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FRAGMENTARY ILLUMINATION OF RESULTS OF FIRE TEST OF WOODEN BEAMS WITH FACING BY FIRE-RETARDANT PLYWOD

This article highlights the current issues of ensuring fire resistance of wooden beams as load-bearing structures. Scientists have studied various types of fire protection of wood from fire. The existing methods of fire protection include fire-retardant impregnating materials, fire-retardant paint, fire-retardant coatings sold. At the same time, research was conducted to create fire-retardant materials. Therefore, in the field of our research there is a question of using fire-retardant plywood as a facing fire-retardant method of protection of wooden structures. This article describes the process of manufacturing fire-retardant plywood. Which is made of 2 mm veneer sheet, which is impregnated with flame retardant. According to the method of the technological bath and glued in a pressed machine to the appropriate thickness. Then in the experimental setup fire tests were performed at standard temperature in three time intervals of 15 minutes, 30 minutes and 60 minutes, highlighting these results in the form of graphs of temperature versus exposure time. Which in turn serve as a basis for determining the rate of charring, as well as determining the range of dependence of the side and end layer of charring on the exposure time for 10 mm and 20 mm layer of refractory plywood. Thus, the research allows us to draw conclusions about the effectiveness of the proposed method of fire protection of wooden structures with fire-retardant plywood and to determine the calculated class of fire resistance for these structures.

Key words: *combustion reaction mechanism, fire protection, humidity, and control of fire-retardant efficiency.*

1. Introduction.

Due to the significant depreciation of fixed assets in the country, and hence the growing number of emergencies of man-made nature, ensuring the structural safety of building systems is becoming increasingly important. Statistics show that 80% of accidents that occur during construction with the collapse of the load-bearing structures of the object occur as a result of human errors in the design, construction and operation of a building or structure. These errors form the internal (object) risk of accidents, the magnitude of which depends on the duration of operation (resource) of the structure. In addition to man-made factors (explosions, fires, traffic accidents, falling cranes, local overloading of structures, design errors, negligence of builders, etc.), there are also natural factors (seismic, karst failures in the foundations of buildings, landslides, hurricanes, etc.), due to the influence of which there may be partial or complete destruction of the building.

Wear and damage of load-bearing structures or their connections and, as a consequence, changes in the strength and rigidity of the elements of the design schemes lead to a decrease in the structural safety of the structure. In the worst combination of negative circumstances, they lead to sudden failure and progressive collapse.

At present, more and more attention is being paid to solving this problem in Ukraine. It is also known that taking into account and complying with all the requirements of regulations does not provide the required level of reliability of the building. The standards set only the minimum level of safe operation and durability of structures, using a set of coefficients that still remain empirical.

In fact, these coefficients provide at the design stage of structures their service life. The onset of an emergency condition of a building or structure implies the presence of an external cause of man-made (explosion, fire, terrorist act, etc.) or natural and climatic nature (earthquake, hurricane, tsunami, landslide, village, etc.).

The purpose of this article is to reveal the patterns of changes in the geometric parameters of the charring zone of wooden beams depending on the method of fire protection from the time of fire with a standard temperature as a scientific basis for determining the most effective method of fire protection to assess fire resistance of wooden beams.

charring of wooden beams depending on the method of fire protection depending on the time of exposure to fire with a standard temperature.

According to the set goal the following tasks are defined:

1) describe the method of experimental study of the behavior of wooden beams with fire-retardant impregnations in the conditions of fire exposure to fire with a standard temperature, and the obtained research;

2) to identify patterns of change of geometrical characteristics of the zone of charring of wooden beams depending on the method of fire protection depending on the time of exposure to the fire effect of the fire with a standard temperature.

2. Literature review and purpose of research

The building or structure as a whole, as well as their individual spatial planning and structural elements must meet the functional purpose. It is considered that wooden building structures can be used only in buildings of III degree of fire resistance, as these structures have a flame propagation limit M2 [1].

The reason for the failure of wooden structures is the reduction of their working cross-section as a result of charring during combustion. As the working cross section of the wooden structure decreases, the stress from the normative load increases and when they reach the loss of load-bearing capacity of the wood, the structure collapses. According to item 1.2 of SNiP II-25-80 "Wooden constructions" [2] at designing of wooden constructions it is necessary to provide their protection against moisture, biodamage, corrosion and from ignition at a fire.

