



Research Paper

Approach of sustainability using paper as a building material in Shigeru Ban works

K. Dhivya¹
G. Yogapriya²

¹(I year M.Arch , School of Environment Architecture and Design, SRMIST, Ramapuram)
²(Associate Professor , School of Environment Architecture and Design, SRMIST, Ramapuram)
Corresponding Author: K. Dhivya

ABSTRACT: Sustainability is a needed topic in the current era because of the depleting of natural resources, disturbance in the ecosystem which in turn breaks the food chain. Among the 17 UN sustainable development goals of 2030, creating sustainable cities and communities is also addressed. Using locally available materials, using materials with low embodied energy, selecting recycled or construction waste materials, or finding a new technique in using natural material can address the issue of the construction industry towards sustainable material selection. Architects play a major role in finding these sorts of sustainable techniques through the exploration of their buildings. Shigeru ban is one of such architects who tried an environmentally sensitive approach in his design strategies and construction techniques using paper. He has been known as a paper architect and in this article, his approach in using paper as the main material has been analyzed from his early career till this period.

KEYWORDS: Shigeru Ban, paper architecture, paper tubes, cost effective material, Sustainable materials

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I. INTRODUCTION

Innovations in building materials and technology play a magnificent role among the most effective forces which guided the development of buildings' forms and styles. Before the Industrial Revolution, the designer's choice of materials was largely limited to locally sourced materials: stone, bricks, timber etc. These were the principal structural materials and also selected few locally available materials such as reeds , bamboo were used. Few materials had been used for centuries with the knowledge required for working and using the materials had been handed down from master to apprentice. The built environment resulted in harmonious developments which relied for the most part on sustainable materials.

Necessity and ease of use resulted in the re-use of materials from redundant buildings; recycling was often a necessity rather than an option. The advancement of manufacturing and development of materials with tools and machinery used on building sites, resulted in new ways of doing things with new materials. Designers started to understand the nature of materials, their physical & chemical properties and structural properties also. Added to that , character in a fire, interface with other materials, predictable durability for a given situation, cost, maintenance requirements are analyzed. The possibility for recycling, the embodied energy, the impact of it terms of health and safety has been critically analyzed for sustainability concerns. The determination of all this necessary information about building materials and its enduring actualization make the choice of appropriate materials for designers , has become one of the task in the whole design process.

II. SHIGERU BAN ON SUSTAINABLE ARCHITECTURE

In the starting stage of his career, Ban paid attention to recycled materials in turn to reduce waste. He started with paper tubes as the main material. Ban, who has been celebrated for his socially conscious architecture, says, "I have no interest in 'Green,' 'Eco,' and 'Environmentally Friendly.' I just hate wasting things, explains his understanding towards finding a new innovation technique in the construction industry. Being a founder of Voluntary Architects Network, he has extensively used innovative material mainly with cardboard and paper. By using paper, he has done various projects starting from temporary shelters for refugees

*Corresponding Author: K. Dhivya

I year M.Arch , School of Environment Architecture and Design, SRMIST, Ramapuram

in places like Rwanda to Haiti, Turkey, Sri Lanka, India, and across the world. In 2014, he was awarded the 37th Pritzker Prize, the most renowned prize in present day Architecture.

2.1 Usage of Paper Tubes

Shigeru Ban designed built screens using Paper tubes for supporting Honeycomb panels for an exhibition on architect Emilio Ambasz at the Axis Gallery in Tokyo in 1985. Though paper tube played a hidden role, in the next project he used that for ceiling panels, partitions, and display stands. These forms were used in the exhibition for Architect Alvar Alto. Shigeru wants to have a cost-effective at the same time recyclable one. He tried to use it in furniture too. In 1989 World design expo, Ban designed an arranged series of tubes fixed on concrete to form a paper arbor placed with a roof with compression ring. Paraffin wax and glue strengthened it. The structure was also dismantled to check the compressive strength and it has been identified as the paper tubes compressive strength has increased. Thus in many of his structures, he started to use paper tubes and it has been famous especially with projects for refugees.

