Museum's exhibition halls (URL8)

In Ban's design approach for the Papertainer Museum:

- The use of paper and metal, which are fully recyclable and easily available, contributed to Ban's ecological design.
- The conveyor system of paper tubes gives the structure lightness compared to the reinforced concrete conveyor system and the effect it has on people.
- The gathering of the paper tubes and the masses in which the containers are located created a "D" shape, a green open space that is actively used by visitors. Thus, Ban created unity by providing flow between interior and exterior space(Figure 7).

**Figure 7.** The Papertainer Museum's structural form and open space design (URL2/ URL8)

- Industrial textile products placed angularly in the upper part of the containers both makes the facade more vibrant and increases natural light (Figure 8).

**Figure 8.** Facade designs made of shipping containers, paper tubes and industrial textiles (URL8)

• Containers placed alternately with blank spaces are used not only for exhibitions, but also as houses, offices and storage rooms. Hosting many different functions within the container gives flexibility to the space.

• The choice of wood and pebbles for the floor, the use of paper tubes in the structure and the design of space with containers emphasize the significance of choosing ecological materials in Ban's design.

### 2.3. The Centre Pompidou Metz: Metz, France, 2010

**Figure 9.** The Centre Pompidou Metz (URL9)

The construction of the Centre Pompidou Metz began in 2007 in Metz, France and was completed in 2010 (Figure 9). The building is regarded as a milestone in Ban's career of architectural innovation. Its roof system, a hexagonal braided structure, is its most striking feature. The building's height of 77 m is formed by a curvilinear upper roof system supported by a metal tower and 4 conical supports [10]. Ban was influenced by the hexagonal form and details of a traditional Chinese hat he bought during his trip to Paris and designed the roof with a similar system (Figure 10).

**Figure 10.** Traditional Chinese hats and the Centre Pompidou Metz's roof system (URL10)

Ban placed hexagons at intervals of about 3 m. The roof's frame of overlaid laminated wood was covered with waterproof membrane made of fiberglass and teflon [10] (Figure 11).

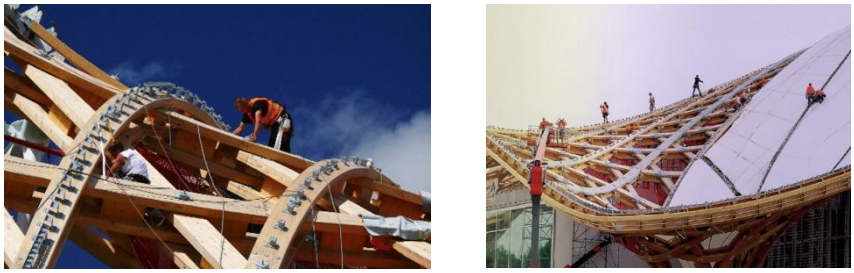

**Figure 11.** Wooden frame and roof system (URL11)

In Ban's design approach for the Centre Pompidou Metz:

- Flow is obtained by the structure's open plan and design, which prioritized the user factor.
- The simplicity in the details, allowing the load-bearing elements to be read by leaving them uncovered, the simple interior design and the small number of furnishing elements support Ban's minimalist and environmentally sensitive design approach.
- The hexagonal braid system used in the roof allows the structure to stand on its own with a shell design built on only a few supporting elements. The use of recyclable laminated wood made the roof durable and resistant. The fact that the roof is compatible with nature and the creation of an organic form contributed to its sustainable design approach.
- Ban's use of translucent membranes on the roof increased natural light.
- Ban's combination of light color wood, white walls, polished concrete floors and a high ceiling create a relaxing interior atmosphere.
- The large windows used in the construction increase the amount of natural light, thus saving energy, give a feeling of spaciousness and allow visitors to see Metz's historical urban fabric (Figure 12).

**Figure 12.** The unity of the materials used in the interior and large windows (URL9)

- Ban's curvilinear roof system, entirely integrated with the inviting main entrance and high ceilings, provides a natural flow between interior and exterior, a reflection of traditional Japanese architecture. Therefore, Ban also connects with the past in a modern structure.
- The continuity of the hexagonal braid wood system from the exterior to the interior also ensured that the roof was regarded as an interior design element. The roof design reduced material use and costs, thus supporting Ban's sustainable design approach. However, the wooden braid system, developed to reduce the number of supports, used wood with different sizes and angles. Not choosing standard material sizes can cause difficulties with assembly (Figure 13).

