Constructive Solutions for Nodal Joints of Wooden Elements with Steel Rods Glued into them along the Grain

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ABSTRACT

The structural solutions of nodal joints considered in the review indicate that joints on glued-in rods are found in almost all types of wooden elements: beams, columns. In addition, wooden elements are joined through rods with reinforced concrete or steel elements, while the versatility of the joints on the glued rods can be noted.

KEYWORDS: *structure, wood, connection, fibers, reinforcement, knot, force, holes, column, joint.*

1. CONNECTION INFORMATION

As is known [2], the efficiency of wooden structures increases with an increase in their spans. In this case, an increase in the spans and heights of buildings is achieved due to an increase in the design forces in the structural elements. In this regard, the main problem is not only the development of element structures, but also the available structural node connections.

Traditional solutions of joints, for example, on bolts, pins made of steel and fiberglass, on toothed plates, claw washers due to the high flexibility in the above cases are not always possible for the mating of elements. All this led to the need to develop more efficient types of nodal joints of wooden structures.

Among the new types of joints that allow creating nodes of high bearing capacity and rigidity, the most promising are joints on steel rods glued into the wood. The development and manufacture of epoxy resin-based waterproof adhesives and sufficient adhesion to wood and metal have contributed to this type of bond.

Various possible types of connections of wooden elements on glued rods differ in bearing capacity and stiffness, depending on the gluing of the rods relative to the direction of the wood fibers and their placement in the volume of wooden elements, as well as the type and position of the force applied to the rod. The last two conditions, in our opinion, have a significant effect on the stress-strain state of the joints. To analyze the existing design developments of joints on glued-in steel rods (SHS) and their sufficient representation when writing a review, we will use the classification [3], according to the following characteristic features:

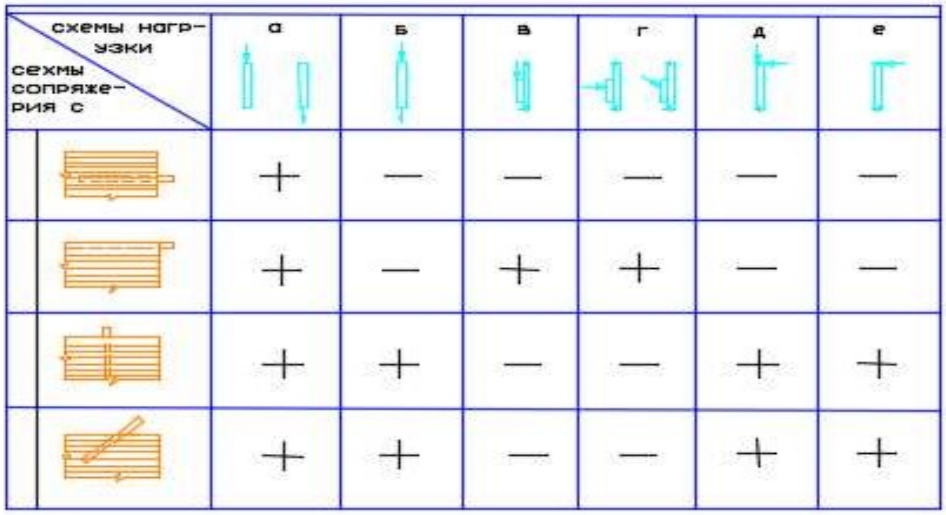
- according to the load scheme (to the middle part, to the free end, to the two ends), as well as in the direction of the application of forces to the rod (at an angle, tolerably or perpendicular to them);
- according to the scheme of interfacing with wood (inside the volume, on the surface), as well as in the direction of the fibers (along, across and at an angle to it).

The classification system in tabular form is shown in table. 1.1. A plus sign (+) in it marks a positive assessment of the possibility of use, a minus sign (-) - a negative one.

The review highlights the design solutions of nodal joints glued along the grain of wood - in accordance with the topic of this study.

In addition, connections on glued steel threaded bolts and GRP reinforcement are not considered. It is assumed that these connections have their own specific manufacturing and stress state.

Table 1.1



The use of a connection on glued rods in timber structures is a young trend in the field of nodal connections. Despite this, the connections on the glued rods are fairly well researched. Strength characteristics of this type of connection were studied in the works of V.F. Bondina, Yu.B. Vylegzhanina, G.N. Zubareva, S.V. Kolpakova, I. G. Ovchinnikova, N. D. Pospelov, S.B. Turkovsky, A.S. Freidin and others (3,4,5,6,7,8).

