Reconstruction of Fixed Fertilizer Folders in the Vladimir Region

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Abstract. The article offered the option of reconstruction of a warehouse of wooden structures using modern derivatising materials. The reconstruction involves the insertion of additional overlap of the modified beams. The article deals not only with the calculation of a new type of beams, but also presents the developed technology of their production, tested on test samples. During the tests it was found that the destruction of the beams reinforced with fiberglass with the inclusion of carbon nanotubes in the composition of the adhesive composition is plastic in nature in contrast to the whole-wood beams. When brought to the limit state of the wood rupture of fiberglass impregnated with modified resin does not occur. The use of a new type of beams symmetrically reinforced in the edge zones of beams will reduce the consumption of wood and increase the height of the operated premises in comparison with conventional glued beams.

1. Introduction

Wood is the most ancient structural material used by man since the time of primitive society. Being one of the elements of material culture, wooden structures throughout their history developed according to the level and state of the productive forces of each historical era. The development of wooden structures has tended to create systems, elements and types of compounds that would save wood and best take into account its physical and mechanical characteristics.

In the postwar years the development of the national economy demanded further industrialization of construction. This requirement was met to the greatest extent by designs of factory production. Therefore, the main feature that characterizes the progress in the field of wooden structures in the USSR and abroad is a focus on glued wooden structures. The development and distribution of glued wooden structures is inextricably linked with the success in the production of synthetic: polymer materials, since adhesives based on them are the best for bonding wood.

The sector of storage and processing of agricultural products functions within the framework of the unified agro-industrial complex of the country, acting as its 3rd sphere together with the branches of the 1st sphere producing industrial means of production, the second sphere is agriculture, the main supplier of raw materials for processing and the production of food products, and the 4th sphere - serving structures that ensure the promotion of products from the producer to the consumer. Currently used agricultural buildings, often has a huge internal building volume, which is often simply not used for its functional purpose. The relevance of the topic is to solve a scientific and practical problem...
aimed at replenishing the missing buildings, buildings and structures that are missing from the agar complex.

2. Relevance

Problems connected with increase of efficiency of use of wood resources in different time engaged Zhadanov V I, Labudin B V, Melekhov B I, Pogoreltsev A A, Roshchina S I, Stoyanov V V, Turokovsky S B, Shchuko V Y, etc.

The analysis of modern tendencies of introduction of new construction technologies and materials allows to claim that the basis of dynamic introduction in practice will become the materials and technologies received on the basis of achievements and developments in the field of nanotechnologies. Angular nanotubes due to high mechanical characteristics, as well as the wide possibilities of surface functionalization providing covalent interaction with the polymer matrix can be considered as one of the most promising types of adhesive modifiers. Due to the high specific surface, the increase in the mechanical properties of composites is achieved already at low concentrations of CNTS while improving the thermal and electro-conductive properties of the material.

Glued wooden structures are used mainly in the following areas of construction: agricultural, livestock and warehouse buildings, public buildings and structures (gyms, swimming pools, stadiums, etc.) and road bridges. Taking into account the requirements of fire regulations, they are also used for industrial buildings, especially for warehouses and buildings with chemically aggressive environment, the use of metal and reinforced concrete in which is associated with high costs for their anticorrosive protection.

In the reconstructed building fully articulated arches glued without torque are used, the thrust is transmitted to the Foundation. The shape is of the pointed arch type, consisting of two polaron. Step arches adopted 6.0 m, span 36.0 m, height 54 thus boom lift is 2/3, the height of the cross-section of the beams 1/30 of the span and is 1.2 m. At the time of inspection the structure were moistened due to the lack of part of the coating, traces of significant rotting were not found. The support nodes of the arches on the foundations were made through metal plates according to the hinged scheme, and at the time of the examination were in working order. The opening of the Foundation pits allowed to establish their performance, a significant increase in the load on the foundations is not expected, and due to the significant service life and compaction of the soil during this time increased the initial bearing capacity of the base. Half-timbering racks were absent from the sides of the building and it was decided to replace the existing racks and install new ones made of glued wood. Wooden girders between the arches for the most part survived and kept working.