**Figure 13**. The Centre Pompidou Metz's main entrance and hexagonal wooden braiding in its interior (URL9)

## 2.4. The Cardboard Cathedral: Christchurch, New Zealand, 2013

**Figure 14.** The Cardboard Cathedral (URL12)

Ban designed a new cathedral for the city of Christchurch in New Zealand in 2013 after the 2011 earthquake destroyed its cathedral, the symbol of the city (Figure 14). The building was considered a temporary cathedral for ten years until the new cathedral was built. Its design used 96 polyurethane covered paper tubes, 20 m in length and 60 cm in diameter. The tubes were resistant to water and fire [11]. The cathedral is Ban's largest paper tube structure. Shipping containers were used to balance the inclined wall structure's A-frame on four corners of the concrete foundation in the chapel and in the storage areas (Figure 15).

**Figure 15.** Container and paper tube combinations used in the Cardboard Cathedral (URL13)

In the Cardboard Cathedral design approach:

- Ban used a combination of shipping containers and paper tubing to reduce the use of concrete as building material. The use of industrial textile products as separating elements in the interior is remarkable. These choices indicate that Ban, as in other designs, used materials that are easily accessible and minimize construction waste.

- The use of wooden, paper and industrial textile products to furnish the interior unifies the structure with Ban's preference for ecological materials.

• The design of cathedral sticking to its original form is one of its most remarkable characteristics, but Ban gave the building a light and modern look by using paper instead of stone as the main building material (Figure 16 and 17).

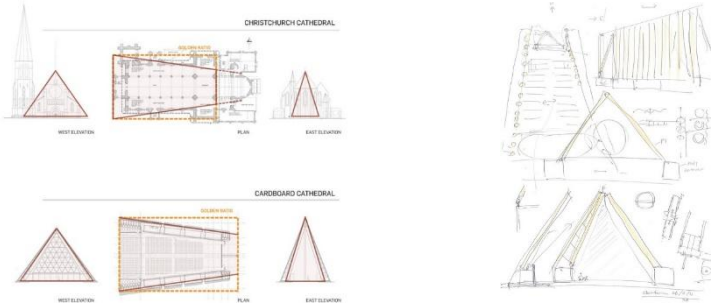


**Figure 16.** Design of the Cardboard Cathedral (URL11)

**Figure 17.** The Old Cathedral and the Cardboard Cathedral (URL2 and URL14)

• The cathedral, which has a capacity of 700 people, is designed not only as a place of worship, but also a place for activities and a concert venue. The designation of more than one function to the structure increased its usefulness.

• Ban left gaps between the paper tubes to take advantage of natural light. The colorful, triangular stained glass on the front facade strengthens spiritual feelings and provides a peaceful environment.

• The Cardboard Cathedral is one of the best examples of Ban's sustainable design approach within structure in terms of materials selection, construction and reusability (Figure 18).

**Figure 18.** Stained glass and light flooding the interior through gaps between the paper tubes (URL2)

## 3. RESULTS AND DISCUSSION

Today's designs emphasize environmentally sensitive and sustainable approaches. Increased environmental awareness and sensitivity to environment are expected. Shigeru Ban, one of the most significant representatives of this approach, created his designs considering both human and environmental factors. Ban demonstrates his sensitivity by considering climate, analyzing materials well and using materials that do not harm human health.

The paper tube system developed by Ban made fundamental contributions to sustainable design. Ban combines his designs with nature, connects with the past, saves energy maximizing the use of natural light, emphasizes the user factor, uses recycled or recyclable materials, all of which contribute to a sustainable design approach. Ban's effort to use technology in an environmentally sensitive manner and minimize material use creates easy combinations and increases the readability of his structures, forms and details. Low-cost designs and easy-to-use paper tubes made significant contributions to the sustainability due to less construction waste the end of structures' lifetime and the reusability and flexibility of the paper tubes in other designs.

Ban brought a modern approach to traditional architecture. His humanitarian aid projects, his encouragement of the use of local materials, development of the use of paper in architecture can guide temporary building designs and future architectural designs.

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