Plancglued wood construction with prestressed non-metallic fittings

Mykhailo Surmai

Department of building structures and bridges, Lviv Polytechnic National University, UKRAINE, Lviv, Karpinskoho St. 6,
E-mail: mychajlo_surmaj@ukr.net

In the article is proposed a methods of anchoring and testing of prestressed nonmetallic reinforcement in timber beams. Offer examples of principal model and recommendations.

Keywords – fiberglass plastic, fiberbasalt plastic, structural timber works, prestressed reinforcement.

I. Introduction

Nonmetallic polymeric composites are now widely used in defense, aerospace and engineering industries. Using nonmetallic reinforcement in building structures is an alternative to their use in buildings with high aggressive environment or the presence of electromagnetic waves. She has such characteristics as corrosion resistance, non-magnetic properties, insulation, and is resistant to cyclic freezing and thawing [1].

Composite fittings consists of oriented glass or basalt fibers and a polymer binder. Actually they determine the properties and characteristics of composite structures. Fibres fully accept compressive and tensile force. Polymeric binder acts as an adhesive environment, combines fiber solid rod and protects them from moisture, chemicals and mechanical damage, because as anisotropic material fiber can withstand lateral loads from compression to 10% of the tensile strength of the longitudinal tension. Alkaline environment of concrete penetrating through the micropores in the polymer matrix reduces the strength of the fibers. To do this, on the surface of the composite reinforcement applied a special thin polymer film [2].

II. Anchoring non-metallic fittings

Experimental tests of glued wooden structures reinforced non-metallic fittings are held at the Department of Building Structures and Bridges and at the Department of Bridges and Structural Mechanics University "Lviv Polytechnic" in 2010. In particular, a study was conducted grip wood samples with metal, fiberglass and fiberbasalt reinforcement at different length anchoring [3]. The results showed underutilization strength of each type of valve (Fig. 1) by breaking down the clutch with wood through epoxy adhesive ED - 1. To solve this problem, it was proposed to use additional anchor measures such as installation of mechanical anchors, or a change in the surface of the valves by creating higher engagement ribs.

Under the direction of prof. Demchyna B.G. designed a special collet clamping mechanism (TSZM-1) (Fig. 2), which provides retention end fittings at the ends of beams and increases the grip reinforcement with wooden structures and its effective use. Collet clamp allows also manufacture prestressed structures with nonmetallic reinforcement. The device consists of a case 1 with a longitudinal conical hole into which are inserted elastic collet 2 and clamped with blank nut 3 still locking installed rebar. Special clutch 4 is designed to create a preloading valves, put in a groove wooden beams.

III. Prestressed wood construction

The research of wooden structures with steel reinforcement engaged I.M. Lin'kov, V.F. Bondin, V.Ju. Shhuko and others [4]. It defines the parameters for efficient and reliable design of such structures. Also found that the application of prestressing reinforcement in wooden structures increases their effectiveness. The use of fiberglass reinforcement in wooden structures first shown B.V. Nakashidze [5], and research of prestressing engaged M.A. Kljajman [6]. The analysis of published works in the field of reinforcement wood showed, that design with fiberglass reinforcement studied to a much lesser extent than with metal, and research wooden structures with fiberbasalt reinforcement virtually no.

The use of metal reinforcement in prestressed wood construction greatly reduces their effectiveness. Changing the temperature and humidity regime between production and operating conditions can create strain in the structure, aggressive environment can contribute to corrosion of reinforcement. This not only reduces the durability of reinforced elements, but also causes their state of emergency. Basic operational characteristics of composite reinforcement (AKS, AKB) fittings are given in Table 1.

Fiberglass and fiberbasalt reinforcement are 3 - 4 times lower modulus of elasticity than metal, the coefficients of linear expansion of wood and non-metallic fittings are close in value, which creates a significant advantage when using it for the reinforcement of glued wooden structures.

Scheme of the test bench for prestressed wooden beams shown in Fig. 3. These structures can be used in buildings for special purposes where the use of metal fittings is not recommended. Besides the fact that reinforcement increases the strength and rigidity of structures, it reduces the cost compared to unreinforced with similar characteristics for 25 - 30% (Fig. 4).

