APPROACH TO CONSTRUCTION OF WOODEN BRIDGES

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ABSTRACT:

Different models of civil engineering constructions, some types of bridges built of solid wood and wood based materials have been described in this work. The issue of approach while making decisions about production similar structures, advantages and disadvantages, forms, approaches to the issue of modeling and designing, technology of making fundamental constructive elements of laminated wood etc. with the aim of getting clearer picture about this type of product and encouraging its appliance have also been described in the paper.

1. INTRODUCTION

There are many reasons for the constructionsof woodenbridges,and even though they are very demanding, they are economically and ecologically rational structures. Until recently, wood was used for construction of traditional objects, however with development of modern design and technology of processing – today, the picture of wood is completely different – there are modern and innovative building materials which developed in High – Tech product. However, energy-saving construction and eco-indicators have dominant and important role in building nowadays. What is the consumption of energy in the construction of an object? What is the extent to which the construction of an object burdens the environment?These are the frequent questions?
In this context there is more interest in wood as building materials owing to its positive ecological balance. Determination of amount of released CO2 and consumed energy which is released by production of unit of building materials is actually "measurement" of ecological potential in material.

Table 1: Determination of the amount of released CO2 and consumed energy:

1 m^2 zidnoga elementa	Drvena kuća	Kuća od opeke
Težina (kg)	71	273
Energija (MJ)	271	876
Emisija CO_2 (kg	-50	58

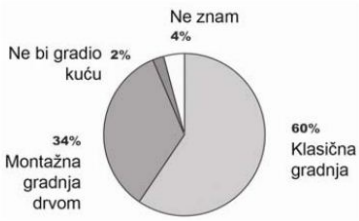
The most important reasons for timber are: good building – physical properties, ecological acceptability, significantly lower consumption of energy in the preparation of materials for installation, fire safety, durability and seismic safety.

2. MATERIALS AND METHODS

Opinion of costumer-user is very important for the appliance of materials which will be used in the realization of construction. In terms of the appliance of wood as the building material good example can be a conducted survey of public opinion of the Slovenes at the age of 25-40 who were specific costumers of wooden house. A questionnaire is made by a group of experts in the area of architecture, forestry sector and construction industry. There were 5 main questions and 2 sub-questions.
The questions were connected with the decision of the examinees about brick or prefabricated wooden construction. They answered why they would choose wooden mounting construction with the special view of advantages with the ecological aspect of wooden building by comparison with passive construction.

2.1. Results of market research

It has been found that interest in wooden construction grows. When asked if they would choose classic buildingor prefabricated wooden building, hypothetical assumptions of the examinees wanted to be found in order to find a way to approach that kind of building in the future.
The results are shown in the Figure1. and it is seen that 1/3 of the examinees are interested in prefabricated wooden building.



4% - I don't know
2% - I wouldn't build a house
34%- prefabricated wooden building
60%- classic building

Figure 1. The answers to the question": "If you are building a new house, would you choose classic building or prefabricated wooden building?

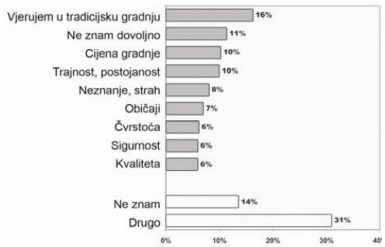


Figure 2. „Why won't you decide to build with wood?"

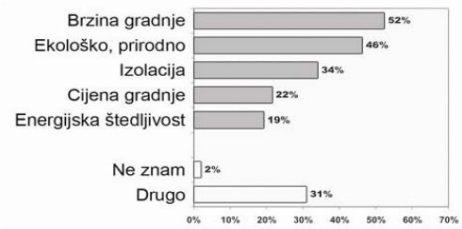


Figure 3. Answer the question: „In your opinion what are the advanteges of wood construction?"

