Development of constructive solutions for interfaces of wooden beams and CLT

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Abstract. Today, the issue of the development of joints of wooden elements, in particular the joints of CLT and wooden beams, is topical. The aim of the work is to develop a nodal connection of wooden beams and CLT, which has increased reliability and has no drawbacks compared to the existing options for such connections in the world. The article presents the main existing ways of connecting wooden beams and CLT, their features, advantages and disadvantages are considered. Based on the world experience in joining wooden beams and CLT, it can be concluded that in most cases, for such purposes, factory-made metal supports of open or closed beams of various designs and shapes are used. The main disadvantage of such methods of connecting the considered wooden elements is the impossibility of making the connection hidden. This leads to a complete lack of fire protection of the connecting elements. It also requires additional finishing measures for supporting structures for an aesthetic purpose, which in turn increases the cost of construction. As a result, a constructive solution for the joints of wooden beams and CLT was developed, which has increased reliability compared to the studied joints and is devoid of their shortcomings.

Keywords: connection of wooden elements, CLT, wooden beams, metal plates, screws.

1 Introduction

Currently, there are various options for connecting wooden elements of building structures. Today, CLT is one of the main progressive technological and design solutions for creating structures based on wooden elements for various purposes. Therefore, the issue of developing constructive and technological solutions for connecting wooden elements, in particular, the interface of CLT and wooden beams, is relevant.

Based on the world experience in joining wooden beams and CLT, it can be concluded that in most cases, for such purposes, factory-made angles or beam supports of open or closed types of various designs and shapes are used [1-3]. The main disadvantage of such methods of connecting the considered wooden elements is the impossibility of making the connection completely hidden. This leads to a complete lack of fire protection of the connecting elements. For this reason, in the event of a fire, excessive heating of the metal elements and destruction of the connection is possible.

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In addition, the disadvantage is that the connection is open, fully visible, this requires additional measures to finish the supporting structures for an aesthetic purpose, which in turn increases the cost of construction. Also, the disadvantage of many technical solutions is that the stiffeners designed to increase the rigidity and bearing capacity of the supports can complicate the process of their fastening to wooden elements if nails are used for these purposes [4-5].

The aim of the work was to develop a nodal junction of wooden beams and CLT, which has increased reliability compared to the studied joints and is devoid of their shortcomings.

2 Methods

It is possible to solve the problem of insufficient fire protection of joints using a hidden method of mounting connecting elements, but in the case of beam supports existing in world practice, it turns out to be problematic to provide a closed version of the connection of wooden elements.

The use of various materials that protect the supports from direct exposure to high temperatures, for example, layered thermal expansion tapes, will increase the insufficient fire protection of the joints. But at the same time, due to the fact that such joints are open, in order to increase their aesthetic parameters after the use of additional materials to increase the fire protection of joints, it will be necessary to use additional finishing measures for supporting structures, which in turn increases the cost of construction.

However, according to global trends, more and more often in recent years in architecture such joints do not provide for additional finishing and structural elements must remain open, in such cases, such methods of increasing the fire protection of joints turn out to be unacceptable.

3 Results

Based on the analysis of the previously considered methods of connecting wooden beams and CLT, other less common methods of connecting such elements, previously conducted studies and the studied literature, a constructive solution for pairing wooden beams and CLT based on metal overlays was developed [6-20].

The developed connection unit is devoid of the shortcomings of the studied joints and has increased reliability in comparison with them due to the design of the linings themselves, the absence of contact between the tongue and groove of the linings in their lower parts, the notches on the sides of the metal linings attached to wooden elements and, as a result, an increase in the coefficient of friction of the surfaces, the fact that the cross sections of the tongue and groove of the linings have a large degree of expansion in the form of a wedge in the longitudinal direction of application of the load to the connection, the fact that the length of the screws screwed into the lining with a groove is greater than the length of the screws screwed into the lining with the tongue, the fact that all the holes for the screws are placed at an angle of 90° to the surface of the lining into which the screws are screwed.

Also, the goal can be achieved due to the impregnation of wood with adhesive compositions uniform in height and depth of the hole in the area of the screw thread and beyond due to an increase in the working area of the screw, an increase in the degree of adhesion of the screws to the walls of the holes, leveling possible violations of the wood structure within the threaded connection, the formation of after polymerization of the glue of the modified layer of wood with increased physical and mechanical characteristics of
wood nests around the screws - the most stressed joint zone, increasing the depth of impregnation of wood around the screw due to the creation of pressure on the glue in the holes at the time of screwing in and pressing it into the walls of the holes, introduction into the structure of the connection adhesive layer between the back surface of the metal lining and the wooden element.

