

ANALYTICAL COMPARISON BETWEEN MASSIVE WOOD AND GLUED LAMINATED TIMBER IN CONSTRUCTION ELEMENTS

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ABSTRACT

The paper illustrates the potential for application of constructive-building components made of glued laminated timber, as alternative to traditionally used elements of solid wood. An example is proposed to demonstrate the promise of these structures by the use of finite element method. The comparison of the stress - strain state between structural element of solid wood and glulam is described in the paper, based on calculations, made according to the national regulations.

Results and the comparison between them gives hope to expand the opportunities for effective application of glued laminated timber structures in the Bulgarian construction practice, as well as, for engineers, designers and architects, and with more complicated shapes and longer supporting distances.

Key words: glued laminated timber, timber, comparison

INTRODUCTION

Glued laminated timber or a short ‘glued wood’ is an innovative and flexible construction material for a residential and commercial construction applications. Increased design values and improved product performance make it suitable for straight line and curved line elements.

Arches, domes and waved forms of supporting large distances are not a problem in the construction of laminated timber. This gives more freedom in design than solid timber.

Glulam is composed of individual wood laminations, or „lams“ (fig. 1), bonded together with durable, moisture-resistant adhesives. This type of bonding of wood has a higher strength and stiffness compared to solid wood and can be compared with a steel sheet metal. Material properties make it applicable to large and even open spaces. Limitation have only during transportation.



Figure 1: Picture of glued beam

Compounds of these elements are usually bolted or steel threaded rods and plates. Large glulam members can be manufactured from a variety of smaller trees. It is possible the preparation of sections of wood glued in which higher quality lams to be placed in areas of greatest stress.

The glued elements are only two-thirds of the weight of the steel, and one-sixth of the weight of the concrete. The energy production was about six times less in comparison with the steel at the same strength.

EXAMPLE

To illustrate the properties of glued is considered an example of a curved beam (Fig. 2) as a simple cantilever beam ends and is part of the roof structure (Fig. 3). A comparison is made between solid wood and glued laminated timber. The materials are in accordance with БДС EN 338 and БДС EN

1194 for solid wood - strength class C14 and laminated wood class strength

GL 24. Cross-section of the beam is 16/34 cm. The beam is loaded with a constant load and snow, according to Regulation № 3 of 21 July 2004 on the basics of structural design of constructions and the actions on them. In order to facilitate the modeling using program Tower Demo 7 working on the finite element method. Calculations are based on current regulations for the design of wooden constructions on 01.07.1990.

For this beam are made and checks stress and deflections were compared with allowable.

