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ENERGY-EFFICIENT TECHNOLOGIES FOR THE USE OF STRUCTURES AND COMPOSITE MATERIALS OF WOOD WASTE

Abstract. In modern low-rise housing construction, metal tiles, rolled roofing, various types of wooden roofing, metal roofing, precast reinforced concrete slabs, wavy asbestos cement sheets, reinforced concrete rafters are used for roofs and roofs. The production of many of these types of roofs has a limited industrial base, requires significant consumption of materials and labor intensity of construction work, or involves significant consumption of wood, and their production volumes do not meet the demand of modern construction. An alternative solution is the production of one of the slab materials – cement-chipboard (CB). The purpose of the article is to develop a roof structure using cement-chipboard, a comprehensive study of the stress-strain state of this structure, and the development of an approximate method for calculating the strength and deformability of a CB on an elastic base.

Keywords: construction, composite materials, energy efficient technology, wood waste, industrial technologies, wood structure.

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Introduction. Due to the introduction of new requirements for thermal resistance of enclosing and load-bearing structures of buildings and structures, the need for the use of modern energy-efficient and industrial building composite materials based on waste is increasing. The increased construction of new facilities, as well as the reconstruction and repair of existing housing stock, ensure stable and long-term demand for such materials in the near future. Insulation materials based on woodworking waste could increase the production of insulation materials, but also somewhat solve another problem – the utilization of wood waste.

It should be noted that woodworking waste remains a stable resource of raw materials due to it is widely used in the construction and wood products industries. The complex use of these raw materials could partly solve the ecological problem.

When creating materials and structures on the basis of woodworking waste it is necessary to take into account the physical and mechanical properties of wood filler, chemical composition, and wood structure. This is due to the relationship between the chemical components of wood, i.e., components of the ultrastructure and highly ordered systems of which the walls (shells) of cells are composed; the latter from the wood tissue. Waste wood used as an aggregate for building materials has the following properties: low average density, good wet ability, ease of processing

The main advantages of using new technologies of production and construction of buildings and structures from composite materials on the basis of wood waste are:

1. Increased heat-insulating properties, allowing for the reduction in the consumption of energy resources i.e., heating buildings and houses, as well as reducing the cost of construction, thanks to the possibility of using lightweight structures - reducing the thickness of walls, loads on the foundation, etc.

2. Environmental safety building materials based on wood raw materials do not allocate harmful volatile substances, do not get electrified, and do not screen natural electromagnetic fields.

3. Could be easily amenable to manual and mechanical handling e.g., sawing, drilling, milling.

4. And most importantly, the active use of energy-efficient and high-tech materials and structures significantly reduces the time and cost of construction and allows you to significantly increase productivity in the construction industry, that is many times increased its performance on manufacturability and industrialist.

5. Most importantly, the active use of energy-efficient and high-tech materials and structures significantly reduces the time and cost of construction and allows you to significantly increase productivity in the construction industry, that is many times increased its performance on manufacturability and industrialist.

The use of wood waste not only reduces the cost of the finished product, but also gives it new properties, allowing it to successfully compete with more expensive finishing and construction materials. Environmental safety is one of the main advantages of the product. Sawdust as a heat insulation preserves all the useful properties of wood and is not dangerous to human health.

Materials and methods. Cement-bonded particleboard (CBC) is made by pressing a molded mixture consisting of softwood chips, Portland cement, minerals and water in accordance with the requirements of [1].

Industry produces two brands of cement-bonded particleboards, which differ in physical and mechanical properties: GRP-1, GRP-2.

According to domestic and foreign researchers' particleboard has a good ability to glue, pull screws and nails out of the stratum or edge. Boards can be processed with a usual tool, but the cutting parts should be made of hard alloys. The boards are non-toxic and can be surface refinished. The surface of the boards can be puttyed, painted, wallpapered, tiled and plastered.

