UDC 624.011.7

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Design of timber structure in accordance with the requirements ДБН В.1.2.-2:2006

Abstract. In the article design of timber structures has been considered according national standards.

In article discusses an example of design methodologic for glulam arch.

A design methodology according new national standards ДБН В.1.2.-2:2006 has been developed for practical use. Check of the ultimate limit states is conducted in accordance with ДБН В.2.6-161:2017. Loads to the arch are determined according to ДБН В.1.2.-2:2006.

The usage new national standards comply with the actual requirements and widens methodological base.

Keywords: timber structures; glulam arch; design of building constructions.

УДК 624.011.7

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Проектування дерев'яних конструкцій у відповідності з вимогами ДБН В.1.2.-2:2006

Анотація. Розглянуто проектування дерев'яних конструкцій у відповідності до діючих національних будівельних норм. Як приклад у статті наведено конструктивний розрахунок дощатоклеєної арки за першим граничним станом згідно ДБН В.2.6-161:2017.

Методика розрахунку застосовується в навчальному процесі Національного університету «Полтавська політехніка імені Юрія Кондратюка».

Ключові слова: дерев'яні конструкції, дощатоклеєні арки, проектування дерев'яних конструкцій.

Introduction. Nowadays in Ukraine used new building codes that are adapted to European codes. There is a need to adapt the design methodology for the elements of timber structures.

The use of glued laminated members (glulam) for structural purposes the advantages of strength and stiffness to weight ratio, can be designed to have a high standard of architectural finish.

Glulam columns, beams, arches, trusses as a main components of braced frame structures are the most common. New national standards ДБН В.1.2.-2:2006 comply Eurocode 5 and all timber designs in the Ukraine must be carried out in accordance with this code.

A design methodology according new national standards ДБН В.1.2.-2:2006 has been developed for the use in Ukraine.

This article discusses an example of design methodologic for glulam arch.

For design of arch use rules of Ukrainian standard [1] which is based on rules [2]. In Ukraine should be use characteristic values of strength classes according [1, 2]. Loads for building construction can be used according rules of Ukrainian standard ДБН В.1.2.-2:2006 [3]. Dead loads determined rules of chapter 5 [3]. Snow (variable) loads determined rules of chapter 8 [3].

Basic material and results. Consider designing of glulam three-pin arch as a frame member accordance with the requirements [1,2]. The arch consists of two glulam beams (top chords) leaning against each other and with a hinged connection at the ridge. The beams (top chords) are straight and of constant depth. The bottom ends of the chords are connected by a tension steel or fiberglass member.

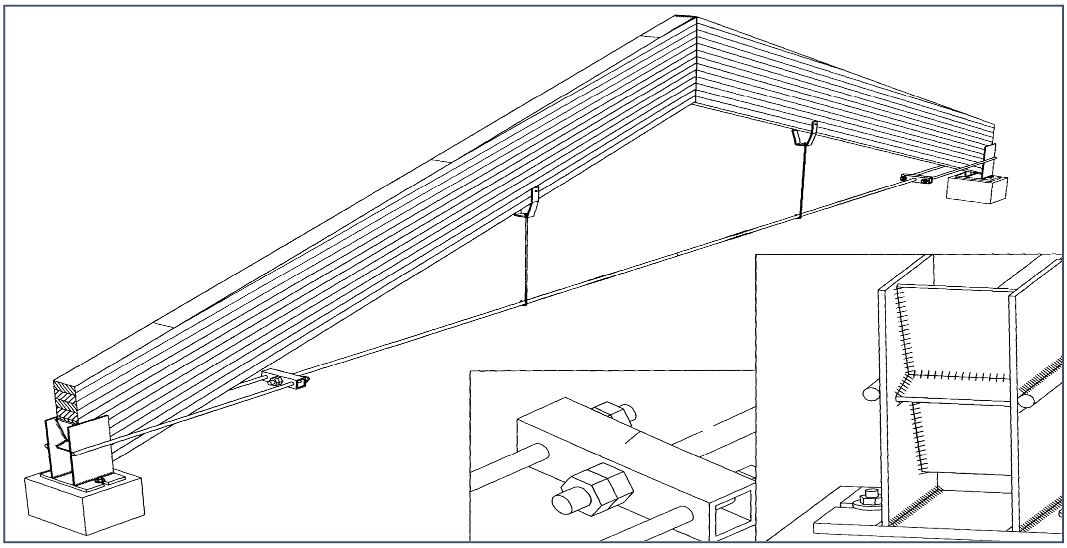

Fig. 1 – Glulam arch.

Design bending strength of glulam product:

$$f_{m,g,d} = f_{m,g,k} \cdot k_{mod} \cdot k_h / (\gamma_n \cdot \gamma_M),$$

were $f_{c,0,g,k}$– characteristic compression strength along the grain glulam members, ([1], Б3, Б4);

k_{mod} – factor for medium-duration loading (snow) and service class (A1, [1]);

γ_n – safety factor depending on the class of building and class of structure members;

γ_M – partial factor for material properties and resistance (Tab. 6.1, [1]);

k_h – depth factor (6.6.3, [1]). For rectangular glued laminated timber, the reference depth in bending or width in tension is 600 mm. For depths in bending or widths in tension of glued laminated timber less than 600 mm the characteristic values for $f_{m,g,k}$ and may be increased by the factor k_h, given by

$$k_h = \min\begin{cases}\left(\dfrac{600}{h}\right)^{0.1}\\ 1{,}1\end{cases},$$

were h – the depth for bending members in mm.