In wooden structures fittings entirely in epoxy resin that protects the fiber even after prestressing, which destroys the surface polymer film. Whereas, to eliminate the influence of alkaline environment on composite rebar in concrete is necessary to use special additives.

For the application of prestressed non-metal reinforcement in wooden structures necessary to conduct comprehensive experimental studies of the coupling it with the timber to the study of strength and rigidity of these structures.

The research program provides test beams of laminated wood cross section 210x100 mm and 2700 mm span, which reinforced prestressed fiberbasalt reinforcement attached to the ends of the collet mechanism TSZM-1 to prevent retraction of the ends and create prestressing. Calculation of stresses in the wood and fittings will be conducted by equation (1) and (2), taking into account the creep of wood under conditions secure grip reinforcement [6].

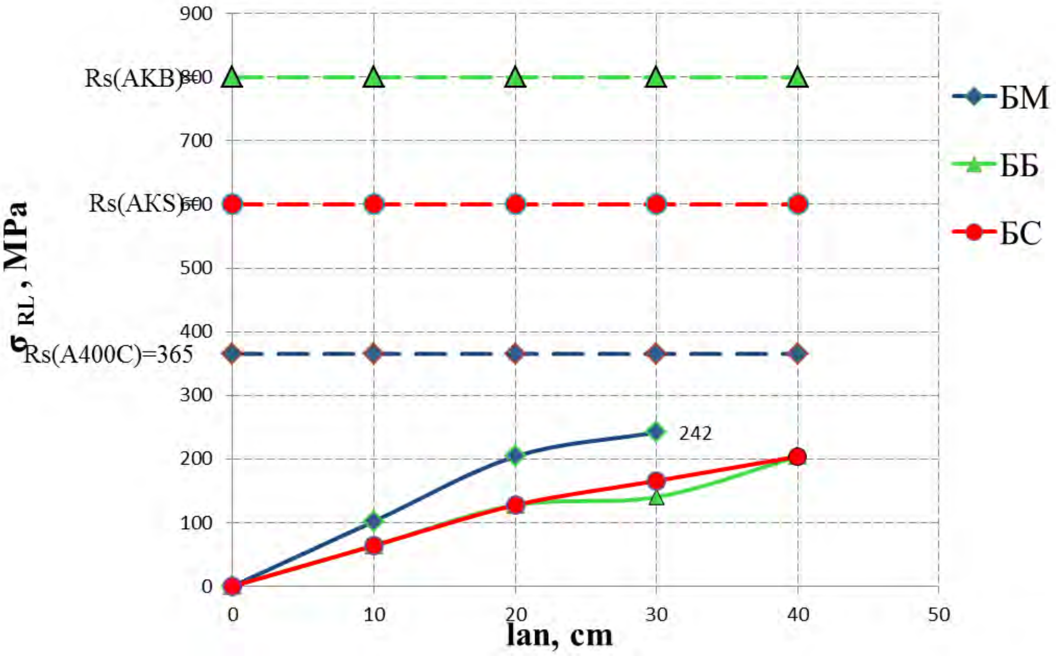

Fig. 1. The dependence of the stress in the reinforcing rods in the boundary condition σ_{RL} grip on the length of anchoring l_{an}. BM, BB, BS - according samples of metal, fiberbasalt and fiberglass reinforcement