The influence of long-term loading on the mechanical properties of particleboard was determined in the Kucherenko Central Research Institute of Scientific and Research Institute of Construction University (MSCU). Samples were loaded with constant load of different magnitudes in tension and compression parallel to the part of the plate [2], in shear and bending perpendicular to the plate under normal temperature and humidity conditions. At statistical processing of results of long-term tests, a value of long-lasting strength coefficient of 0.49 and long-lasting deformability coefficient of 0.52 were established, which are recommended for practical use in the calculation of structures with CBPB.

Application of the CBPB as a constructional material was preceded by the above mentioned researches on the definition of its temporary and design resistances under different types of the stressed state. At the same time, the long-term action of operating factors was taken into account. All this made it possible to develop recommendations for the rational application of particleboard [3].

Cement-bonded particleboards can be one of the most important elements of lightweight and durable construction systems in many sectors of the construction industry. The Faculty of Engineering of "Toraighyrov University" conducts scientific research on the development of promising energy-saving, environmentally friendly building materials based on wood waste. In this case it possible to obtain materials with higher thermal insulation property and enhancing materials characteristics without increasing the cost of construction. In particular at the faculty are engaged in scientific developments and pilot production of wood-polymer composites:

Together with the Central Research Institute of Building Materials named after V.A. Kucherenko there were developed and investigated ogre-grating constructions meant for roll roofing for industrial buildings. Covering slabs of 1.2×3 m and 1.2×6 m in size have a wooden framework of 40 mm thick boards and 10 mm thick chipboard cladding. The connection of the sheathing with the frame elements is provided with screws. The tests showed that the developed constructions have sufficient durability and reliability.

The particleboard most widely used as panel cladding with wooden frame in low-rise housing. Due to its strength, the boards give additional rigidity to the wooden frame and serve as protection against environmental conditions. Bearing and building envelopes of the house with the chipboard cladding due to its smooth surface do not require additional treatment. The outer surface of the particleboard wall is simply painted [4].

For professional processing of boards and to obtain a quality machined surface, it is necessary to use tools and cutting surfaces. In opposite the usage of particleboard in construction and the finishing works lead to savings in pricing, time and labour costs. According to new thermo-mechanical standards in the construction industry, the insulation of new and existing buildings has become relevant. This work shows a variant of insulation using particleboard, which does not require high capital investments and weighty labor costs.

The nature of the method is to create a cage of wooden bars by 50x80 mm or 50x50 mm, or framing of aluminum profiles with a pitch of 600 mm. The thickness of cladding plates of lies in range from 12 to 16 mm. Between the wall and CFPB placed thermal insulation, waterproofing materials and windproof film. In the joints of the CBPB placed airtight gaskets, mounted on the slips, which can be made of available materials: CBPB, wood, metal, and plastic. The production the technical specifications for the board, lined with stone chips in a wide range of colors [5]. Environmentally friendly boards create smooth wall surfaces and interior partition walls. The boards are used as interior wall coverings in residential, civil and industrial buildings with dry, normal and wet conditions. Fixing the boards is carried out in different ways:

- on wooden boards - with nails or screws;
- on metal profiles - using self-tapping screws.

Boards 12 and 16 mm thick are used to construct moisture-resistant partitions. This is due to the corresponding physical and mechanical properties of the material.

CBPB can be used in the partitions of the sanitary units of buildings of various purposes. In this case, the boards must be primed on all sides and coated with paint suitable for moisture conditions.

Cement-bonded particleboards 16, 24 and 36 mm thick can be used as the following flooring elements: subfloor under different coverings, underlayment, levelling layer, finishing floor with facing layer.

Floors made of cement-bonded particleboard are laid on the joists. Determine the distance between the beams to carry out the calculation, depending on the actual loads. The space between the substrate and the cladding, depend on the demand of heat and sound insulation, is filled with mineral wool boards or left free, separated by fire partitions [6]. The thicknesses of the board: 12 mm, 24 mm. can be used as elements of permanent formwork for foundations of low-rise buildings.

In addition, the cement-bonded particleboard can be used for the device:

– sandwich-type internal partitions filled with mineral wool, polystyrene foam;

– ventilation boxes, garden paths.

