BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Publicat de
Universitatea Tehnică „Gheorghe Asachi" din Iaşi
Tomul LVII (LXI), Fasc. 1, 2011
Secţia
CONSTRUCŢII. ĂRHITECTURĂ

MODERN WOODEN STRUCTURES, BETWEEN ARCHETYPE AND INOVATION

BY

**CĂLIN CORDUBAN, NICOLAE ŢĂRANU*
and DORINA ISOPESCU**

"Gheorghe Asachi" Technical University of Iaşi,
Faculty of Civil Engineering and Building Services

Received: September 6, 2010
Accepted for publication: February 8, 2011

Abstract. An overview on the continuous development of wooden structures from historical models to contemporary types is presented. Although it doesn't detail the archetypical forms of wood architecture, that would have been an extremely extended endeavour; the paper nominates the most important types of modern wood structures, and creates counterpoints between some relevant contemporary architecture models and traditional buildings. The paper also intends to make a case concerning the significant modern innovations in wood technology and how they relate to the evolution of structural systems over a long period of time. In the conclusions, after a review of the most significant innovative aspects of wood as a structural material, the paper analyses the benefits and the losses of the evaluative process.

Key words: wood; structure; timber frame; archetype; traditional architecture; contemporary structure.

1. Introduction

Wood is one of the oldest construction materials utilized by humanity. Its use has been based rather on traditions and past experiences then on engineering principles, and therefore the standing of wood and wood based materials users has been one of „low-tech" or auxiliary material. Contrary to

* Corresponding author: *e-mail*: taranu@ce.tuiasi.ro

this opinion is the fact that wood and wood based materials are used more in construction, than concrete and steel (Friedley, 2002). Throughout the ages, wood has developed into a incredibly beautiful form of construction, which leaves the large wooden structural elements exposed within the building, to be viewed and admired.

Wood has many advantages as a structural material: it is renewable, is machinable, has a good strength-to-weight ratio, wood is immune to corrosion and is aesthetically pleasing. It is not only the worlds most widely used building material but also one with characteristics that make it suitable for a wide range of applications, thus, products can vary from a minimally processed log in a log-home building site to a highly processed and highly engineered wood composite manufactured in a large production facility (Aghayere & Vigil, 2007). Over the past decade, the concept of green building has brought attention to another important quality of wood – its environmental benefits, including low embodied energy, low carbon impact and sustainability.

On the other hand, the disadvantages of wood include the following: it is affected by fire, it can decay or rot and can be attacked by insects such as termites and marine borers. The high levels of moisture in the air accentuate the decay and rot in the wood. The moisture content variability makes wood susceptible to volumetric instability. Wood's characteristics are highly variable; thus can differ widely between species and even between trees of the same species. There is also variation in strength and stiffness within the cross section of a tree log (Aghayere & Vigil, 2007).

2. The Viable Model of Past Experiences

The evolution of wood structures to present days can be compared with a curve which had a significant increase in the last half of century but this virtual diagram cannot be dissociated by the thousands of years of constant progress marked by some peaks – monumental buildings that amaze even today with the refinement of the technical solutions.

The Romanian architect, Nicolae „Gipsy" P o r u m b e s c u, was speaking of "*a truth of the place*", meaning that each topos leads different architects to very similar solutions. If there is an inherit truth of the place, there must be a consistent truth of the material. The physical characteristics of wood that determine the technical solutions of implementing it into constructions have remained unchanged since its early use by mankind for shelters, determining in thousands of years a permanent evolution of conversion methods, structural models or finishing techniques. A debate could be related to contemporary engineering discoveries for wood structures, because, no matter how complex, the technological advancements can always be compared with the evolution in hundreds or thousands of years of the use of wood in different cultures that ultimately led to the survival and perfection of the best structural techniques that successfully compete the innovations of the last 50 years.

Rather, we can acknowledge an accelerated evolution of perfecting and industrialization of existing engineering techniques. On the other hand, all the technological innovations of the twentieth century have categorically influenced the use of wood in construction, transforming a craft into an industry. This transition has brought benefits, but also came with a cost, in the loss, along with the craftsmanship, of the spirit of certain communities transposed so directly and sensibly in the dwellings that housed them.

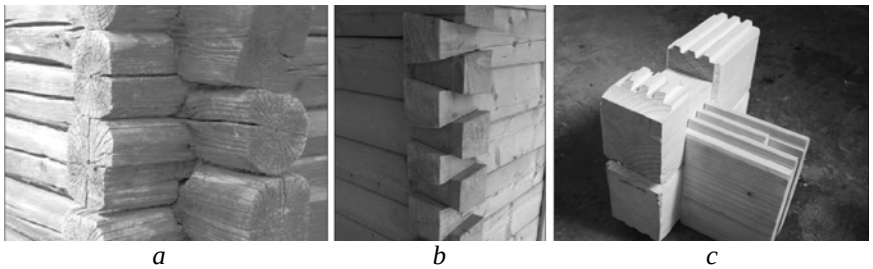
The value of old structures, is reflected in the number of UNESCO World Heritage Sites, that comprise many wooden constructions all over the world. They include the Kasubi Tombs in Uganda, the Churches of Chiloe in Chile, and the significant timber engineerings of Chineese temples, that iclude the Temple of Heaven (38 m high), from Ming Dinasty (1420 AD), The Summer Palace in Beijing, and the pagoda in Ying-xian, which was built in 1056 AD, and reaches a height of 67.31 m. Also, in Japan, wood had a prevalance as building material, both in dwelings and in the religious buildings, with the UNESCO Heritage Sites as the temple of Nikko and the villages of Shirokawa-go. In Europe, the sites vary from the wooden churches as those of Maramureş in Romania, those of Southern Little Poland, those Carpathian wooden churches in Slovakia, the old church of Petajovi in Finland, the Urnes Slave Church in Norway, to the housing examples, such as the old city of Rauma, in Finland, or the Cultural landscape of Wochau, in Austria, all of which beeing recognized as UNESCO Heritage Sites.

