Construction and technical examination of wooden structures (on the example of a wooden country house)

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Abstract. In practice, the construction of wooden buildings of low-rise residential construction is carried out based on the experience and knowledge of the builders, and does not agree with the legal framework of the construction industry. Therefore, many low-rise and garden houses are typical, unequal spacing of the beams, overestimated the distance between the bearing walls, the construction of attic floors without regard to bearing loads of the lower floors, uneven box joints timber, use of faulty material or materials from different batches with different parameters and characteristics. All these violations in the construction and operation of objects made of wooden structures lead to civil disputes in the framework of which it is necessary to conduct construction and technical expertise.

1. Introduction

Wood is the oldest material used by man in a variety of industries. Its strength, hardness, wear resistance and at the same time good deformability, elasticity, water absorption and water repulsion, hygroscopicity, external properties (texture, texture, gloss, color), dielectric qualities, anisotropy make wood a unique and versatile material.

Russia is the richest country in the world in terms of timber reserves, and the lands of the forest fund occupy the largest area in comparison with lands of other categories, which favorably affects the popularity of the material during construction. According to BR 55.13330.2016 «Residential single-family houses»: «it is possible to carry out the construction and reconstruction of residential single-family houses with the number of ground floors of no more than three» [15]. Therefore, wooden structures are widespread in the construction of cottages, private and country houses.

The legal side has a particular impact on the construction industry, namely obtaining a building permit. The new edition of the Urban Planning Code of the Russian Federation (GRK RF) establishes part 3. Article 48, the following: «Implementation of the preparation of project documentation is not required during the construction, reconstruction of an individual housing project, a garden house» [18]. In the event that the construction of townhouses or houses with a storey of more than three floors is carried out, the owner’s passport, a document establishing ownership of the land and an application for permission to build, must add project documentation, in accordance with Decree of the Government of the Russian Federation of 16.02.2008 No. 87 «On Composition sections of project documentation and requirements for their content” [19].
2. **Main defects and damages of wooden structures**

All defects of wooden structures arise due to: the use of low-quality materials, improper construction and operation

2.1. **Vice of wood**

Taken into account during construction and technical examination, stated in **GOST 2140-81**, divided into types and varieties:

- Knots (branches, open and overgrown are divided according to the shape of the cuts, by position and relative position, by condition, by exit to the surface);
- Cracks (by type, position, depth and width);
- Defects in the shape of the tree trunk (stamina, rounded or ribbed lumps, ovality, growth, curvature simple or complex);
- Wood structure defects (fiber inclination, roll, traction wood, sagging, curl, eyes, pockets, core, germination, pseudo-nucleus, spotting, tar, etc.);
- Chemical color spots (by type and color intensity);
- Mushroom lesions (mushroom spots, mold, saponified mushroom stains, browning, rot, hollow);
- Biological damage (wormhole, parasitic plants, from birds);
- Foreign inclusions, mechanical damage (foreign inclusions, carbonization, peeling of the bark, cut bevels, pickle, risks, waviness, hairiness, notch, washed down, chips, burr, dents, etc.);
- Warp (along the seam and along the edge, transverse, winged) [4].

2.2. **Defects and damages of wooden structures**

The most common practice, obtained during the operation and construction, in the course of lectures **E.G. Zhuravleva** shows: rot, wall roll, lower crown crowns, bulging, crevices on horizontal joints, fixing crowns with nails, hanging upper crowns on window frames, weathering of the sealant from the joints, etc. [7].

3. **Subject of civil disputes**

The most frustrated in practice during the construction and technical examination comes down to establishing:

- compliance of the project data with the requirements of regulatory and technical documentation, and with the provisions of the contract (part 1 of article 754, part 3 of article 744, part 4 of article 744, part 1 of article 761 of the **Civil Code of the RF** [22]);
- causes of destruction: complete or partial loss of the functional, operational and other properties of the object (part 1, part 2 of article 741; part 2 of article 745; part 2 of article 748; part 2 of article 351; part 3, part 4 of article 744; part 3 of article 753; part 1 of article 761; part 4 of article 743; part 2 of article 1065; part 1 of article 1079; article 1100 of the **Civil Code of the RF** [22] and etc.);
- compliance of types, volumes, quality and cost of work, requirements of normative and technical documentation, project provisions, contract terms (part 1 of article 754; part 2 of article 748; part 3 of article 753 of the **Civil Code of the RF** [22]);
- the possibility of using residential buildings for living (articles 166-170, part 6 of article 753, part 1 of article 222 of the **Civil Code of the RF** [22]);
- the presence (absence) of defects in the supporting structures, if any, the causes of the appearance and development of defects (part 2 of article 9.4 of the **Code of Administrative Offenses** [1]; part 1 of article 741 of the **Civil Code of the RF** [22]), their belonging to the category of hidden or explicit (166-170 of the **Civil Code of the RF**) defects, the possibility and cost of eliminating them (part 6 of article 753 of the **Civil Code**
of the RF [22], Article 5 of the Law of the Russian Federation «On Protection of Consumer Rights» [21]), etc.

4. The regulatory framework
In the production of construction and technical examinations of wooden low-rise buildings, it consists of the requirements:

- **GOST 11047-90** «Details and wooden products for low-rise residential and public buildings. Technical conditions» [3];
- **GOST 2140-81** (ST SEV 2017-79, ST SEV 2018-79, ST SEV 2019-79, ST SEV 320-76, ST SEV 321-76, ST SEV 391-76, ST SEV 3286-81, ST SEV 3287-81, ...) «Visible defects of wood. Classification, terms and definitions » [4];
- **GOST 30974-2002** «Corner joints of wooden block and log low-rise buildings. Classification, design, dimensions» [5];
- **BR 131.13330.2018** «Construction climatology. Updated edition of SNiP 23-01-99 *» [8];
- **BR 14.13330.2018** «Construction in seismic areas. Updated edition of SNiP II-7-81 *» [10];
- **BR 17.13330.2017** «Roofing. Updated edition of SNiP II-26-76» [11];
- **BR 20.13330.2016** «Loads and impacts. Updated edition of SNiP 2.01.07-85 *»[12];
- **BR 30-102-99** «Planning and development of territories of low-rise housing construction» [13];
- **BR 42.13330.2016** «Urban planning. Planning and development of urban and rural settlements. Updated edition of SnIP 2.07.01-89 *»[14];
- **BR 55.13330.2016** «Residential single-family houses. Updated edition of SnIP 31-02-2001» [15];
- **BR 64.13330.2017** «Wooden structures. Updated edition of SNiP II-25-80» [16];
- **BR 70.13330.2012** «Bearing and enclosing structures. Updated edition of SNiP 03.03.01-87» [17];
- **Federal Law of July 22, 2008 N 123-ФЗ** (as amended of December 27, 2018) «Technical Regulation on Fire Safety Requirements» [21] and others.

5. Production of construction and technical expertise of wooden structures using the example of a country house
Federal budget institution Irkutsk Laboratory of forensic examinations, in the last two years, has carried out several construction and technical examinations of wooden structures for the purpose of ships and investigating authorities. Violations of the erection of log cabins, country houses, wooden roofs are detected during the operation of the facility and lead the facility to an emergency state.

In the course of the construction and technical examination in civil matters, a number of discrepancies were identified: volumetric planning and design decisions specified in the contract and the builder’s estimate. The construction of the object was carried out according to the "Design project” developed by the construction company, without the accompanying justification of space-planning and structural solutions.

Inspection and inspection of the facility was carried out in accordance with **GOST 31937-2011** «Buildings and structures. Rules for the inspection and monitoring of technical condition» [6] and **BR 13-102-2003** «Rules for the inspection of load-bearing building structures of buildings and structures» [9].