In connection with the increase in the production of particleboard with the expected mass application of structures on the basis of particleboard new structural elements are developed, the material itself is improved, work to increase the strength and deformation characteristics, increase the durability of structures made of particleboard is carried out.

Research results and discussion. The fundamental solution of cement-bonded particleboards application in the roof structure of low-rise and homestead houses is the use of large-size sheets of particleboard combining carrying (own weight, snow and wind loads) and enclosing functions (protection from atmospheric influences). All this meets the requirements for the development of new structures using cement-bonded particle boards [7,8].

As the roofing elements used chipboard according to GOST 26816-86 thickness 10, 14 mm. Trusses are made of softwood lumber in accordance with GOST 8486-86, the recommended dimensions of cross-sections of laths 40×40 , 70×70 mm in Table 1. Drainage gutters, made of galvanized steel according to GOST 14918-80, 0.8 mm thick, are also used in the roof structure.

For the cutting of sheets of particleboard are used format-cutting machines with circular saws in accordance with GOST 976979 “Circular saws with hard-alloy blades for processing wood materials”. For a stronger adherence of the CBP and sealing under the metal parts, the cold-resistant sealing rubber strips or gaskets made of roofing felt are installed. According to the developed drawings and specifications of the sheets of cement-bonded particle boards used in the roof structure of farmstead and low-rise houses are laid on wooden crates as shown in Figures 1-2 constructive schemes: across and along the slope of the roof.

Table 1

Physic -mechanical properties of wooden boards (WB)

Indicators	Cross section, mm			
	40×40	50×50	60×60	70×70
1	2	3	4	5
Cross-sectional area ***F***, sm	16	25	36	49
Moment of inertia per torsion, J_{tor}, sm^4	85.3	208.3	432	800.3
Moment of inertia per bend, J_{bend}, sm^4	21.3	52.1	108	200

Table 1 (continued)

1	2	3	4	5
Modulus of elasticity E, MPa				
a) long -term	10000	10000	10000	10000
b) short-term	12300	12300	12300	12300
Density, kg/m^3	500	500	500	500
The Poisson's ratio				
μ_{xy}	0.5	0.5	0.5	0.5
μ_{yx}	0.02	0.02	0.02	0.02

Table 2

Physic-mechanical properties of cement-chipboard (CBPB)

Indicators	Plate thickness, mm		
	10	12	14
The modulus of elasticity of chipboard when bending perpendicular to the plane, E, MPa			
a) short-term	3320	4110	5010
b)long-term	1400	1710	2084
Shear modulus, MPa			
a) short-term	2850	3013	3170
B)long-term	1197	1253	1319
The Poisson's ratio	0.17	0.17	0.17

Table 3

Comparison of the values of the maximum moments in the CBPB obtained during the calculation according to beam theory and plate bending theory

Rafter pitch, mm	Maximum moments in the CB during the calculation		Percentage (%) of the results of the beam theory
	according to the beam theory	according to the theory of plates	
800	8.18	6.16	24.8
1000	8.18	7.07	13.5
1200	8.18	7.23	11.61
1500	8.18	7.46	8.8

In calculating the roof structure according to the variant, the modulus of elasticity of the wooden crate was artificially increased by an amount equal to the ratio 5/2.12 = 2.35, by artificially increasing the rigidity of the crate, its deflection was the same as that of the two-span, which corresponds to the required calculation scheme according to standard. These components were also used in the research in the ratio (cement binders are shown in Table 3.

The longitudinal (along the slope of the roof) joint between the sheets of particle board is carried out with an overlap of not less than 100 mm in order to avoid water penetration into the premises through this joint. The longitudinal joint must be located over the sheathing.

The transversal (across the roof slope) joint between the sheets of particle board is made according to one of the options shown in Figures 2-3.

In Figure 2 the sealing of the joint is implemented by fixing to the longitudinal (to the slope of the roof) edges of the CBPB rectangular wooden battens with a section of 30×40 mm, followed by overlapping the two adjacent battens with U - shaped profile of galvanized steel. Profiles are installed along the slope of the roof

with a minimum overlap of 40 mm and fastened to the wooden battens with nails 30 mm long and 1.5 mm in diameter [9].

