

MORE THAN JUST ANOTHER BOOK – PAPER IN ARCHITECTURE

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ABSTRACT

Books, notes, documents, parcels or kitchen towels are only a few representatives of how paper is present in modern world. It is known for its remarkable features such as common availability or recyclability. Even though it is already a material of various usage, there are still several aspects to be discovered.

Although paper production have been developing for ages, it's structure invented by Cai Lun haven't changed. Chinese minister of agriculture, in 105 AD, had soaked cellulose fibers in water, conjoined them and dried, starting the new era of passing the knowledge for the following generations. He later have been experimenting with various trees types to gain the lighter material. Nowadays the source used for production are recycled paper and raw materials: coniferous trees and cellulose-fiber containing plants - straw, hemp, cotton, bamboo or cane. [1].

The aim of cardboard architecture is more than just creating new clever forms. Paper materials follows the idea of circular economy as it can be recycled up to seven times [2]. Furthermore, the availability and relatively low cost opens a wide gate not only for large objects, but also for a temporary or emergency architecture.

The cardboard industry is producing five products with can be used as an architectural components: paperboard, paper tubes, L-shapes and U-shapes, corrugated cardboard and honeycomb panels. They all characterize by different mechanical, thermophysical or acoustic properties.

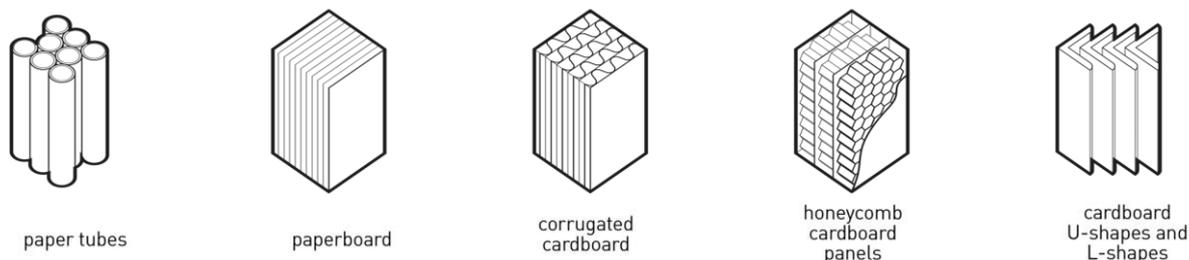


Fig. Various cardboard products

The paper in architecture was present since the eight century A.D. when China and Korea have begun to produce folding screens [3], later becoming very representative element of Japanese culture in form of *Fusuma* and *shoji* panels [4]. In the end of 19th century it was firstly used in larger scale as a series of prefabricated buildings produced by French Company [5].

The architect who have promoted paper tubes as a building material was Shigeru Ban. The winner of a Pritzker Prize have introduced this material in 1986, creating exhibition for Alvar Alto's architecture. Since than he have designed numerous projects with use of paper tubes, e.g. Japanese Pavilion for 2000 EXPO. The structure was firstly design as a wooden pavilion but Shigeru Ban have proposed paper tubes in order to reduce cost and have the possibility to recycle the pavilion. The tunnel 73.8 m long, 25 m wide and 15.9 m high is so far the largest existing paper structure.

The architect has also remarkable achievements in emergency architecture. In 1995 Japan had to face after effects of an earthquake with have destroyed over 240 000 houses. Shigeru Ban in cooperation with Art Gallery of Vancouver have designed Kobe Paper Log House – the 15,8 sqm house made of paper tubes and tent fabric, insulated by waterproof sponge tape. The house costs less than 2000\$, is demountable recyclable [6].



Fig. 1 a) Japan Pavilion Expo in Hannover, 2000, by courtesy of Marcin Brzezicki; b) Kobe Paper Log House, 1995

Use of the cardboard elements in architecture is being systematically examined by students and researchers from Wrocław University of Science and Technology. One of the most recognizable structure was built in 2019. The pavilion was made of paper tubes with was curved during a production process. The form of the structure was inspired by coping from Museum of Architecture, being a polemic between eternity and temporality in architecture. The pavilion was impregnated by biodegradable wax and oil. It have withstood a whole year.

The other structure built by WUST team was pavilion called “Obverse-Reverse” with was an illustration of architects dilemma – *to create clever, imaginative structures, or to fulfill client’s pragmatic needs?* The outer skin was designed parametrically by and supported by hidden paper tubes. The interior walls was made from a composition of honeycomb panels and corrugated cardboard.



Fig 2. a) Curved tubes pavilion, 2019; b) Pavilion Awers-Rewers, 2019

The other branch of paper architectural applications developed at WUST are low-cost and temporary houses. The series of TECH (Transportable Emergency Cardboard House) had started in 2014, when the first concept of paper emergency structure was drawn. Further, the smaller and full-scale prototypes were implemented as a proof (or false) of concepts. Twelve prototypes were build in cooperation with the Department of Architectural Engineering + Technology TU Delft. The prototypes of TECH 03 and TECH 04 were built at WUST. Both structures are characterised with different structural system and the use of material properties.

In the first building had rod structural system. The full board T-shapes constituted pillars , beams and rafter. Such a structure was infilled with honeycomb cardboard sandwich panels. The building envelop was placed on timber floor slab. Tech 04 was designed as shelter easy to

transport in form of flat panels, and easy to build. Longitudinal panels were worked as singular elements that constituted walls and roof. Those prefabricated building components had a dimensions of 7 x 1,2 m. Special grooves allowed for folding the panels into desire house-like shape to connect them with a timber base. The panels had a sandwich composition made of corrugated cardboard, honeycomb panels and aluminium sheet from the outside. Aluminium provided an extra protection and its overlaps were used for segments connection.



Fig. a) TECH 03, 2016; Fig. b) TECH04, 2018

At the current stage of the research at WUST, there is an interdisciplinary research group TECH. The research is supported by the National Centre for Research and Development within the *Leader* programme. Team of 8 scientists and students from four faculties conducts research on architecture (including sustainability), structural mechanics, building physics, acoustics and chemistry. The aim of the project is to design, research and develop a low cost, eco-friendly and comfortable living unit made of paper-based products. The research is divided into five phases. Literature review and preparation, mirco – meso – and maxi – scale research. A testing house should be built as an ultimate output of the project. The project is planned for three years, and it began in March 2021.

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