In 1988 Ban used paper tubes for an arched enclosure that extended the structure with the architectural potentiality of the paper tubes. Ban joined with Frei Otto for the project Japan Pavilion Expo 2000 Hannover and developed a 35m long-span structure with paper tubes of the lattice-like structure covered. White ropes were used to tie the members. In 2000, paper Arch MoMa, cardboard were used for lateral arches with Architect Dean Maltz. The next stage of Paper tubes usage has been extended to Cardboard Cathedral in 2011 as the main material and Paper church in 1995, visualized as temporary structures received more accolades. Table 1 gives the idea of stages, the paper tube material has been tested for various structural aspects and for its durability.

Table 1 Properties of Paper tubes in Shigeru Ban Projects

Project	Moisture content (%)	Compression Strength (mpa)	Axial Young's Modulus (GPa)	Bending Strength (mpa)	Bending Modulus (gpa)
Library of Poet	-	10,12	1.82	-	-
Paper House	8,8	11,17	2.36	16,82	2,17
Paper Dome	10,10	9,74	2.07	14,9	2,11
Japan Pavilion	8,7	9,53	1.57	14,5	1,46

Source : Latka, Jerzy. (2017).

III. PAPER AS A BUILDING MATERIAL

Shigeru Ban thought that paper could be a flexible material as it is derived from the pulp and can be molded to whatever shape he wanted. Over 55 projects designed by Shigeru Ban involved the use of cardboard as an architectural material. The nature of the projects varies according to their function (furniture, exhibitions, pavilions, educational and cultural, and relief buildings), lifespan (temporary and permanent) and specific materials. Most projects featured paper tubes, but sometimes honeycomb panels were used, as well. The table 2 gives the idea of few structures with the use of Paper tubes.

Table 2 – Projects by Shigeru for usage of paper as building material

Project /year	Material	Picture (Source - http://www.shigerubanarchitects.com)
Paper Loghouse - Kobe, Japan, 1995	Walls – Paper tube of 106mm diameter and 4mm thick Area – 52 sq.mt Roof – Tent Material	

Paper House - Yamanakako, Japan, 1995	Walls – Paper tube of height 2.7m and 280 mm in diameter and 15 mm thick Area – 10 sq.mt	
Paper Church (1995-2005, disassembled) Kobe, Japan	Walls – 325mm in diameter, 14.8mm thick, and 5m high Area – 150 sq.mt Roof – Tent-like roof of white, Teflon-coated fabric	
PAPER DOME - Osaka-cho, Gifu, Japan, 1998	Area - 633 sq.mt Single Arch - 1.8m long paper tubes with an internal diameter of 250mm and walls 20mm thick Roof - spanning 27m, 8m in height at the center and covering a space 23m wide Material – Paper tubes treated with liquid urethane. Additional material – Plywood Dome cover - corrugated polycarbonate panels Foundation - concrete	
Library of a Poet, 1991	Walls - 100 mm diameter and 12mm thick Roof - two horizontal paper tube beams post-tensioned with steel rods Joints - 38 mm square timber pieces Area – 35 sq.mt with prefabricated book shelves.	
Nemunoki Children's Art Museum, 1999	Area - 320.2 sq.mt Roof – Card board honey comb panels with plywood boards inside with bolt connection with aluminum plates	

IV. ECOLOGICAL APPROACH OF SHIGERU BAN

Shigeru Ban has widely been involved in disaster management projects and most of his buildings are temporary structures that could be dismantled and reused for refugees. Ban is known for his groundbreaking work with paper and cardboard tubes as a construction material. With his paper house, he was the first architect in Japan to design a building mainly out of paper, and his building necessary special approval to pass Japan's building code. Paper appeals to Ban because it is low-cost, eco-friendly, low-tech, and replaceable. He gives the employment opportunity to local people like craftsman to construct his building than going to skilled professionals. He works in the basis of vernacular architecture than for universal approach. He used the idea of universal floor that's is found in Japanese architecture as Shoji (door, window or room divider used in traditional Japanese architecture, consisting of translucent (or transparent) sheets on a lattice frame.) Minimalistic approach towards design are carried by his way of practice in all ways. The design approach of environmentally friendly, non-toxic, long-lasting, non-hazardous and biodegradable steps are considered by him in best possible way.

V. CONCLUSION

People involved in the construction industry like architects, civil engineers, policymakers, clients, and various stakeholders have to have a concern with the environment in developing, ideating, allowing sustainable materials. The definition of sustainability can be achieved to a minimum extent if the construction industry reduces the waste, working with recycled material, opting for ecological material, experimenting new combination of cost-effective material that is durable with aesthetically appealing features with structural stability.

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