Wooden framing laths reach the top of the chipboard sheet edge by the size of the overlap of these sheets. The framing laths of particleboard sheets adjacent to the ridge part of the roof have a bevel, which makes it convenient to install a triangular ridge element made of galvanized steel or boards.

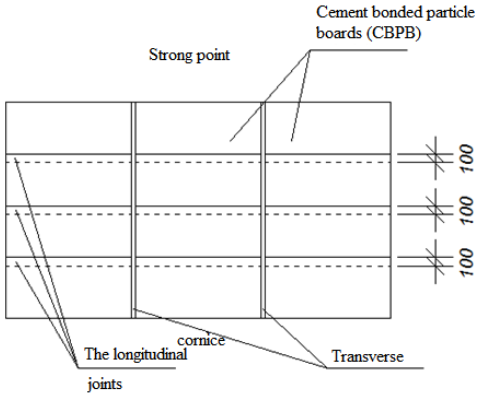

Fig.1. Layout of particleboard sheets across the slope of the roof

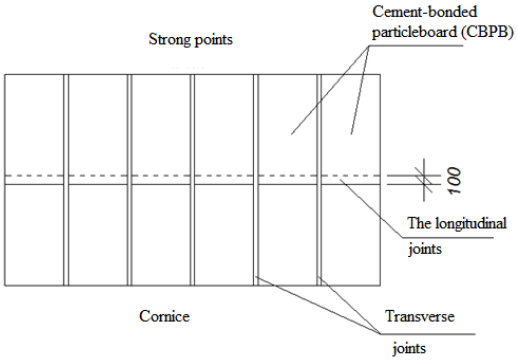

Fig. 2. Layout of particleboard sheets along the roof slope

In Figure 3, the sealing of the joint between the sheets of particle board is made by placing a drainage element of U-shaped or angular (triangular) profile made of galvanized roofing steel over the joint. In places of longitudinal joint in sheets of CBPB are made "traces" before mounting the roof in the form of semicircular or other forms of depth of 5 mm, width of 5 mm, set off from the edge of the sheet at a distance of 10-15 mm.

Figure 3 shows schemes of fastening of particleboard sheets in the roof structure. Fastening of particleboard sheets to the purlins is carried out with nails with diameter of 4 mm and length of at least 80 mm. Nails are installed into the pre-drilled holes in the chipboard (to avoid cracks, chips on the reverse side the holes are made with the size of 0.5 mm larger than the diameter of the nail).

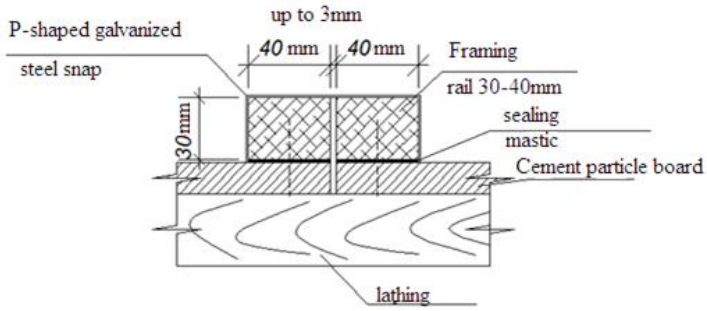

Fig. 3. Sealing the transversal joint between the sheets of particleboard with the framing battens and U-bolt

Under nails are established metal zinc-coated or protected from corrosion in other way washers in thickness of 3 mm, in diameter of 30 mm.

For sealing and waterproofing under the metal washer installed washers of porous rubber thickness of 5-6 mm or washers of three layers of roofing felt, noted above [8].

Fixing the framing laths of the joint is also carried out with nails not more than 2 mm in diameter. Sealing mastic is applied to the contact surfaces of the cement-bonded particleboard and the framing laths before fixing the framing laths. The nail spacing for fixing the framing battens is 150-200 mm.

Fastening of cement-bonded particleboards of no more than 600 mm in width is carried out with metal fasteners, which greatly simplifies the technology of roofing and makes it possible to use waste cement-bonded particleboards, small pieces of particleboard for the roofs of summer houses and temporary structures.