The works note a number of positive properties related to joints on reinforcing bars glued into the wood along the fibers, and also determine the strength and durability of the joints under the condition of short-term and long-term loading.

In addition, in the works, the influence of temperature and air humidity on the adhesion strength and the stress-strain state of the adhesive composition of the reinforcing bar with wood was studied, and engineering methods for calculating joints on steel rods were proposed. The first studies date back to 1967-1968.

Soyuzdor Research Institute [4] manufactured and tested more than 300 different samples and designs in order to find the most reliable ways to connect pins to wood, to reveal the influence of various factors on the operation of the joints. As a result of the research, the field of application of the joints was revealed, proposals were made for their calculation, and their effectiveness was assessed. Metal consumption for such joints is 10 times less than for joints with dowel joints and glue washers. The joint is strong, compact, has no protruding parts, does not require special protection of steel elements from corrosion.

The proposed connections (Fig. 1.1) can be used, according to the authors, as an assembly joint for conventional wooden and glued structures operating in tension, compression and bending. According to the classification proposed above, the joint refers to cases a1 (central tension, compression and pure bending) and d1 (bending in the presence of a transverse force). In accordance with the table. 1.1 the first case d1 is not desirable, this is due not only to the weak work of the wood to crush the

rods in the direction across the grain, but also to technological difficulties.

The joint disadvantage associated with poor perception of the lateral force is to some extent eliminated by the solution proposed by Khabarovsk PI [5]. For this, toothed plates (Fig. 1.2) with holes for the passage of the glued rods are pressed into the ends of the elements to be connected. Therefore, having support on the plates, the rods are able to perceive to a certain extent the lateral force. The limitation in the perception of force is associated with the pliability of the connection of the plates to the wood with the help of teeth pressed in this case along the fibers. It should be noted that the authors also tried to eliminate technological difficulties, for which there is provided an exit of channels for gluing the rods on the surface of the faces of the elements to be connected.

–1 A fundamentally different approach to solving a joint on glued-in rods was proposed at NISS [6]. Distinctive features of this constructive solution are the prefabrication of the joint, located the grooves for the rods on the surface of the elements to be joined, and, finally, for the first time, the application of forces to the rods is carried out in the middle of their length,

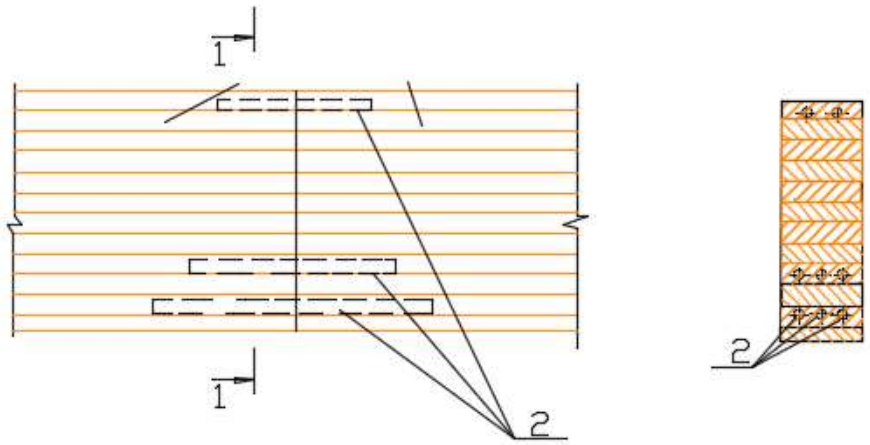


Fig. 1.1 The joint of a wooden beam (SoyuzdorNII): 1 - joined wooden elements; 2 - glued-in reinforcing bars