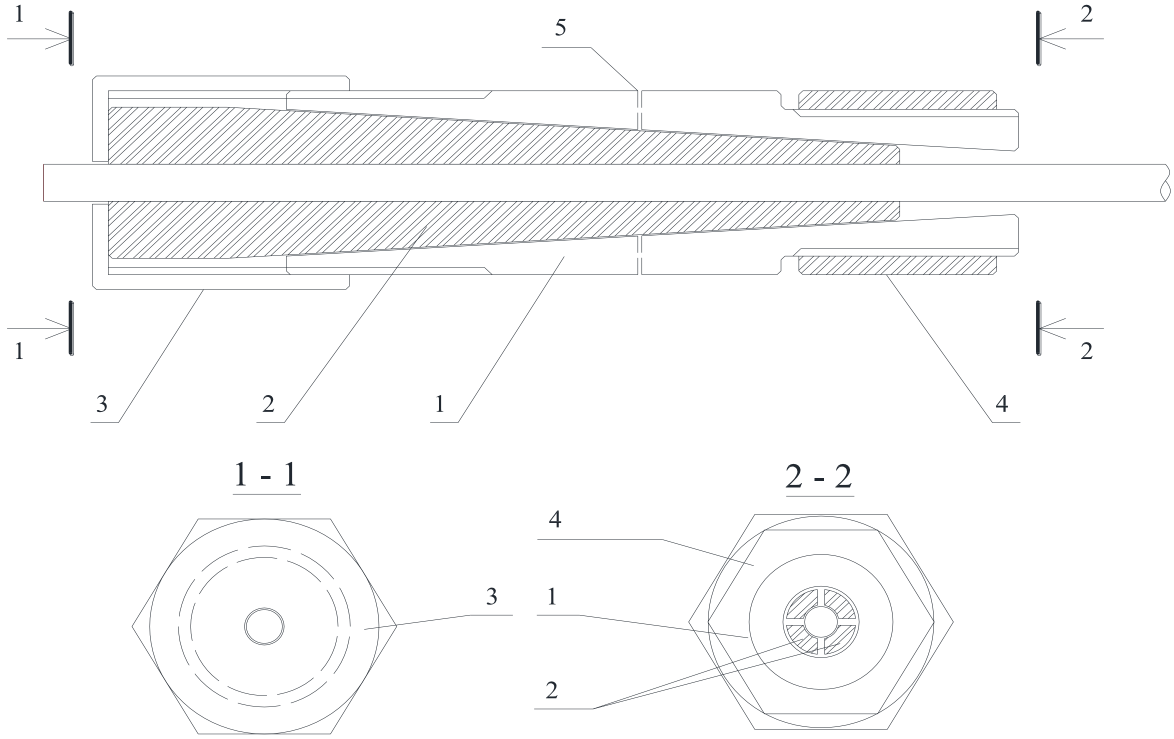

Fig.2. Scheme collet clamping mechanism TSZM-1. 1 - casing, 2 - collet, 3 - blank nut, 4 - coupling, 5 - hole for collet lubricate

TABLE 1

SPECIFICATIONS FIBERGLASS (AKS) AND FIBERBASALT (AKB) REINFORCEMENT

№	CHARACTERISTICS	AKS	AKB
1	Temporary resistance to tensile, MPa	1200	1800
2	Modulus of elasticity in tension, MPa	55	70
3	Relative elongation after rupture, %	2	
4	Temperature coefficient of linear expansion	$0{,}58 \cdot 10^{-5}$	
5	Electric strength in the initial state, kV / cm	12	
6	Electrical resistance in the initial state, GOhm	20000	