Design compressive strength of glulam product:

$$f_{c,0,g,d} = f_{c,0,g,k} \cdot k_{mod} \cdot /(\gamma_n \cdot \gamma_M),$$

were $f_{c,0,g,k}$ – characteristic compression strength along the grain glulam members ([1], Б3, Б4);

Design strength of local compression perpendicular to the grain:

$$f_{V,d} = f_{V,k}\ \ k_{mod} \cdot /(\gamma_n \cdot \gamma_M),$$

were $f_{V,k}$ –characteristic shear strength ([1], Б3, Б4).

For design top chord of arch set parameters of cross-section as bxh, were h is depth (h=δxn). Size of laminate members is bxδ (according dimensions of sawn and planning timber).

For unloading moment set eccentricity for line of internal force N about geometric axis.

Check stress under combined compression and bending (ULS) according 9.6.1 [1] and $\lambda_{real} > 0{,}3$:

$$\frac{\sigma_{c.0.d}}{k_{c,y} \cdot f_{c,0,g,d}} + \frac{\sigma_{m.d}}{f_{m,g,d}} = \frac{N_d}{A_{net} \cdot k_{c,y} \cdot f_{c,0,g,d}} + \frac{M_d}{W_d \cdot f_{m,g,d}} < 1,$$

were $k_{c.y} = \dfrac{1}{k_y + \sqrt{k_y^2 - \lambda_{rel.y}^2}}$ ([1], 9.3.3).

Slenderness:

$$\lambda = l_d / i_{min} = l_{ch} / (0{,}289 \cdot h).$$

Relative slenderness according 9.3.4 [1]:

$$\lambda_{rel.y} = \frac{\lambda_y}{\pi}\sqrt{\frac{f_{c.0.k}}{E_{0.g.05}}},$$

were $E_{0.g.05}$ – fifth-percentile modulus of elasticity parallel to the grain ([1], Б3, Б4).

Instability factor according 9.3.3 [1]:

$$k_y = 0{,}5 \cdot (1 + \beta_c(\lambda_{rel.y} - 0{,}3) + \lambda_{rel.y}^2),$$

were $\beta_c = 0{,}1$ – for glued laminated timber ([1], 9.3.3).

The stresses for stability of top chord should satisfy the following expression ([1], 9.6.1):

$$\left(\frac{\sigma_{m,d}}{k_{crit} \cdot f_{m,g,d}}\right)^2 + \frac{\sigma_{c,0,d}}{k_{c,z} \cdot f_{c,0,g,d}} \le 1.$$

Critical bending stress ([1], 9.4.4.2):

$$\sigma_{m,crit} = \frac{M_{y,crit}}{W_y} = \frac{\pi\sqrt{E_{0,g,05} \cdot G_{0,g,05} \cdot I_z \cdot I_{tor}}}{l_{ef} \cdot W_y} = \frac{\pi \cdot b^2}{h \cdot l_{ef}}\sqrt{E_{0,g,05} \cdot G_{0,g,05} \cdot \left(1 - 0{,}63\frac{b}{h}\right)},$$

were l_{ef} – distance between attachment points on top chord;

$E_{0.g.05}$ – fifth-percentile modulus of elasticity;
$G_{0.g.05} = 5 \cdot G_{g,mean}$ – fifth-percentile shear modulus.

Relative slenderness for bending according 9.4.4.2 [1]:

$$\lambda_{rel,m} = \sqrt{\frac{f_{m,g,k}}{\sigma_{m,crit}}}$$

Lateral stability factor (9.4.4.1, [1]):

$$k_{crit} = \begin{cases} 1 \quad \lambda_{rel.m} \leq 0{,}75 \\ 1{,}56 - 0.75 \cdot \lambda_{rel.m} \quad 0{,}75 < \lambda_{rel.m} \leq 1{,}4 \\ \dfrac{1}{\lambda_{rel.m}^2} \quad otherwise \end{cases}$$

Instability factor ([1], 9.3.3):

$$k_z = 0{,}5 \cdot (1 + \beta_c(\lambda_{rel.m} - 0{,}3) + \lambda_{rel.m}^2)$$

Instability factor $k_{c.y}$:

$$k_{c.z} = \frac{1}{k_z + \sqrt{k_z^2 - \lambda_{rel.m}^2}}$$

Conclusion. For design cross-section of glulam arch according national building Ukraine standard, it can apply a design methodology of university education. The presented design methodology can be used to design timber structure under combined compression and bending (ULS) in accordance with the requirements ДБН В.1.2.-2:2006.

References

1. ДБН В.2.6-161:2017. Дерев'яні конструкції. - К.: Мінрегіонбуд України, 2017. - 111 с.

2. EN 1995-1-1 (2004) (English): Eurocode 5: Design of timber structures - Part 1-1: General - Common rules and rules for buildings [Authority: The European Union Per Regulation 305/2011, Directive 98/34/EC, Directive 2004/18/EC]

3. ДБН В.1.2.-2:2006. Навантаження і впливи. - К.: МБА та ЖКГ України, 2006. - 60 с.