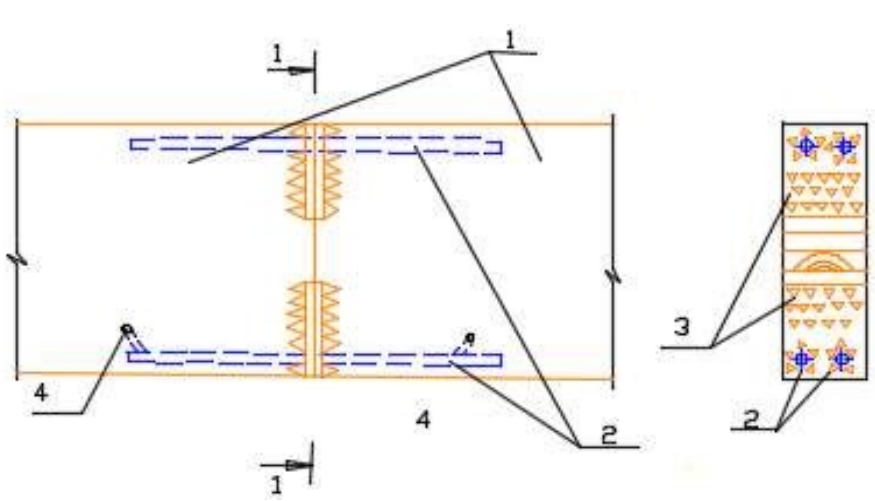


Fig. 1.2 Node of connection of elements of wooden structures (Khabarovsk PI): I - joined wooden elements;2 - reinforcing bars; 3 - toothed metal plates; 4 - through holes for air outlet

(according to the classification - a combination of B2), which makes it possible to improve the distribution of shear stresses in the joint. The butt connection can be used for symmetrical (Fig. 1.3)

and non-symmetrical connections. Efforts are transferred through the plates welded to the rods before they are glued into the grooves; the constructive solution requires the setting of tie bolts.

It should be noted that the design solution can have many options: two thinner elements can be overlays at the junction of more than two thicker ones; these linings can be completely steel; with the help of such steel plates, the wooden element can be fixed to the foundation (the plates turn into anchors), etc.

The column support node is the most common area of application of SHS, which is determined by the specifics (wood is combined with concrete) and the established tradition of using steel connecting elements. The greatest interest in solutions for fastening wooden columns to foundations with the help of SHS is shown at the present time, the first proposals in this regard in the domestic design practice date back to the early 70s [7]. On the basis of the experience of Finnish construction companies, which embed reinforcing rods glued into columns in wells of concrete or reinforced concrete foundations, a similar fastening to a welded steel shoe has been proposed, which in turn can be fixed to the foundation using conventional anchors.