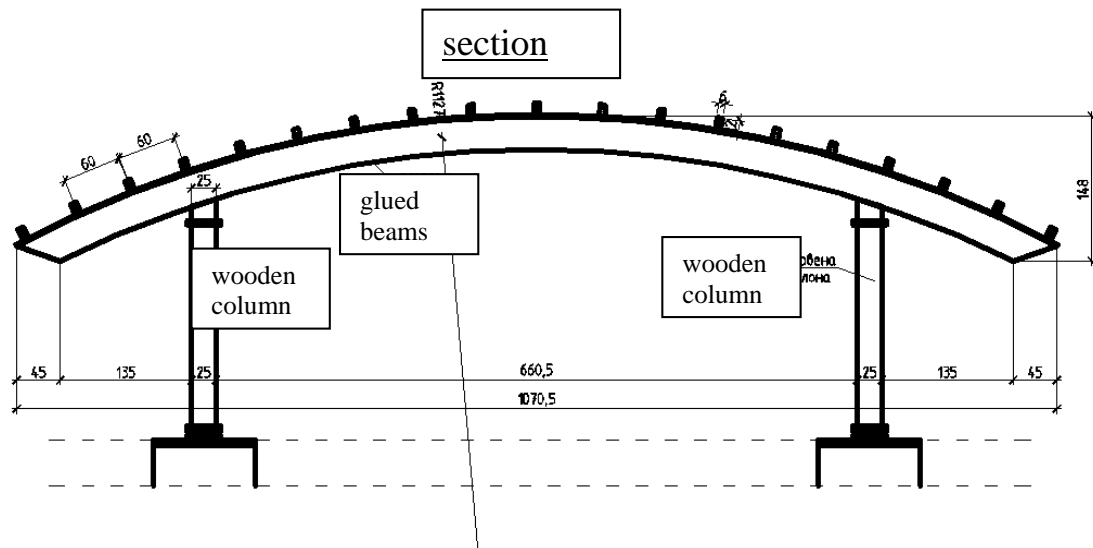


Figure 2: Arch beam

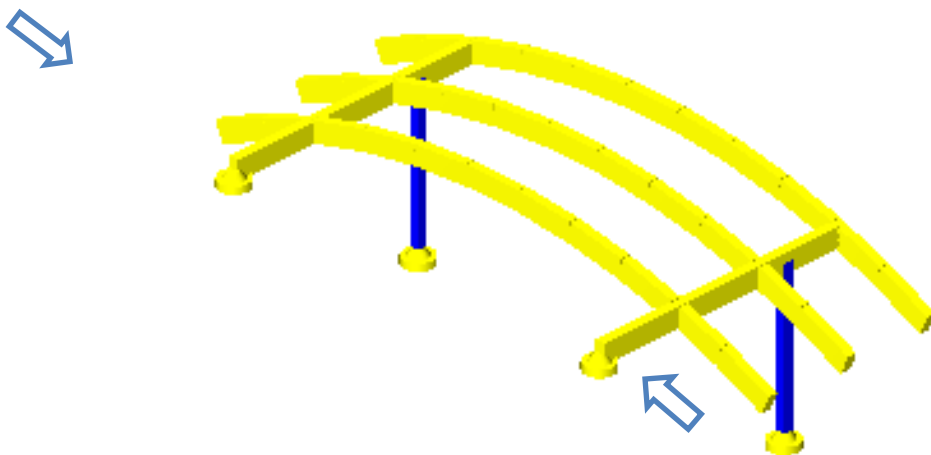


Figure 3: Isometric of wooden construction

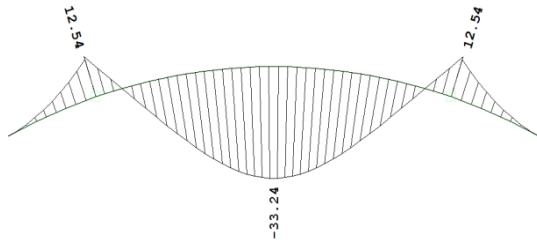


Figure 4: Bending moment of a beam with C14 material

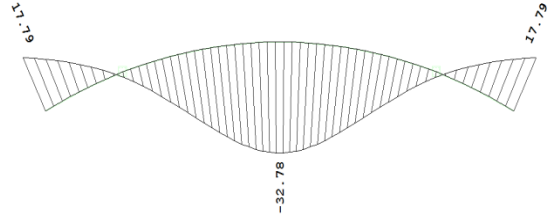


Figure 5: Deflection of beam with material C14

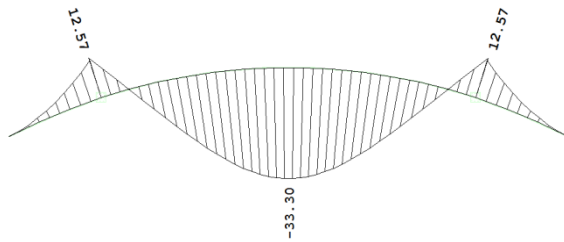


Figure 6: Bending moment of a beam with material in GL24

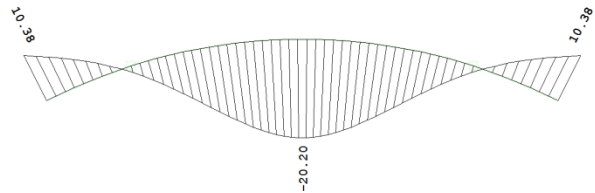


Figure 7: Deflection of beam with material GL24

1. CALCULATIONS

1.1. STRESSES FOR THE MATERIALS C14

$M = 33,24kN.m$ (fig.4)

$$W = \frac{b \cdot h^2}{6} \quad (1)$$

$$W = \frac{b \cdot h^2}{6} = \frac{16.34^2}{6} = 3082,67cm^3$$

$$\sigma = \frac{M}{W} \leq \gamma_{cb} \cdot R_b \quad (2)$$

$$\sigma = \frac{33,24 \cdot 100}{3082,67} = 1,08kN/cm^2 = 10,8N/mm^2$$

$$\gamma_{cb} \cdot R_b = 0,85 \cdot 1,4 = 1,19kN/cm^2 = 11,9N/mm^2$$

$$10,8 < 11,9N/mm^2$$

γ_{cb} – coefficient of condition of work in bending

R_b - flexural strength

M – bending moment

W – section modulus

1.2. DEFLECTION FOR THE MATERIAL C14

Deflection limit $\frac{l}{300} = \frac{660.10}{300} = 22mm$

22mm < 32,78mm (fig.5) C14 deflection is greater with the allowable

1.3. STRESSES FOR THE MATERIAL GL24

$M = 33,30kN.m$ (fig.6)

$$W = \frac{b \cdot h^2}{6} = \frac{16.34^2}{6} = 3082,67cm^3 \quad -$$

section modulus

$$\sigma = \frac{M}{W} \leq \gamma_{cb} \cdot R_b$$

$$\sigma = \frac{33,30 \cdot 100}{3082,67} = 1,08kN/cm^2 = 10,8N/mm^2$$

$$\gamma_{cb} \cdot R_b = 0,85 \cdot 2,4 = 2,04kN/cm^2 = 20,4N/mm^2$$

$$10,8 < 20,4N/mm^2$$

γ_{cb} – coefficient of condition of work in bending

R_b – flexural strength

1.4. DEFLECTION FOR THE MATERIAL GL24

$$\text{Deflection limit } \frac{l}{300} = \frac{660.10}{300} = 22\text{mm}$$

22mm > 20,20mm (fig.7) GL24 deflection is less with the allowable

CONCLUSION

From the described example, it is clear that the resulting stresses are smaller than the limit stress for the two materials C 14 and GL24. C14 in material stresses are close to limit stress, while at GL24 the difference is greater. Deflection material in C14 is greater than the limit, and if GL24 deflection is within an allowable. If the used solid pine material C24, then the stress is less than the limit stress, but the deflection is greater with the allowable for section 16/34 cm. This

increases the dimension of the section. In use of the larger cross-section is increased dead load. Curved shape can't be made with solid wood with similar section and loses the design elegance.

REFERENCES

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