So in the general case for calculation of limit of fire resistance of wooden designs the decision of two problems is necessary: heat engineering and durability. The solution of the thermal problem of fire resistance of wooden structures is:

a) in determining the time τ, from the beginning of the thermal impact of the fire to the ignition of wood in the structure;

b) in determining the change in the working cross section of the wooden structure after the ignition of wood in a fire, due to the process of charring. The solution to the problem of strength of wooden structures is:

a) in determining the change of the corresponding stresses in the calculated cross sections of structures from the standard loads depending on the change in the working cross sections of the wooden structure due to charring of wood after its ignition in a fire;

b) in checking the conditions of strength of the wooden structure on the influence of the relevant regulatory loads, taking into account the change in stresses from these regulatory loads, depending on the time of burning wood to the loss of load-bearing capacity. In solving both problems, it is equally important to ensure fire protection of building structures on the example of wooden beams from fire, which includes impregnation with fire-retardant substances, application of fire-retardant paint and cladding with non-combustible or flame-retardant materials.

Plywood is made by gluing three or more layers of peeled veneer. Peeled veneer is a thin layer of wood with a thickness of 0.3 to 2 mm.

After drying, the veneer sheets are coated with a thin layer of glue and glued in hot hydraulic presses. Glued plywood bags are cut to standard sizes. Adjacent sheets are arranged so that the direction of the fibers in them was mutually perpendicular. Due to the cross-direction of the fibers, plywood differs from other sheet materials by the relative homogeneity of physical and mechanical properties, as well as less warping and cracking in different operating conditions.

According to the current standards [3, 5, 6] for the manufacture of peeled veneer use the following species of wood: deciduous - oak, maple, ash, birch, elm, beech, hornbeam, alder, aspen, poplar, linden; conifers - pine, larch, cedar, spruce, fir. All this confirms that under certain economic conditions as raw materials for the plywood industry are suitable many species of wood that meet the conditions of production.

Technical requirements for general purpose plywood manufactured at the enterprise [4]:

• FC plywood is glued with urea-formaldehyde adhesives prepared according to the recipe;

• in the outer layers of plywood are not allowed defects of wood and defects of processing that exceed the norms [5];

• plywood with outer layers of veneer of the following varieties is produced in terms of quality: II / II, II / III, II / IV, III / IV, IV / IV;

• according to the degree of machining of the surface, polished plywood is made on both sides;

• sheets of plywood should be cut at right angles. The bevel should not exceed 2 mm per 1 m of leaf edge length;

• deviation from the straightness of the edges should not exceed 2 mm per 1 m of sheet length;

• the number of layers depending on the thickness of the plywood should correspond to the data of the scheme of the technological mode of plywood production;

• symmetrically placed layers of veneer in plywood should be made of wood of the same species and the same thickness, with the same direction of fibers.

In the production of plywood and plywood products used urea-formaldehyde resins, the characteristics. The designation of urea-formaldehyde resins consists of the name of the product (CF) and the purpose of the main properties of the resin:

B - fast-curing;

F - increased viability;

MT - low toxicity.

The raw materials for urea-formaldehyde resins are urea (NH_2) 2CO, formaldehyde CH_2O and various catalysts (urotropin (CH_2) $6N_4$, ammonia NH_3, sodium hydroxide NaOH, ammonium chloride NH_4CL, capable of changing the acidity of the environment.

The research of scientists [8] includes impregnation with flame retardant sheets of raw peeled veneer, their drying, applying glue on them, forming and pressing veneer packages, pressing plywood. They used as a flame retardant 30% aqueous solution of a mixture of diammonium phosphate, ammonium sulfate and ammonium bromide in the ratio 1: 0,625: 0,375. Raw peeled veneer sheets with a moisture content of 60-100% are impregnated with flame retardant in a cold bath at an impregnation solution temperature of 20 ° C for 10-70 minutes. After impregnation, the veneer sheets are folded into feet with mutually perpendicular direction of the fibers in adjacent layers and stored in the feet for 1 hour, then dried and fed to the operations of applying glue, forming and pressing veneer packages and pressing plywood.

Also known by scientists [9] a method of manufacturing fire-resistant plywood of high water resistance by impregnating the finished plywood sheets in an autoclave with 25-30% aqueous solution of flame retardants with a temperature of 30-80 ° C, after which the apparatus creates a vacuum with a residual pressure of 0.05- 0.20 kg / cm^2 and withstand such conditions for 10-35 min, then the pressure is equalized to atmospheric, and then increase it to 2-6 kg / cm^2 and withstand such conditions for 20 min, equalize the pressure to atmospheric.

The residual solution is removed from the apparatus, and flame-retardant plywood sheets are treated with a spray with 2% aqueous solution of polymeric antiseptic at the rate of 0.01-20 g / m^2 of active substance, followed by drying to a moisture content of plywood sheets of not more than 10%.