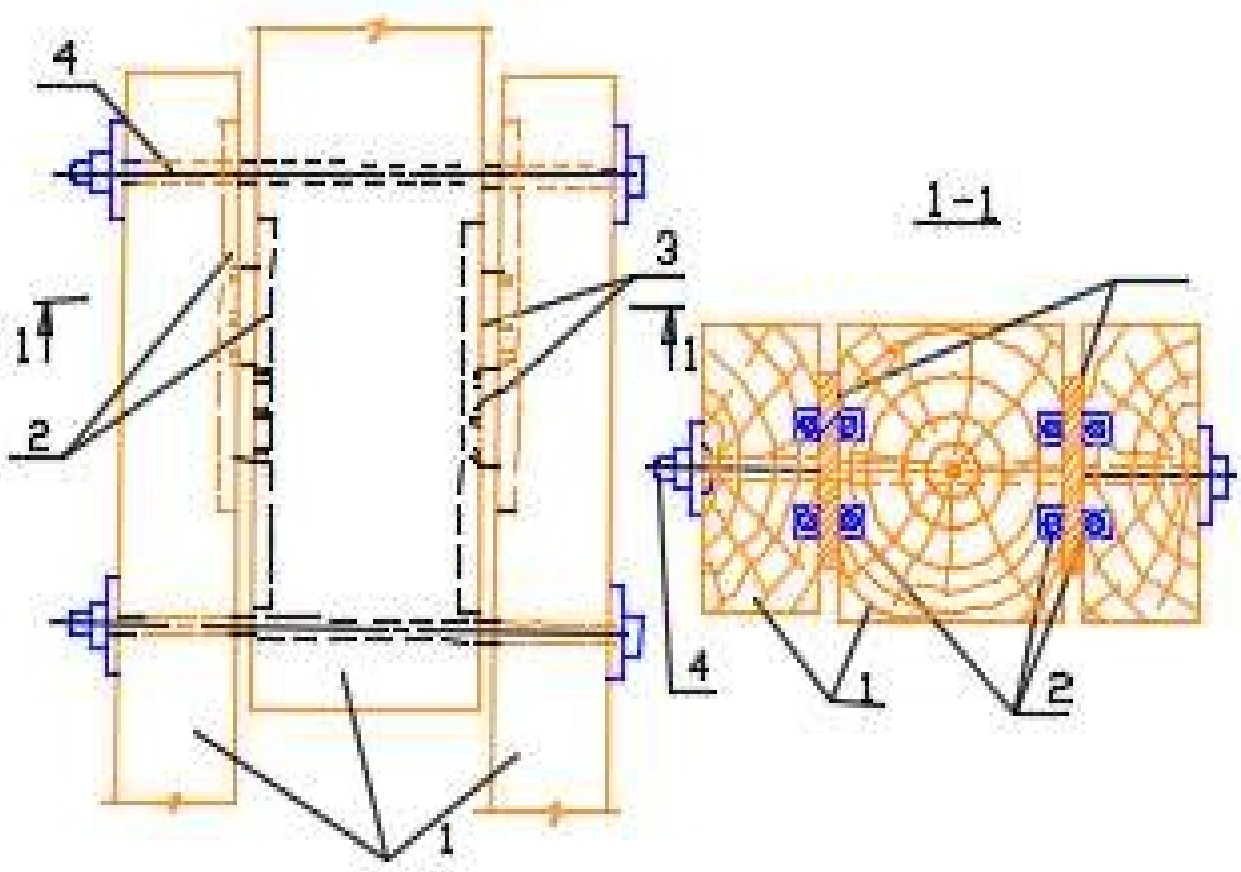


Fig.1.3 Butt joint of elements of wooden structures (NISS): 1 - joining wooden elements; 2 - reinforcing bars; 3 - steel plates; 4 - coupling bolt

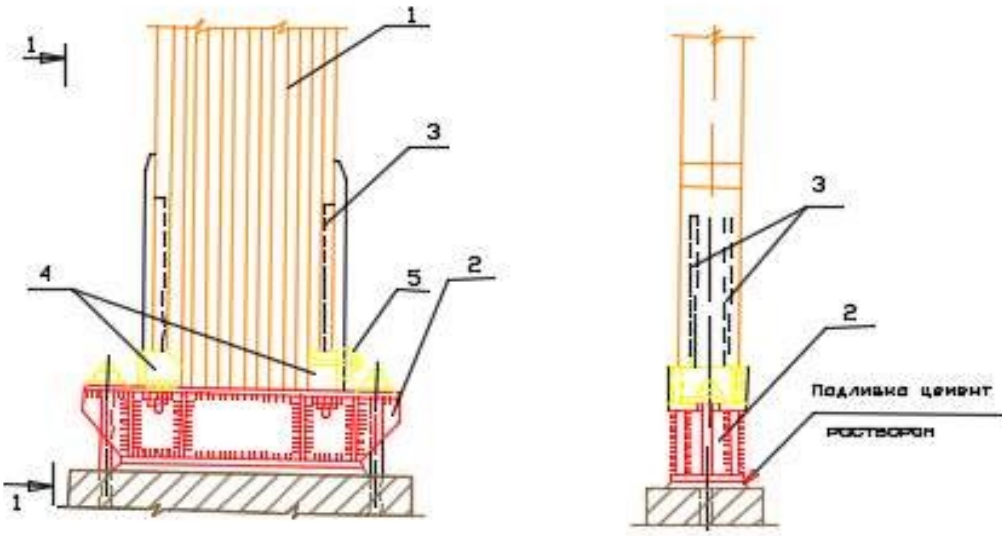


Fig.1.4 Support node of a glued column with an intermediate metal shoe (NISS): I - glued column; 2 - metal shoe; 3 - glued-in rods; 4 - stops for the perception of lateral force;5 - tensioner

This avoids the vulnerability of the fittings during transportation.