3. The Connotations of Contemporary Wood Structures with the Archetypical ones

One of the oldest structural types of wood constructions is the log house, its use on the European continent being traceable to antiquity, with a high prevalence in medieval times in Scandinavia, Russia and Eastern Europe. The log houses can be generally separated into two main categories: “handcrafted”, typically made of logs that have been peeled but are otherwise unchanged from their original, natural appearance, and “milled”, built of logs that have run through a manufacturing process which converted them into timbers that are consistent in size and appearance. The log houses have evolved considerably in the last century, especially regarding the degree of manufacturing and the assembly technique. Milled log homes have an assortment of profiles, including “D” shape logs, full round logs, square logs, and Scandinavian Cope logs. Almost every profiled log on the market today features an integral tongue and groove milled into the top and bottom of the log that aids in stacking (Ross *et al.*, 2010).

The system is rendered up-to date by the good characteristics of wood as thermal insulator, its permeability to vapours that determine an overall satisfactory behavior of the dwelling from a hygrothermal approach. The possibility of finishing with varnish that enables the structure and the colour of

wood to remain visible gives real aesthetic values, according to the theory of organic architecture. Fig. 1 shows different types of joinery, from left to right, in the succession of their evolution.



a *b* *c*

Fig. 1 – Types of joinery (http://www.casedelemnbalazs.com…; http://www.podreg.ro…): *a* – handcrafted logs; *b* – dovetail corner; *c* – square style logs.

Nowadays, the most prevalent contemporary structural type in the individual housing is the timber framed structure. The dwellings built in a "platform framing" system account for more then 90% of the residential housing stock in the United States of America, the development of this segment being greatly responsible for the number one rank worldwide, that wood holds as a building material for housing. The refining of the method to the degree of which it is applied today represents the result of a progressive process who's origins can be traced back to the Middle Ages. In those times, the craft of timber framing, using vertical, horizontal, diagonal and curved large elements that remained apparent, accomplished a high level of aesthetic refinement. The lack of metal fastenings, that are available today, assumed a better understanding over time of the structural features of wood, translated in the use of complex joinery. Analysing those structures with today's theoretical knowledge reveals just how sophisticated was the response to the structural challenge (Isopescu, 2002).

a *b*

Fig. 2 – Past and present wood structures (http://lcjb.cjsonline.gov…; http://www.elcivics.com…): *a* – medieval timber-frame house with projecting upper stories; *b* – modern platform framing house.

Light framed construction, utilizing standardized elements, has become the dominant building technique in the United States of America, Canada and Australia, due to economical factors. Furthermore, for the same factors, in addition to the ecological concerns and the excellent performance under earthquakes, this method is gaining ground in Europe and certain Asian countries, especially Turkey, Japan and Taiwan, where it is supported by governmental policies intended to provide safer housing. In our country, as well as in other Eastern European states, there is an increasing interest in this technique because it is researched, proven, economical, flexible and capable of meeting the code requirements, with manufacturers emerging in the regions with an old tradition of wood construction such as Bucovina, Maramureş and Székely Land.

As a result of industrialization and economical efficiency today's wood framed structures are assembled into panels in manufacturing facilities either manually or in an automatic system and, then, transported over long distances to the site where are assembled in a short period of time. This method enables unique architectural solutions and/or standardized housing.

An excellent example of modern wood structure on a system of posts and beams is Japan's pavilion at the World Exposition in Seville, in 1992. The architect and engineer Tadao A n d o wanted through the means of an impressive wood structure to bring the world's attention to the aesthetic traditions of Japan, one of the beauty through simplicity. The aim of the project was to reinterpret the architecture of wood with the modern technical innovations and to create a building that embodies tradition and modernity, engineering and culture (Masao, 2006). Fig. 3 illustrates the relation between

a *b*

Fig. 3 – The art of Japan wood, past and present (Masao, 2006; http://u000010155.photoshelter.com…): *a* – Japan's pavilion at the World Exposition in Seville, in 1992; *b* – wood temple in Nara, Japan.

the new pavilion and the old Japanese temple. It is obvious how the two utilize the wood in the same structural composition, although the new building uses less decoration.