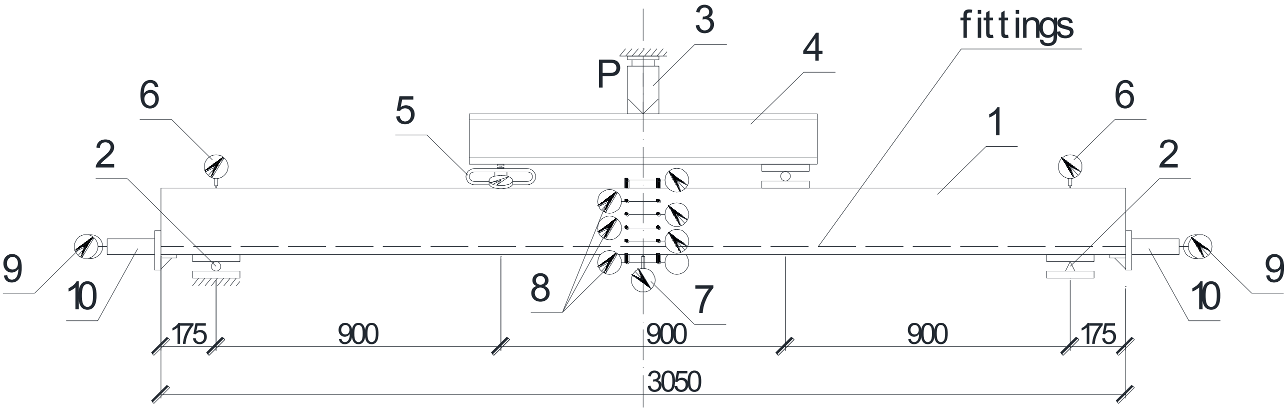

Fig.3. Scheme of the test stand for prestressed wooden beams: 1 - prototype, 2 - bearing hinges, 3 - hydraulic jack, 4 - distribution traverse, 5 – dynamometer, 6 - deflections indicators, 7 - the central indicator, 8 - microindicators 9 – microindicators on the ends fittings, 10 - collet TSZM-1

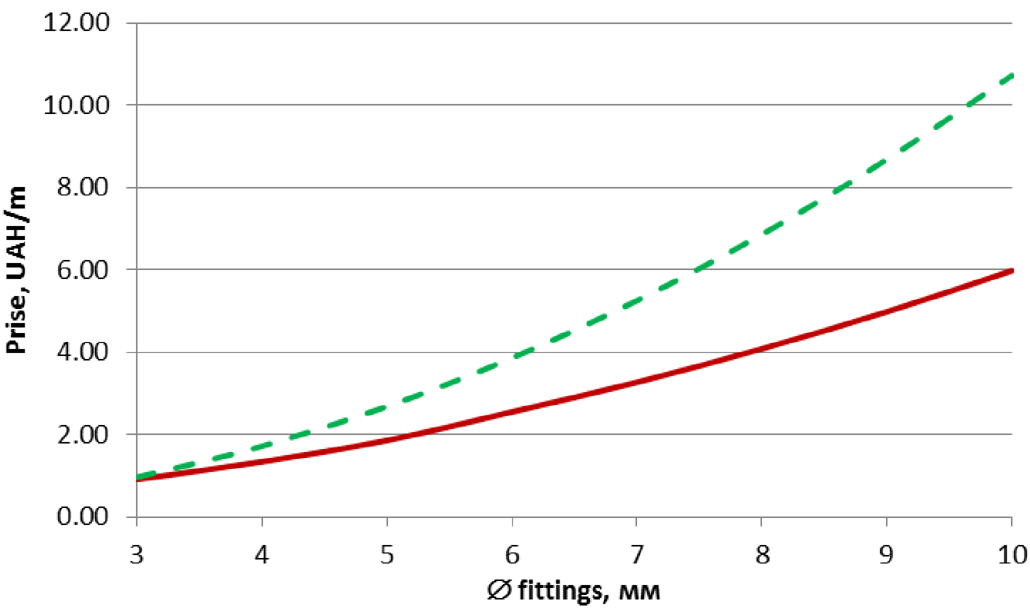

Fig.4. Comparing the cost of 1 m reinforced (1) and unreinforced (2) plancglued wooden beams with the same load capacity and rigidity

$$\sigma_{\partial}(t)=\frac{N_{01}}{F_n}\left[\frac{\alpha_1}{\beta}+\left(1-\frac{\alpha_1}{\beta}\right)e^{-\beta(t_1+t)}\right]\pm$$
$$\pm\frac{N_{01}\cdot e_0\cdot y}{I_n}\left[\frac{\alpha_1}{\beta_1}+\left(1-\frac{\alpha_1}{\beta_1}\right)e^{-\beta_1(t_1+t)}\right]\pm \qquad (1)$$
$$\pm\frac{M\cdot y}{I_n}\left[\frac{\alpha_1}{\beta_1}+\left(1-\frac{\alpha_1}{\beta_1}\right)e^{-\beta_1 t_1}\right]$$