The disadvantage of this method is the equipment and complexity of the technology of manufacturing fire-resistant plywood, it is difficult to impregnate plywood sheets along its entire thickness, which can also lead to destruction of adhesive layers and deterioration of mechanical properties of plywood sheets. salt crystals on the outer surfaces of plywood, as well as to its significant gouging. There is a method of manufacturing fire-retardant plywood, studied [10], according to which the peeling of veneer, impregnation of raw veneer with flame retardant (diammonium phosphate) in the bath, rolling and drying of impregnated veneer, forming a package and its pressing. The disadvantage of this method is the complexity of the technological process of manufacturing fire-retardant plywood, because the impregnated veneer must be rolled before drying.

Another method of manufacturing fire-retardant plywood, which includes impregnation of veneer in an impregnating solution of flame retardant, drying veneer and gluing plywood [11]. According to this method, diammonium phosphate with the addition of ammonium sulfate (ammonium sulfate) was used as a flame retardant. However, the disadvantage of this method is the high corrosion activity of ammonium sulfate, which adversely affects the equipment, in particular roller dryers.

3. Formulation of the problem and its solution.

The results of exposure of samples-fragments of wooden beams with fire-retardant cladding are presented in Fig. 1– 3 in the appropriate coordinate planes, for the appropriate time intervals of 15, 30, 60 minutes.

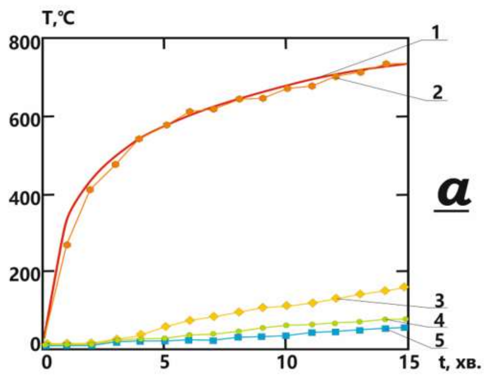

Figure 1. – Graphs of temperature versus exposure time at 15 minutes of fire tests: 1 - standard temperature curve; 2 - the average value of the thermocouple to determine the temperature in the installation; 3 - average value of the first thermocouple; 4 - the average value of the second thermocouple; 5 - the average value of the third thermocouple; a) the samples are protected by fire-retardant plywood 10 mm thick

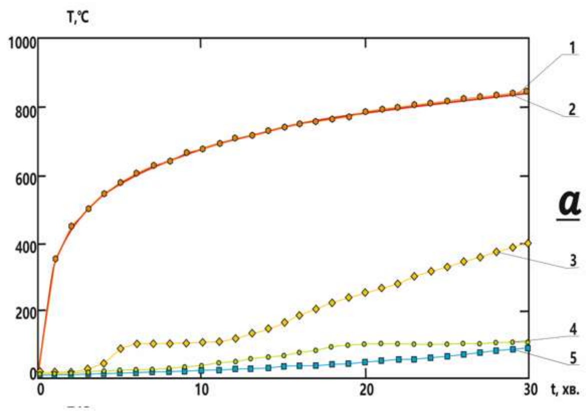

Figure 2. – Graphs of temperature versus exposure time at 30 minutes of fire tests: 1 - standard temperature curve; 2 - the average value of the thermocouple to determine the temperature in the installation; 3 - average value of the first thermocouple; 4 - the average value of the second thermocouple; 5 - the average value of the third thermocouple; a) the samples are protected by fire-retardant plywood 10 mm thick

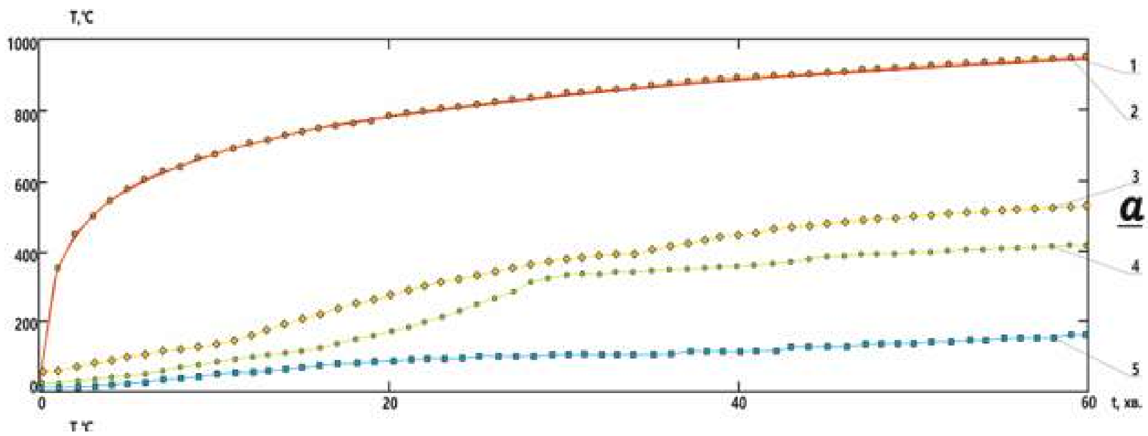

Figure 3. – Graphs of temperature versus exposure time at 60 minutes of fire tests: 1 - standard temperature curve; 2 - the average value of the thermocouple to determine the temperature in the installation; 3 - average value of the first thermocouple; 4 - the average value of the second thermocouple; 5 - the average value of the third thermocouple; a) the samples are protected by fire-retardant plywood 10 mm thick.