For particular usages that require a large open space, such as churches, leisure buildings, barns, the span is accomplished with arch and dome structures. The arch structures generally utilize the benefits of laminated timber, the form and the span of the structure being limited especially by the imagination of the architect (Ross *et al.*, 2010).

For the ice-skating arena, build for the 1994 Olympic Games in Hamar, Norway, they have opted for the shape of eight centuries old Viking ships, interpreting the simple and original, still beautiful lines. The large arches, made of glue-laminated timber layers, span on 96 m and 4 m high. With transversal stiffening and metal bracings, they remind us the structural geometry of a Viking's ship hull (Cerver, 2006). Fig. 4 suggests the similarities between the contemporary shape of the arena and that of an 11th century Viking ship. This is demonstrative both to the exterior of the structure as it is in the interior.

a *b*

Fig. 4 – Exterior of the Hamar Olympic Arena , compared to a Viking ship (http://www.touristphoto.no…: http://dowling.mpls.k12.mn.us…):
a – Olympic Arena in Hamar; *b* – Hull of an 11th century Viking ship.

Radial-rib domes are a category of innovative new-age structures consisting of curved members extending from the base tension ring to a compression ring on the top of the dome along with other ring members at certain elevations. The ring members can be straight or curved, and depending on that of the dome will have a spherical surface or an umbrella look. It is a special type of construction and care must be taken to stabilize the structure because the dome has a tendency to rotate about the central vertical axis (Ross *et al.*, 2010).

Other dome patterns, called Varax and Triax, are also used. Their geometries are quite complex, and specialized computer programs are used for their design. Steel hubs used at the joints and supports are of critical importance for the connections performance. Built between 1982 and 1983, the 161.5 m in diameter Tacoma Dome is one of the largest clear roof spans in the world and is a great example of a Triax dome as shown in Fig. 5.

Fig. 5 – Tacoma Dome (Ross *et al.*, 2005).

4. Conclusions

Just as modern artists synthesized in modern shapes the archetypical Romanian sculptures, in the same manner today's engineers sublimate the essence of traditional wooden structures into contemporary expressions. This creative process is either the principle of an evolution, by perfection and distillation or a re-invention that involuntarily resumes an extinct cultural model. This phenomenon though, as it was illustrated in this paper, has only a formal, illusory character, in connection to the physical properties of wood, unchanged since its use by mankind as a construction material. In substance, the contemporary technology has brought fundamental differences in the way in which wood is converted and assembled into the finished product. We can no longer speak of a material utilized in regions where it has been available, at a local level, but as of a resource so important today mainly due to its potential for prefabrication, the ease of transport and montage. This distinction of social, cultural and economical character differentiates categorically the contemporary use of wood from the traditional one.

REFERENCES

Aghayere A., Vigil J., *Structural Wood Design*. J. Wiley &Sons, Hoboken, New Jersey, **23**, 2007, 66-68.

Cerver F.A., *Panorama de L'Architecture Contemporaine*. Konemann Verlags-gesellschaft mbH, Köln, 2006, 452.

Friedley K.J., *Wood and Wood Based Materials Current Status and Future of Technical Material*. ASCE, Amer. Soc. of Civil Eng., Reston, Virginia, 2002.

Isopescu D., *Timber Structures*. Edit. „Gheorghe Asachi", Iaşi, 2002.

Ross J.R., Ritter M.A., Wegner T.H., Falk R.H., Wiemann M.C., Wiedenhoft A., *Wood Handbook-Wood as an Engineering Material*. General Techical Report FPL-GTR-190, US Dept. of Agr. Forest Serv., Forest Prod. Labor., Madison, Wisconsin, **17**, 1-8 (2010).

Masao F., *Tadao Ando, The Geometry of Human Space*. Ed. Taschen, Köln, 2006, 51.

http://www.casedelemnbalazs.com/images/DSCF1574

http://www.podreg.ro/PhotoGallery/saissac-la_bourdette

http://lcjb.cjsonline.gov.uk/area3/images

http://www.elcivics.com/images/wood-frame-house

http://u000010155.photoshelter.com/image/I0000oyarqthJYgw

http://www.touristphoto.no/hedmark2.htm

http://dowling.mpls.k12.mn.us/uploads/size-500/viking_ship_gokstad_4.jpg

STRUCTURI MODERNE DIN LEMN, ÎNTRE ARHETIP ŞI INOVAŢIE

(Rezumat)

Se studiază relaţia evolutivă a structurilor din lemn în construcţii, subliniind caracterul de continuitate şi reprezentarea modelelor arhetipale în tipologiile contemporane. Sunt prezentate principalele caracteristici ale lemnului ca material de construcţie subliniind faptul că aceste caracteristici au rămas neschimbate de când lemnul este utilizat de umanitate. Se subliniază importanţa lemnului în istoria arhitecturii şi a patrimoniului moştenit de construcţii din lemn. Sunt reliefate principalele inovaţii în acest domeniu din ultimii 50 de ani şi modul cum acestea pot fi relaţionate cu experienţele arhetipale. În final sunt subliniate direcţiile marcante de evoluţie ale lemnului ca material de construcţii, din perspectivă economică, socială şi culturală.