3. CONSTRUCTION OF WOODEN BRIDGES

Recently, owing to different surveys and growing demand on the world market it grows interest in scientific research in the field of modeling and designing of modern bridges construction which use wood for building. In the last ten years, interest has especially grown in Europe and North America,

where the wooden bridges often appear as road and pedestrian and gain more significance in the terms of efficiency, aesthetics and durability. The existence of many positive economic and other indicators of justifying wooden bridgesand offer of newer types of construction etc. increases interest of other countries and the building expands in Norway, Croatia, Canada, Sweden… The appliance of all-purpose adhesive, modern materials of wood and wood-based (factory produced girders, glued-laminated girders – GLULAM, veneer girder – SVL, different types of boards – veneer VLV, multilayer, plywood, OSB board etc.) new types of timber joints (hobnails, screws, screws for wood, staplers) contributes to the development and building of wooden bridges.
When designing wooden bridges it is important to know the following facts:
ADVANTAGES:
- Lightweight construction
- Simple and quick performance
- High durability of elements (constantly immersed in water)
- Easy possibility of strengthening of structure,
- Simple foundation

DISADVANTAGES:
- Inadequacy for high traffic loads
- High costs of maintenance
- Quick reduction of solidness with time
- Small/short durability with contact with soil or water
- Compliance of compounds on dynamic activity

Good knowledge about the advantages and disadvantages of specific construction and materials for building represents a base for research of its influence and elimination of negative phenomena.

3.1. Preparation and production of glued-laminated wood /timber for building bridges

Glue-laminated timber is a building material composed of thin, parallel glued slice mutually glued with specific types of glues under certain circumstances and it mostly represents dowel-type element of construction, prismatic skew section practically unlimited dimensions and length. There are flat, trapezoidal and curved girders. This type of material enables usage of small pieces of wood in constructions of large range and loans, complex shapes with the possibility of avoiding the mistakes in the wood. Little weight of materials with the relatively solid firmness enables performance of laminated constrictions of large ranges with greater freedom of design different from classic wooden/timber constructions, as seen in the Figure 4.

Figure 4. The bridge of complex construction with the curved girders made of laminated wood

Laminated wood/timber is widely used among other things in bridge construction – for pedestrian or road bridges with range of 20 meters or more, depending on the static system.
Laminated wood is modern product madeof coniferous wood or deciduous wood. It has been used for 80 years, and its performance especially encouraged development of chemical industry of glue. In today's factories the process of production is controlled and guided by modern discovery/knowledge

about the glued wood which is more often used in bridge construction. Its characteristics contribute to different improving of in the bridge construction and are reflected in the following:

- Can be made in different shapes (bends, curved beams)
- Chemically neutral and resistant - no corrosion
- Good fire resistance characteristics
- A good proportion of its own weight to payload
- It does not require additional surface coating or treatment

Technology of making glue laminated girders of wood consists of the following operations:

- Sorting and classification of boards
- Artificial drying of boards for the final required humidity
- Conditioning of dried boards
- Longitudinal continuation of boards, gluing, conditioning of glued constructive elements, planing of glued constructive elements and final treatment/processing.

Figure 5. Details of the process of production of glued laminated beams of wood

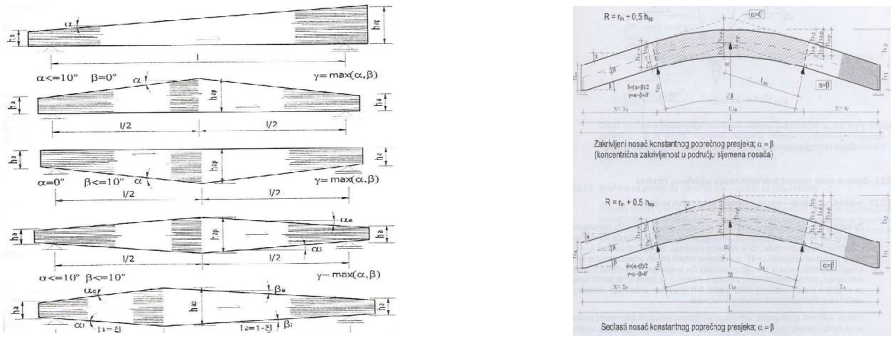


Figure 6. View of basic forms of laminated structural elements of bridges

3.2. Stresses

The fact that we know the load that the bridge will be exposed to during exploitation represents one of the important factors for the calculation of the critical and other sections in ordertosatisfy pre-set criteria**.** When calculating the following changes should be considered: due to the change of carrier greatest strain of bending does not occur at the point of maximum bending moment, the position of the section in which the maximum stress depends on the carrier, due to vertical uniform distriution that creates a complex stress state, simultaneously stresses in the direction of perpendicular to the fiber and shear stresses in the fiber direction, etc. Form carrier directly affects the nonlinearity distribution of stress along the height of the bracket, and for many of stress are given EC5 standards.