The scientific novelty of the article is to investigate the composite beams of the overlap, used when building an interstitial overlap that is built into the internal volume of the three-hinged arches. Composite wood-fiber beams are an experimental design and to date their work is poorly understood.

The scientific nature of the article can be traced in the study of the strained-deformed state of the beams by examining the results of the engineering (manual) calculation and the numerical experiment performed in the software calculation complex and searching for optimal design parameters.

3. Research Methodology

The main objective of the renovation is the installation of the technological overlap. The new production necessity requires an addition of overlapping structure in the existing volume of the building. Recessed ceiling provided a span of 12.0 m, and is around 36.0 m. Fastening of the beams to the existing half-frames is performed through the metal plates on the bolts. As load-bearing structures it is proposed to use laminated wood beams reinforced in the edge zones of fiberglass on a modified epoxy oligomer. Beam reinforcement was performed symmetrically in the upper and lower zones according to studies [1]. For the calculation of beams used rune and numerical methods of calculation.

The space-planning solution of the main volume of the building should provide free arrangement of technological equipment, freedom of movement of workers and the possibility of modernization of
production or technical equipment. At the same time, it is important that the structural solutions of the building are optimal and ensure their durability, rigidity and stability at all loads and impacts, avoiding unnecessary costs. The use of reinforced fiberglass beams in the reconstruction allows to reduce its construction height, which in addition to the technological advantages of using the volume of the building allows to save wood resources.

Currently existing methods of calculation of wooden structures allow to estimate with sufficient accuracy their bearing capacity and deformability for any sections and at any stage of work. From the point of view of design applied is the engineering method of calculating wooden structures on the reduced geometric characteristics. During the calculation the load-bearing capacity and deformability of wooden composite beams were determined.

The calculation is performed on two groups of limit States. Calculation by the first group of limit States on the action of the maximum bending moment. Bending moment for simply supported beam on two supports at its load point load is determined according to the accepted formulas of strength of materials taking into account the boundary conditions and loading schemes.

The maximum edge stresses in the wood of the stretched and compressed zones shall not exceed the calculated resistance of the wood to stretching and compression, respectively:

\[
\sigma_p = \frac{M}{W_{np} \cdot k_{yn}} \leq R_p \cdot m
\]

\[
\sigma_c = \frac{M}{W_{nc} \cdot k_{yn}} \leq R_c \cdot m
\]

The calculation of the stability of the plane form of deformation is performed on the action of the maximum bending moment:

\[
\sigma_u = \frac{M}{\varphi_M \cdot W_{np} \cdot k_{yn}}
\]

\[
\varphi_u = 140 \cdot \frac{b^2}{L_p \cdot h} \cdot k_\psi
\]

The calculation of the second group of limit States is to determine the maximum vertical displacement and compare it with the limit. At the initial stage, the deflection of the beam is calculated without taking into account the shear deformations on the distributed load action:

\[
f_0 = \frac{5}{384} \cdot \frac{P \cdot l^4}{E \cdot I_{np} \cdot k_{yn}} \cdot k_i
\]

\[
k_i = 1 + 0.67 \cdot \frac{q}{d} \quad \text{(7)}
\]

- factor taking into account the duration of the load.

The greatest deflection in the middle of the span of the beam shall not exceed the maximum permissible deflection:

\[
f = \frac{f_0}{k} \left(1 + c \cdot \left(h_0 \cdot \frac{l}{l}ight)^2\right) \leq f_{np},
\]

where k - coefficient taking into account the effect of the variability of the height of the cross section; C - coefficient taking into account the effect of shear deformation from lateral forces, - normalized value of the vertical movement; coop and kuzh – coefficients increase the strength and stiffness, which was determined on the basis of calculations and the obtained experimental results for
engineering calculations derivatising symmetric beams with the application of the modified composition ED-20+CNT: BGC=1,45...1,5 and $k_{ub}=1,4...1.45$.

![Figure 1. General view of the reconstructed warehouse](image)

Figure 1. General view of the reconstructed warehouse

However, the calculation of composite structures and elements is usually carried out only under the assumption of the elastic work of the materials, which does not correspond to the actual work of the elements beyond the limit of elasticity and does not reveal the actual values of the force resistance of the material structures.

When loading composite structures with an external load to failure, three characteristic and successive stages of the stress-strain state are clearly manifested: conditionally elastic, elastic-plastic and fracture.