Further development and research of nodes with rods glued along the columns belongs mainly to NISS (PA Dmitriyev and co-workers) [8]. Improvement of the shoe design, the device of stops for the perception of the lateral force and the tension device for ease of fixing the column in the stops were reflected in the solution in Fig. 1.4. The presence of a gasket between the column and the shoe clearly fixes the crushing areas at the end of the column, the shoulder of a pair of forces with the help of gaskets can be increased by shifting the resultant crushing force to the edge of the column and thus reducing the force of pulling out the pins. Carrying out the glued pins outside the section redistribution with the help of overlays glued to the column on a toothed spike (Fig. 1.5) not only increases the bearing capacity and rigidity of the column, but also allows you to select high-quality timber for the zone of critical wood chipping near the adhesive joints with the pins. Drilling holes for pins and their gluing is simplified due to the fact that these operations are performed before gluing the linings to the columns. The constructive solution is confirmed by the copyright certificate [9]. Some modified shoe designs and the use of gaskets and linings made of corrosion-resistant materials allow the unit to be used for buildings with an aggressive environment. The entire part of the support shoe, containing steel parts, is monolithic with polymer concrete.

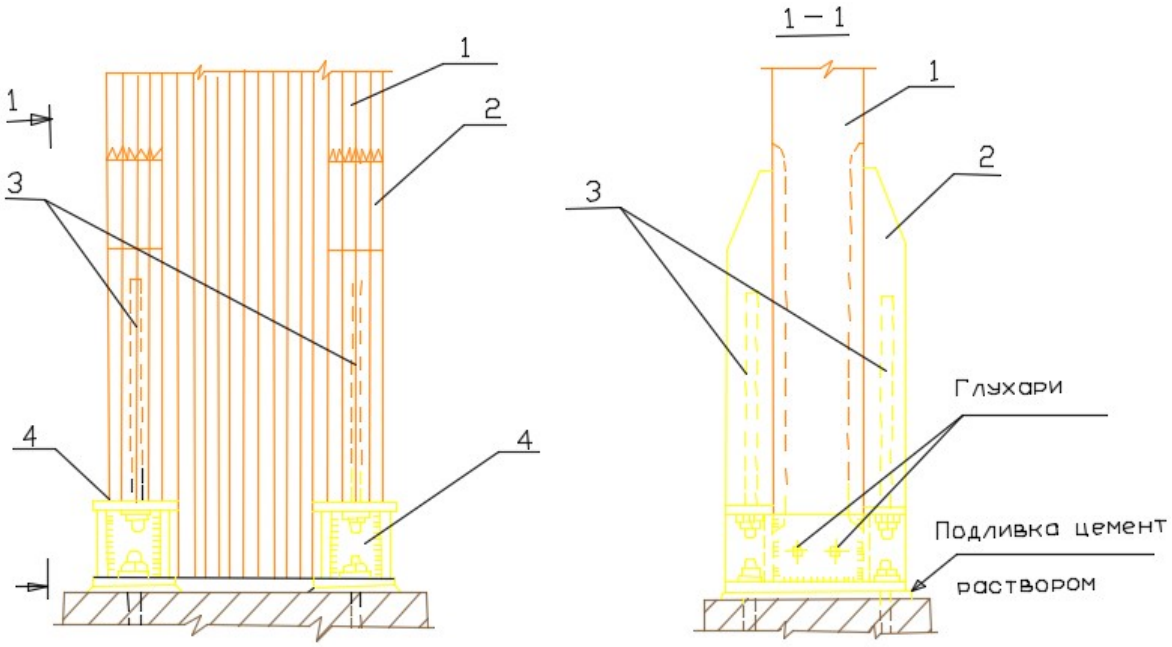


Fig.1.5 Support node of the column equipped with side plates (NISS): 1 - Glued column; 2 - overlays; 3 - glued-in rods; 4 - metal shoes; 5 - gasket.

1.2. RESEARCH OBJECTIVES

Assessing the structural solutions considered in the review, it can be noted that the use of glued in rods covers almost all types of joints in the nodes of wooden structures. At the same time, in all developments, the rods were used for pulling out, by the end. This leads to a sharp increase in shear stresses in the areas of the glue seams located at the exit of the rods from the wood. A significant unevenness of shear stresses leads to incomplete use of the bearing capacity of the glue joints along the entire length of the rods, which is a disadvantage of such joints.

To eliminate this disadvantage, i.e. To reduce the unevenness of shearing stresses along the glue seams, it is planned to investigate the joints on the glued rods, in which the places of application of loads are located in the middle of the rods. In this case, the most difficult case is outlined when the load is applied at an angle to the axis of the rods.

This method of loading bars undoubtedly opens up a new kind of connections on glued bars, the possibilities of which are indicated in the above structural developments.

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