4 Discussion

A general view of the developed connection node is shown in Figures 1, 2 and 3. The node is a detachable connection of a CLT wall panel and a laminated timber beam (LVL beams as an example), consisting of connected elements (CLT wall panel, LVL beams), timber and connecting elements (two steel plates (one with a tenon, the other with a groove), the cross-sections of the tenon and groove of which are dovetail-shaped and expand in the form of a wedge in the longitudinal direction of application of the load to the connection, which are fixed to two wooden elements with glue-screwed screws, to form a rigid and reliable connection according to the dovetail principle and transfer loads from one element to another). Between the screw and wood, as well as between the metal plate and the wooden element, there is an adhesive layer of epoxy resin and hardener. This solution provides a reliable perception of forces inside the connection in all directions (perception of torques in three mutually perpendicular directions and forces in tension and compression), with the exception of those that are directed in the direction opposite to the loading of the connection and lead to separation of the linings. All holes for screws are placed at an angle of 90° to the surface of the lining into which the screws are screwed. The cross sections of the tongue and groove of the linings have a large degree of expansion in the form of a wedge in the longitudinal direction of the application of the load to the connection. There is no contact between the thorn and the groove of the linings in their lower parts. Structural alloyed steel is used as the material for the manufacture of connecting elements. Notches are made on the sides of the metal plates attached to the wooden elements. They can be single, double cross, rasp or arc. The shape of the tongue and groove of the linings provides a self-centering effect for the possibility of connecting the linings without significant forces and shocks and reliable connection of the linings without unwanted jamming, even in case of misalignment of the linings and their initially incorrect position relative to each other. The cross-sectional shape of the dovetail slot with a wedge-shaped flare makes it easy to insert the tenon pad into the slot pad. A gap of 3 mm is made between the spike of the lining with a spike and the groove of the lining with a groove in their narrow parts in the vertical direction to ensure the distribution of internal stresses arising when the joint is loaded along the length of the side faces of the spike and groove.
Fig. 1. Scheme of the location of the metal plate on the CLT wall panel

Fig. 2. Scheme of the location of the metal plate on a beam of laminated wood (as an example - on a beam of LVL timber)
Due to the design of the connecting elements presented in this utility model, the installation of linings on wooden elements is mainly carried out in the factory, and not at the construction site, only the wooden elements are connected to each other at the construction site, as a result of which the quality of the work performed increases and the probability and number of installation errors and inaccuracies, as a result, labor productivity increases, industrialization and the speed of assembling structures at the facility increase. The pre-assembly of the linings on the connected elements and their mating can be performed...
easily, quickly, reliably and at the same time with an extremely low level of risk of damaging the linings during their connection, with minimal requirements for the positioning tolerance of the linings and without significant financial costs.

The fastening of the metal plates to the wooden elements is carried out with glued screws that pass through the holes in the plates and press the back side of the plate to the wooden element. Glued screws are placed at an angle of 90° to the end of the wooden element to which the overlay is attached.

For diffusion impregnation of wood around a pre-drilled hole at atmospheric pressure without the use of high pressure and special equipment, the walls of the hole were preliminarily impregnated with glue by gradually filling the hole with a low-viscosity adhesive composition using a syringe and a needle.

An overlay with a groove is fixed to a wooden element, into which the screws are screwed along the wood fibers, an overlay with a spike is fixed to a wooden element, into which the screws are screwed across the wood fibers. The total length of the screws screwed into the escutcheon with a groove is greater than the length of the screws screwed into the escutcheon with a tenon.

An adhesive composition is applied to the back surface of the lining. Epoxy resin ED-20 and hardener TETA, epoxy resin ED-20 and hardener PEPA, epoxy resin DER-331 and hardener TETA, epoxy resin DER-331 and PEPA hardener.

The connection can be made in an open way without milling a groove in the LVL beam, provided that fire protection is provided by filling the gaps formed after the installation of metal linings, for example, with wooden inserts, which in the event of a fire will prevent the spread of fire to the metal linings and their heating and not will degrade the architectural expressiveness of the connection.

Also, the connection can be made by the closed method of milling the groove in the beam from the LVL beam. In this case, the width of the sides of the fire unprotected from joining with all, except for the lower one, consists of 5 mm, it is experimentally confirmed that such a gap size does not require increased measures of fire protection of the overlays. From the bottom side, this value takes 15 mm. The lower gaps can be blocked by natural deposits, which, in the event of a fire, will prevent the spread of fire to the metal plates and their heating and will not worsen the architectural tension of the joints. Also, thanks to the found successful completion, it is possible to achieve an improvement in the sealing effect, increase the airtightness and thermal insulation of the building in its structures, in particular, reduce the likelihood of insects, gases and emissions penetrating and spreading within the formation.

The location of metal plates on wooden elements, the location of holes in wood and metal plates, as well as the minimum allowable distances from the edges of wooden elements to the ends of metal plates are assigned taking into account the requirements for the arrangement of holes established by SP 64.13330.2017 "Wooden structures" and SP 16.13330.2017 "Steel structures".

5 Conclusions

The studies carried out made it possible to develop a constructive solution for the joints of wooden beams and CLT-panels based on metal linings, which has increased reliability compared to the studied joints and is devoid of their shortcomings. The developed connection can be made completely hidden. This provides sufficient fire protection of the connecting elements. In addition, the connection does not require additional finishing measures for supporting structures for an aesthetic purpose, which in turn does not increase
the cost of construction and corresponds to the recent global trends in architecture, when such connections do not provide for additional finishing and structural elements should remain open. The developed connection unit can be used in the construction, reconstruction and restoration of wooden buildings and structures for various purposes, including multi-storey and large-span ones.

References


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