Actual volumetric - planning and design solutions identified during the inspection: 1 storey building (7.0x8.0m and 2.7m high) with an attic floor of the same area, 2.58m high. and an attached garage (3.9x6m). The beam of the common wall of the garage and the house with a section of 100x180mm differs from the dimensions of the main load-bearing walls of the house and the garage 180x180mm. The internal walls in the house are also made of 100x180mm timber. Interventional insulation - jute. Ceilings - planks on wooden beams of timber. The roof is gable (Broken ramp), rafter
legs from a wooden board. Roofing - Profiled steel sheets. Drainage - organized from the northwest slope of the roof along the suspended gutters made of PVC; unorganized from the southeast slope. Door and window openings - windows in wooden frames with single glazing. Door and window openings are made of 40x180mm boards. Foundation - Screw piles. Structural diagram: 1 floor: frameless with longitudinal and transverse load-bearing walls made of timber; Attic floor: frame of wooden boards.

The erected property does not comply with the requirements of building codes and the mandatory requirements in the field of construction specified in the «Regulatory Base» section for the following violations:

- Deviations of building structures exceed the maximum deviations: - Deviation of the edges of the walls of the walls from the vertical by 1 m. Length and walls of the partitions from the vertical by 1 m. Height to 17 mm - non-compliance with clause 8.1.7. 1. BR 70.13330.2012 «Bearing and enclosing structures. Updated edition of SNiP 3.03.01-87 » [17].
- Longitudinal deep cracks were recorded on the surface of the beam with a disclosure width of up to 9 mm., Blunt obzol and violation of the integrity of the beam - extrusion, cleavage. - non-compliance with table No. 1 GOST 11047-90 «Details and wooden products for low-rise residential and public buildings. Technical conditions» [3]. Along the perimeter of the property there are numerous areas between the bars with cracks..
- From the attic side, natural ventilation in the roof is not provided through openings. - non-compliance with clause 4.4. BR 17.13330.2017 «Roofs. Updated edition of SNiP II-26-76» [11].
- Snow retention devices are not provided in the object under study - does not comply with clause 6.4.4.5 and clause 6.4.4.7. 3. BR 17.13330.2017 «Roofs. Updated edition of SNiP II-26-76» [11].
- The partition in axes 2-3 / AB is attached to the load-bearing wall along the 3 axis end-to-end with fastening with wooden dowels, which does not exclude the possibility of transferring to them horizontal loads acting in their plane - does not correspond - clause 6.5.2. BR 14.13330.2018 «Construction in seismic areas. Updated edition of SNiP II-7-81 *» [10].
- The spatial rigidity of the rafter system is not provided, since there are no horizontal connections between the vertical frames in the direction parallel to the ridge - does not comply with clause 9.6. BR 64.13330.2017 «Wooden structures. Updated edition of SNiP II-25-80» [16].

Identified inconsistencies of the constructed property, it is necessary not only to indicate how the actual violations, but also to justify them with the necessary calculation methods developed by construction and technical mechanics.

A.Yu. Butyrin highlighted the most common: «methods for determining internal stresses in parts of structures from external loads, temperature effects, etc., methods for determining deformations, studying stability conditions, studying various changes in deformations during long-term operation of structures» [2,91].

During the construction and technical examination of a country house located in the Irkutsk region, calculations were made in accordance with the requirement of BR 64.13330.2017, clause 4.3. «According to the bearing capacity (1st group of limiting states) and deformations that do not interfere with normal operation (2nd group of limiting states), taking into account the nature and duration of the load» [11]. During the calculation, the formulas and coefficients of SP 20.13330.2016 «Loads and impacts» [12] and BR 64.13330.2017 «Wooden structures” were used» [11]. The calculations were carried out according to the measured drawings built in the AutoCAD software package. During the calculation, the loads from all the beams of the first and attic floors were determined and it was revealed that:

- The load-bearing capacity of the first and second groups of limiting states of ordinary beams of the interfloor overlapping with a span of 4.24 m, taking into account the load from the roof,
is not provided - does not meet the requirements of **BR 20.13330.2016** «Loads and impacts» [12].

- The load-bearing capacity of the main beam of the interfloor overlap in the first group of limit states is not provided - does not meet the requirements of **BR 20.13330.2016** «Loads and impacts» [12].