3.2.1. EC 5 standards

For the purposes of practice the European standards and regulations complex stress state in these girders describe with a series of correction coefficients of stress that are usually determined on the beams of constant height and flat longitudinal axis. Theoretical base for the budget of trapezoidalgirders is the theory of anisotropic girders.

Table 2: Static characteristics - Recommendation size (DIN)

Statisches System	System-Skizze	Spannweite l (m)	Binderhöhe	Binderabstand	Dach-neigung (α)
Einfeldträger parallel		10 bis 35	$\frac{l}{17}$	5 bis 7,50 m	–
Einfeldträger satteldachförmig		10 bis 35	$\frac{l}{16}/\frac{l}{30}$	5 bis 7,50 m	3 bis 8°
Einfeldträger geknicktes Satteldach		10 bis 35	$\frac{l}{16}/\frac{l}{30}$	5 bis 7,50 m	max. 12°
Einfeldträger Pultdach		10 bis 35	$\frac{l}{18}/\frac{l}{25}$	5 bis 7,50 m	8 bis 12°

3.2.2 Static systems of modern arch bridges

The design is often based on the basic models of bridges, and some of them are given in the figure 7.

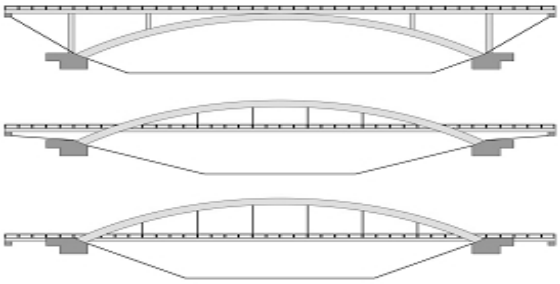


Figure 7. Static scheme of individual arch bridges

The basic characteristics of these bridges are: static section with the pavement above the vertex, arch with recessed pavement and arches above pavement construction. Shapes of the arches are: circular segment, parabola and ellipse segment. Pavement construction often serves as a brace between two support arches. Brace can be made of wood or laminated wood.
The main constructive elements are: laminated timber (usually), mechanically laminated timber and laminated block girders. Forms of construction may be very complex (figure 4), and simple (figure 8).

Figure 8. Bridge over the river Neckar (Rottenburg)

3.2.3. Cable-stayed bridges

These types of bridges (figure 9) aremore often performed static systems of cable-stayed bridges. The main characteristics are: one or two pylons, braces in one or two planes, leaning or broken pylons, combination of steel, wood and concrete – wood, flat or slightly curved beams, beams of variable height and rounded cross-sections more resistant to the wind.

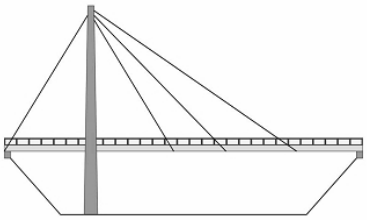


Figure 9. Cable-stayed bridge-detail

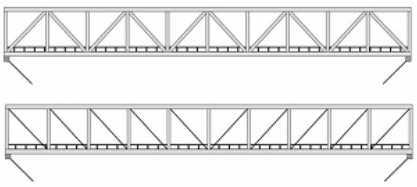


Figure 10. Truss bridges

3.2.4. Truss bridges

- can generally handle larger loads than the beam solutions

Most frequently performed systems of truss bridges are:

- Modified Warren (verticals and diagonals loaded tensile and compressive)
- Pratt (diagonal loaded tension and possible variants: the vertical pressure)
- Howe systems of truss girders – the main characteristic of Howe system is that the diagonals are constantly loaded compressive, while the verticals are loaded tensile)

The main characteristics of truss systems are:

- pavement structures above or below the main girder (lattice)
- truss flange girders can be flat or slightly curved
- Truss flange can be straight or slightly curved.
- Performed as a simple beam or continuous beams
- Normal ranges trusses varies between 9-45 m
- Minimum two main truss girders in cross-section

For this type of bridge used solid wood (soft or hard) as the base material in the form of laminated beams, round-laminated beams and mechanically laminated beams (hardwood) so far recorded the highest derived range in length from 70.3 m

4. CONCLUSION

In this work, it's been shown that almost all types of bridges can be made of wood. Professional and intensive approach for every task is required, fromthe beginning, during the performance till the implementation of the project task. The disadvantages of these types of construction represent huge space and great challenge for researchers in terms of search and finding optimal solutions in the specific cases as well as in the general cases with the aim of increasing interest for their intensive building.

5. LITERATURE

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