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MODERN TIMBER TECTONICS: FROM CONSTRUCTION TECHNIQUE TO BUILDING SYSTEMS.

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Tectonics, the poetics of technology

1 Introduction

The architectural use of timber has involved, from the beginning, a process of rationalization. The trunk is taken from nature and converted to a preformed part that is connected to other parts, according to rules arising out of technical, climatic and social conditions.

In timber, prefabricated elements show many advantages over traditional types of construction. Traditional timber construction is more expensive to design and implement (about a quarter of the material used in a structure is simply waste), slower and also more complicated than prefabricated timber construction. Prefabrication minimizes the waste of resources (because less adaptation and adjustment is necessary), simplifies the collection and recycling of waste, allows a rational form of building and can achieve a high standard of quality [5]. Also, the erection costs on site are lower and timber is not exposed to construction moisture during erection. But prefabrication in timber demands a close cooperation between designers and manufacturers: this constructive process demands a change in the nature of timber design.

There is a close relationship between prefabrication, mass production and systems. Taking housing as an example of typology, prefabrication of houses was rare until the beginning of the twentieth century, when prefabrication became a possibility on a mass scale. In other words, prefabrication was only economically feasible in a mass produced way, where the prefabricated parts or components were connected to other parts according to certain rules. In reality, every form of construction is based on a set of rules which are the result of the properties and conditions of the materials employed and the requirements they have to meet. They dictate the specific properties of the building components, their use and their processing. These rules, derived from technical and representational conditions, form a system. Then, any form of construction involves designing and building with a system. Since a building system is mainly an intellectual approach to structure and construction, building systems and tectonic form are closely related. Therefore, the evolution from the traditional approach to structure and construction (traditional systems) is a prerequisite to modern tectonics. The different types of systems, as design and construction tools, are reviewed in order to analyse if such evolution has taken place.

2 Modular theories and systems

Since the industrial revolution, several attempts to develop specific systems as an alternative to traditional timber construction were made [2]. The success of the 40's industrialization in America inspired Konrad Wachsmann and Walter Gropius to develop an industrialized constructive system in timber between 1941 and 1949. It was the General Panel System and was mass produced, modular and comprehensive: it included manufacture, transport and assembly requirements; services, structure and thermo-acoustic needs were also addressed. Elements were based on a module and could be assembled following any direction. It was a closed system: the elements were not designed to be used individually. The system wasn't successful enough to beat the simplicity of platform frame construction.

During the second half of the 1950s, high hopes were placed in building systems in order to meet the huge housing needs



after the Second World War [4]. At the beginning of the 1960s, building systems were seen to represent the spirit of modern architecture, but after little more than a decade this attempt failed. Industrial methods and machine technology became a central issue in the debate on modern building culture, being

used to systematize construction and technological developments. But despite the intention to shape the everyday world in a creative and productive form, the call for economic forms of automation resulted in rigid layouts with monotonous and repetitive solutions, based on the modular theory. Poor design and the attempt to subject everyday life to the imperative of adaptability led to a dead end.

In the 1970s, the US government initiated the "Operation Breakthrough" to overcome the housing crisis in the States at that time. The programme favoured closed systems, including modular construction systems that had reached the end of their useful life in Europe [3]. After the 1970s were forgotten, the notion of construction unit systems from a single source was revived. These are made up with parts that fit only a specific building system, in other words: they are closed systems.

2.1 Closed systems

A closed system is a complete and finished product: its components or planning can't be freely replaced, extended or completed. Their main drawback is that they are aimed at a very limited market. In the manufacture of technical systems, traditional construction is often more efficient than closed building systems[4].

The KFN System, designed by Kaufmann 96 Architektur, can be shown as an example of closed system, offering dwellings with a high degree of prefabrication. Within this system, the architects developed a timber container called Fred. This mobile home consists of two boxes, one of which slides inside the other to form a 3 x 3 x 3-metre element that can be transported on an articulated lorry. On site, the two sections are drawn apart to form a living space with a floor area of 16 m². The dwelling is ready for occupation after site assembly. The structure of the boxes is made with a sawn timber stud frame between plastic-coated plywood panels either side and



rockwool insulation in the cavity.

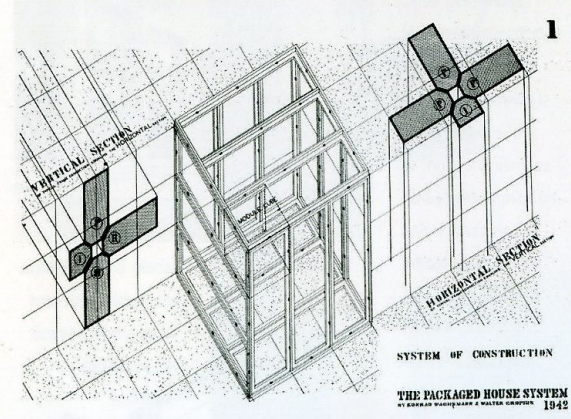
2.2 Meccano systems

Meccano systems can be considered a special type of closed system. They represent a way of forming bigger objects using coordinated smaller standard units (elements or modules). The principle is based on the combination of a limited number of modules to produce a reasonable amount of different constructive elements or buildings. They require a high degree of prefabrication and can't be freely completed or extended.