$$\sigma_a(t)=\frac{N_{01}\cdot F_{\partial}}{F_a\cdot F_n}\left[\frac{\alpha_1}{\beta}+\left(1-\frac{\alpha_1}{\beta}\right)e^{-\beta(t_1+t)}\right]\pm$$
$$\pm\frac{N_{01}\cdot I_{\partial}}{F_n\cdot I_n}\left\{\frac{I_n}{I_{\partial}}-\left[\frac{\alpha_1}{\beta_1}+\left(1-\frac{\alpha_1}{\beta_1}\right)e^{-\beta_1(t_1+t)}\right]\right\}+ \qquad (2)$$
$$+\frac{M\cdot e_0\cdot E_a}{I_n\cdot E_{\partial}}\left[\frac{A_1+\alpha_1}{\beta_1}+\left(1-\frac{A_1+\alpha_1}{\beta_1}\right)e^{-\beta_1 t_1}\right]$$

де N_{01} – efforts prestressing reinforcement taking into account all losses other than loss of creep of wood; M – bending moment of the external load; F_n, I_n – given area and moment of inertia design section; $F_a, F_{\partial}, E_a, E_{\partial}$ – sectional area and modulus of elasticity of reinforcement and wood; I_a, I_{∂} – moments of inertia of areas F_a and F_{∂} relative to the neutral axis of section; e_0 – eccentricity of application N_{01} relative to neutral axis; y – distance from the neutral axis to the current layer; t_1 – beam exposure time without external loading, days;

t – beam exposure time after loading, days.

$$\beta=\alpha_1+\frac{A_1\cdot m}{1+m},\quad \beta_1=\alpha_1+\frac{A_1\cdot m_1}{1+m_1},$$
$$m=\frac{E_a\cdot F_a}{E_{\partial}\cdot F_{\partial}},\quad m=\frac{E_a\cdot I_a}{E_{\partial}\cdot I_{\partial}},$$
$$A_1=0.0275,\quad \alpha_1=0.0625.$$

Substituting in equation (1) and (2) the value t_1 and t equal to zero, we get elastic-momentary solution of the problem.

This principle was used by the authors [4, 6] for research of wooden beams with metal fittings, excluding consideration of prestressing, as composite rebar is elastically until the break, and upon the occurrence of a metal fittings strength prestressing effect disappears.

Conclusion

1. Previous studies of wooden beams with non-metallic reinforcement have shown their reliability and efficiency.
2. Lack of standards, guidelines and design standards significantly hinder the process of widespread use of such structures, and this applies even more prestressed wooden structures with nonmetallic reinforcement.
3. Create technically possible to perform non-metallic prestressing reinforcement of wooden structures by applying the proposed collet clamping mechanism will enable broad applications.

References

[1] H.Sh. Salyia and A.L. Shahyn, Betonnye konstruktsyy s nemetalycheskym armyrovanyem. M.: Stroiyzdat, 1990.
[2] N.P. Frolov, Stekloplastykovaia armatura i stekloplastbetonnye konstruktsyy. M.: Stroiyzdat, 1980.
[3] B.H.Demchyna, D.O.Oreshkyn and M.I. Surmai, “Vyznachennia maksymalnykh dotychnykh napruzhen metalevoi ta nemetalevoi armatury v doshchatokleienykh pryzmakh”, Sovremennye stroytelnye konstruktsyy iz metalla i drevesyny: Sbornyk nauchnykh trudov, vol. 15, no. 3, pp. 34 – 39, Mai 2011.
[4] V.Iu. Shchuko, Ed., Kleenye armyrovannye dereviannye konstruktsyy: Uchebnoe posobye, SPb.: HYORD, 2009.
[5] B.V. Nakashydze, Ispolzovanye stekloplastykovoi armatury v kleenykh dereviannykh balkakh: avtoref. dys. na soyskanye uch. stupeny kand. tekhn. nauk: spets. 05.23.01 «Stroytelnye konstruktsyy», Mynsk: 1973.
[6] M.A. Kliaiman, Izghyb predvarytelno napriazhennykh dereviannykh kleenykh balok so stekloplastykovoi armaturoi pry dlytelnom deistvyy nahruzok: avtoref. dys. na soyskanye uch. stupeny kand. tekhn. nauk: spets. 05.23.01 «Stroytelnye konstruktsyy», M.: 1985.