All identified defects and construction defects of the wooden structure of the country house were summarized in table. 1:

**Table 1.** Description of materiality and disposability, as well as ways to eliminate the shortcomings of a country house

| Construction flaws                                                                 | Material / non-material                          | Disposable / unrecoverable                        |
|------------------------------------------------------------------------------------|--------------------------------------------------|--------------------------------------------------|
| The deviation of the faces of the wall crowns from the vertical by 1 m. Of length and the walls of the partitions from the vertical by 1 m. Of height to 17 mm. | A significant drawback. Dismantling / installation of walls and partitions with jacks, winches, and a truck (as an emphasis), with the partial addition of new material. The fastening of the timber is recommended to be performed with the help of pins. With a survey, the identified areas should be cleaned. | Disposable flaw. |
| Longitudinal deep cracks on the surface of the beam with an opening width of up to 9 mm., Blunt obzol and violation of the integrity of the beam - extrusion, cleavage. | Unacceptable wood defects according to **GOST 11047-90** [3]. We will eliminate the means of dismantling / installation of walls and partitions with the partial addition of new material. | Disposable flaw. |
| Along the perimeter of the property there are numerous areas between the bars with cracks. | A significant drawback. To eliminate this drawback, it is necessary to pierce the gaps and gaps. | Disposable flaw. |
| From the attic side, natural ventilation is not provided through openings in the roof. | A significant drawback. The correct technological device of ventilation grilles in the gables of the attic. | Disposable flaw. |
| The object under study does not provide snow-holding devices. | Not a significant drawback. The device of snow-holding devices on the roof | Disposable flaw. |
| The partition in axes 2-3 / AB is attached to the load-bearing wall along the 3 axis end-to-end with fastening with wooden dowels, which does not exclude the possibility of transferring to them horizontal loads acting in their plane - does not correspond - clause 6.5.2. **BR 14.13330.2018** «Construction in seismic areas. Updated edition of SNiP II-7-81 *» [10]. | A significant drawback. Dismantling / installation of the partition, followed by its fastening with flexible connections, on the basis of **GOST 30974-2002** «Corner joints of wooden block and timbered low-rise buildings. Classification, design, dimensions» [5]. | Disposable flaw. |
| The spatial rigidity of the rafter system is not provided, since there are no horizontal | A significant drawback. | Disposable flaw. |
connections between the vertical frames in the direction parallel to the ridge.

Installation of wooden girders in the nodes of vertical frames, as well as the installation of wooden braces between the uprights of the frames in the longitudinal direction.

The load-bearing capacity in the first and second group of limiting states of the ordinary beams of the floor beams with a span of 4.24 m, taking into account the load from the roof, is not provided.

A significant drawback.

To exclude the transfer of load from the roof to the floor beams by dismantling the central pillars, by installing struts with the vertical frame (tightening) resting on the upper belt. The upper belt should be reinforced. Dismantling racks above the beams of the garage, installing a strut with support on a load-bearing wall.

The bearing capacity of the main beam of the interfloor overlap in the first group of limit states is not provided.

A significant drawback.

Strengthening the supporting section of the main beam by installing steel corners on three sides that distribute the load on the walls.

The causes of all the shortcomings, except for deviations of the faces of the wall crowns from the vertical, are a violation of the technological process during construction. It is impossible to determine the reason for the deviations of building structures exceeding the maximum deviations, because there can be many reasons, for example: non-compliance with the design, design errors, violation of the process during construction, weather and climatic conditions (when one side of the house warms up better than the other, it sits faster).

6. Conclusion

On the example of the construction and technical examination of a country house located in the Irkutsk Region, a mismatch of the contract, technical specifications and estimates with the actual work performed was revealed, which is a common feature of low-rise construction as a whole.

The defects and damages considered within the framework of the requirements of regulatory documents revealed significant violations of the technological process during construction. All defects identified as a result of an expert diagnostic examination must be eliminated in accordance with the regulatory and technical requirements in force in the Russian Federation, but it is impossible to rectify the identified defects of the property without dismantling the main load-bearing structures of the house, followed by determining the suitability of the building material for further use - i.e. definition of quality.

In the process of conducting an examination, a shortcoming of the lack of design documentation was found, as a justification of the space-planning and structural solutions of the construction site. Violation of the technological process during construction, justified by the lack of accounting for design loads, led to the emergency state of the facility.

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