Complete room units or modules can be suspended from or supported by a load-bearing frame. The replacement of the complete unit is needed if adaptation to changing conditions or renewal from time to time is required. When there is no independent load-bearing structure (load-bearing room units are those that can be stacked), the aspect of interchangeability no longer applies. Since the room units are assembled like building blocks, they can also be dismantled without damage and re-erected elsewhere. This is the case of the Transform System for example, that has modules that can be stacked vertically or horizontally and extended after completion. The modules have plan dimensions of 3x3, 3x6 or 3x9 m and are

3.23, 3.38 or 3.63 m high. Their load-bearing frame uses glulam pillars and beams connected with galvanized steel plates. Walls and floors are made with composite timber panels. The units are assembled on the workshop and transported to site. Room units are usually fully finished internally and ready for occupation after they have been transported to the building site. They are coupled with transport restraints.

However, when large scale production is confined to repetitions within the same structure, the universal application of



room units is almost non-existent.

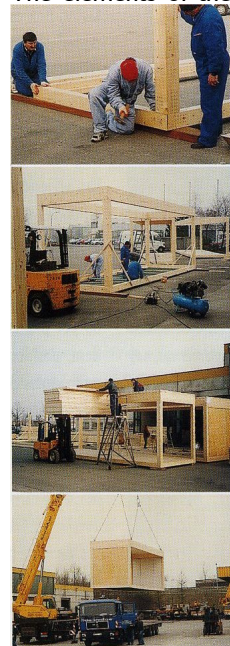
2.3 Open systems

Non modular prefabricated construction allows for the interchangeability of different types of structure and the location of components in a variety of positions; in other words, an open system. Designing with open systems involves coming to terms with things that already exist: an open system is a set of parts co-ordinated with each other. One of the aims of the open system approach is to develop and co-ordinate the subsystems and construction elements produced by different manufacturers. Developing the parts is as important as the sets of relationships between them in the manufacturing and assembly processes and in use. Today's timber constructive systems are mainly open systems: they are flexible to be used individually or combined with other systems but need to be combined with services and finishes.

The Finnframe Floor System is an example of open system. The elements of the system include Finnjoist, Kerto-S and Kerto-Q.

Finnjoist is an I-joist with LVL flange and OSB web and forms the main element of the floor system. Kerto serves as flange material for Finnjoist; but it can also work as a structural linear element in itself: long span beams, rimbeams, lintels and other structural applications. All these can be combined with this or other systems.

3 Conclusion. Systems today
Usually, prefabrication is related to cost- and time-savings and improved workmanship. Nowadays, we can use two fundamentally different prefabrication principles: dimension-related systems with modular coordination (closed and meccano systems) and individual prefabrication systems with specified jointing principles (open systems). They relate to the two ways of designing and building with a system: systemised building and system building. The difference between them relates to the various degrees of prefabrication.



In systemised building, the quality and dimensions of individual components are defined by the relevant standards with a view to achieve optimised working procedures, but, in a way, limiting the degree of design freedom.

Today, as industrialization moves forward, the new manufacturing processes are giving system building a new impetus. At the beginning of the 1990s, the technological innovations that



took place in the manufacturing process provided greater flexibility through the use of computer-controlled machines. They made it feasible to produce every element as a unique

item (even complex geometries), thus changing the concept of mass production which is not an absolute dogma any longer because it does not ensure economic feasibility.

The fact that on site construction yielded to systems is closely related to the improved manufacturing technology because rationalization, standardization and prefabrication can be constrained by the inadequacies of the machines. Systems are replacing on-site construction throughout the spectrum of typologies. Almost all building systems in today's timber architecture are flexible enough to be able to react to individual designs. Today is not the module but the maximum span what influences the final form and, in the end, only transport restrictions impose the limit. Therefore, the traditional design process in timber architecture is being reversed: the structure can be designed with a high degree of freedom and then customised by breaking it down into suitable individual elements.

Talking in constructional terms, systems can be broken down into complementary systems and synthetic systems [1]. The former consist of many complementary, partially autonomous layers (monofunctional components); the latter are those whose components are almost permanently attached and result in elements that satisfy the load-bearing, insulating and weather-protecting requirements simultaneously (a complex layer with multiple functions). The layered construction of timber frame, for instance, is complementary because every

individual layer is monofunctional and complements the others.

Also, in a large number of innovative new systems the relationship between design aspects such as thermal-acoustic requirements and cladding, as well as new constructive possibilities is more and more complex. This interaction is bridging the distance between the constructive technique and the system. Today, finished multi-layer products can offer what a carpenter would construct on site. All these changes have an impact on the design process and the way architecture is formed. In other words, modern technologies are changing traditional timber tectonics, moving towards synthetic open systems.

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