According to the regression dependences found in the graphs in (figures 1-3), graphs of the thickness of the layer of charring of samples-fragments of wooden beams lined with fire-retardant plywood from the exposure time, and determining the field of maximum and minimum value of the layer of charring of samples-fragments, which in the future will make it possible to predict the depth of charring for wooden beams of different volumes. These graphs are shown in Figure 4.

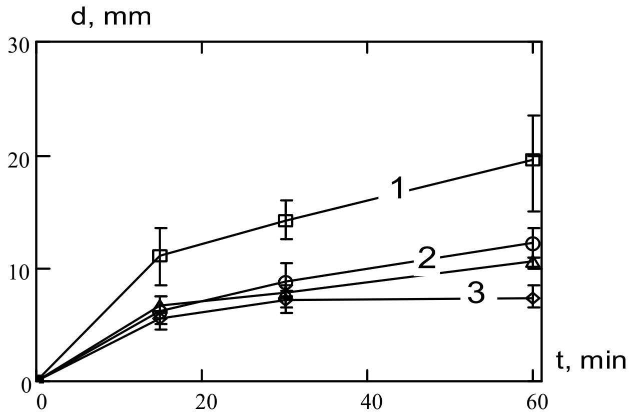

Figure 4. – Graphs of the dependence of the thickness of the charred layer on the exposure time 1) 15-minute fire tests; 2) 30-minute fire tests; 3) 60-minute fire tests, samples-fragments of wooden beams lined with fire-retardant plywood in 10 mm.

Thus, we determined the temperature distributions in the cross section of the fragment of the wooden beam, which was tested using the recommendations containing the relevant standard for the calculation methods for assessing the fire resistance of wooden building structures. The results of the calculation allow to develop an effective method of interpolation.

4. Conclusion

According to the research, the following conclusions can be drawn. The results of the study of charring of fragments of wooden beams with fireproof impregnation and without it were presented in the section. temperature, and in some cases, spontaneous combustion of samples. This changes the structure of the wood, which in turn correlates with a change in the strength properties of the wooden beams.

Modification of wood leads to a decrease in the rate of charring by about 2.8 times and changes in the structure and properties of the contact zone of wood, increasing its ability to withstand high temperatures. It is established that this zone is a layer of wood, characterized by resistance to external energy sources (high-temperature flame), which indicates the protective nature of the modifiers on the wood surface. The stability of the modified wood, estimated by the change in compressive strength, is on average 3 times higher than untreated, when the wooden structure burns out.

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ФРАГМЕНТАЛЬНЕ ВИСВІТЛЕННЯ РЕЗУЛЬТАТІВ ВОГНЕВИХ ВИПРОБУВАНЬ ДЕРЕВ'ЯНИХ БАЛОК З ОБЛИЦЮВАННЯМ ВОГНЕЗАХНИСНОЮ ФАНЕРОЮ

У цій статті висвітлено актуальні питання забезпечення вогнестійкості дерев'яних балок як несучих конструкцій. Вчені вивчали різні види протипожежного захисту деревини від впливу вогню. У існуючих методах протипожежного захисту представлені вогнезахисні просочувальні матеріали, вогнезахисна фарба, вогнезахисні покриття, що продаються. Паралельно проводились дослідження зі створення вогнезахисних матеріалів. Тому в області наших досліджень є питання використання вогнезахисної фанери, як облицювального вогнезахисного методу захисту дерев'яних конструкцій. У цій статті описується процес виготовлення вогнезахисної фанери. Який виготовлений з 2-міліметрового листа шпону, який просочений антипіреном. За способом технологічної ванни і склеюються в пресованому верстаті на відповідну товщину. Потім в експериментальній установці проводили вогневі випробування при стандартному температурному режимі в трьох часових інтервалів впливу 15 хвилин, 30 хвилин та 60 хвилин, висвітливши дані результати у вигляді графіків залежності температури від часу експонування. Які в свою чергу слугують підґрунтям визначення швидкості обвуглювання, а також визначення діапазону залежності бічного і торцевого шару обвуглювання від часу експонування для 10 мм та 20 мм шару вогнестійкої фанери. Таким чином, дослідження дозволяють зробити висновки про ефективність запропонованого способу протипожежного захисту дерев'яних конструкцій вогнезахисною фанерою та визначити розрахунковий клас вогнестійкості для цих конструкцій.