A valid chart of operation of wood in compression and tension have a non-linear dependence, and can be used in the calculations for the limits of elasticity. The detailed analysis of stress-strain state (VAT) of structures at all stages of work with the use of the finite element method in the Lira software complex is performed in the thesis. The calculation was carried out taking into account the actual work in the static setting, taking into account physical nonlinearity of the material wood.
4. The results

The reliability of the obtained results is ensured by the correctness of the tasks, using existing in structural mechanics hypotheses and assumptions; modern exploration tools with certified tool base; a technique of carrying out numerical experiments with the use of computer programs; acceptable convergence of experimental and theoretical studies [1].

Production of designs will be carried out in factory conditions since it raises quality of products and in this case delivery on public roads is possible. The process of production of beams includes several stages. On the first – mechanical processing of wood is carried out, on the second – preparation of the reinforcing element - fiberglass on the basis of basalt fiber, on the third – preparation of epoxy structure is carried out. The epoxy resin, precursor and hardener are thoroughly mixed in a degassing mixer, and the mixture is heated to a temperature of 25...30 °C. When the temperature rises, the resin increases its fluidity and reduces viscosity, which allows to obtain a high degree of homogeneity of the processed viscous product, on the fourth – the process of gluing of the wooden billet and fiberglass is carried out. Before bonding, surfaces are degreased, then apply the adhesive with a thickness of 0.4 to 0.5 mm. The ambient Temperature should be 15...25 °C, humidity – 50...80%. Gluing is performed by the method of vacuum infusion. After the reinforcing material is laid, vacuum channel, sealing harness and sacrificial cloth are laid. Then, a vacuum bag is placed on the composition and fixed along the perimeter with an adhesive harness. Next, the system tightness is checked and the vacuum pump is connected. The air is pumped out of the system, and due to the pressure the resin evenly impregnates the reinforcing material and the material is tightly pressed against the beam. After curing the binder, the film is removed and the product is disbanded, the fifth – the structure is subjected to heat treatment in the drying chamber. To comply with the technological process, the composite structure is heated to a temperature of 60...70 °C and maintained for six hours. Thus humidity of air in the chamber support 70 ... 80% that there was no further drying of wood of a design. At the final stage, the treatment of the surfaces of the composite beam; trim excess fiberglass, marking, registration of product passports.

In tests it was found that destruction of steel I-beams, reinforced fiberglass with inclusion in the adhesive composition of carbon nanotubes is of a plastic nature in contrast to solid wood beams. The presence in the UNT system allows to achieve a higher conversion, and therefore to obtain a more regular and frequent grid of chemical crosslinking than in the source systems. It is obvious that such pre-hardened compositions will have a higher glass transition temperature, a higher modulus of
elasticity, greater tensile deformation and, as a consequence, a higher tensile strength. The strength of the epoxy matrix ED-20 has a composition of carbon nanotubes increases by 6-8% with cold curing and 12-18% with hot curing [3].

Figure.3. Plot distribution of normal stresses for glued laminated beams (half the span)

Figure.4. Plot the distribution of shear stresses for glued laminated beams (half the span)

At bringing wood to a limit condition, rupture of a fiberglass impregnated with the modified resin does not occur. It is experimentally confirmed that the destruction of composite beams occurs only on normal sections. The use of carbon nanotubes in the adhesive composition increases the crack resistance of wood, increases the adhesive-cohesive characteristics of the compound and operational reliability of structures. This eliminates the possibility of destruction of reinforced beams from chipping and splitting in the abutment areas, i.e. ensures the reliability of structures on the action of shear forces in the support sections, thereby increasing the reliability of the structure against collapse.

5. Conclusions

Examination of the warehouse of bulk fertilizers made it possible to conclude on the possibility of reconstruction and putting the building into operation after a long idle period.

Reconstruction carried out using glued symmetrically reinforced in the edge zones of the beams will reduce fuel consumption and increase the height of the exploited areas in comparison with usual glued laminated beams. The use of metal beams in this building is not rational due to the significant costs of corrosion protection. The decision to use this type of beams has allowed to comply with the terms of reference for the reconstruction of the object with the implementation of all technological features.

References
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