To ensure the service life (durability) of the construction of the roof with the elements of cement-bonded particle boards use a variety of protective paint and impregnation compositions that perform not only protective functions, but also give the building an architectural expression.

CBPB, recommended for use in the construction of the roof, its geometric dimensions are thin plate – a resilient body of prismatic shape with a small compared to the dimensions of the base height (width 1200 mm, length 3200 mm, a thickness of 10, 12, 14 mm).

Conclusion. The results of studies on the problems of improving the use of wood waste in the production of building materials and products and its active use in modern construction can make the following conclusions:

1. Application of cement-bonded particleboard in building structures and, in particular, roofing of homestead and low-rise houses is expedient because they are distinguished by ecological purity, fire- and bio-resistance, good physical and mechanical indices and weather resistance. Roofing with the use of particle board meets the requirements of reliability, durability and architectural expressiveness, presented: to the structures of buildings and constructions, as well as roofs of homestead and low-rise houses.

2. For the solution of the roofs of farmstead and low-rise houses are recommended roof structures with the use of cement-bonded particle boards with laying of particleboard sheets across and along the slope of the roof. The principal constructive solution in this case is the use of large-sized particleboard sheets, combining bearing and shielding functions, which significantly reduces the number of roofing materials used and the labor intensity of construction work.

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АҒАШ ҚАЛДЫҚТАРЫНАН ЖАСАЛҒАН КОНСТРУКЦИЯЛАР МЕН КОМПОЗИЦИЯЛЫҚ МАТЕРИАЛДАРДЫ ПАЙДАЛАНУДЫҢ ЭНЕРГИЯ ТИІМДІ ТЕХНОЛОГИЯЛАРЫ

Аңдатпа. Қазіргі заманғы аз қабатты үй құрылысында шатырлар мен шатырларды орнату үшін металл плиткалар, роликті шатырлар, әр түрлі ағаш шатырлар, металл шатырлар, құрама темірбетон плиталары, толқынды асбест-цемент парақтары, темірбетон рафтерлері қолданылады. Шатырдың осы түрлерінің көпшілігінің өндірісі шектеулі өндірістік базаға ие, материалдарды едәуір тұтынуды және құрылыс жұмыстарының күрделілігін талап етеді немесе ағаштың едәуір шығынын қажет етеді, ал олардың өндіріс көлемі сұранысты, заманауи құрылысты қанағаттандырмайды. Балама шешім – Плиталық материалдардың бірі цемент-тақталарын (ЦТ) өндіру. Мақаланың мақсаты-цемент тақталарын қолдана отырып, шатырдың құрылымын жасау, осы құрылымның кернеулі деформацияланған күйін кешенді зерттеу, серпімді негізде ЦТ беріктігі мен деформациясын есептеудің шамамен әдісін жасау.

Тірек сөздер: құрылыс, композиттік материалдар, энергия үнемдеу технологиялары, ағаш қалдықтары, өнеркәсіптік технологиялары.

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ЭНЕРГОЭФФЕКТИВНЫЕ ТЕХНОЛОГИИ ИСПОЛЬЗОВАНИЯ КОНСТРУКЦИЙ И КОМПОЗИЦИОННЫХ МАТЕРИАЛОВ ИЗ ДРЕВЕСНЫХ ОТХОДОВ

Аннотация. В современном малоэтажном домостроении для устройства крыш и кровель применяется металлическая черепица, рулонная кровля, различного рода деревянная кровля, металлическая кровля, сборные железобетонные плиты, волнистые асбестоцементные листы, по железобетонным стропилам. Производство многих указанных видов кровли имеет ограниченную индустриальную базу, требует значительного расхода материалов и трудоемкости построечных работ или сопряжено со значительным расходом древесины, а объемы их производства не удовлетворяют спрос, современного строительства. Альтернативным решением является производство одного из плитных материалов – цементно-стружечных плит (ЦСП). Цель статьи состоит в разработке конструкции кровли с применением цементно-стружечных плит, комплексном исследовании напряженно-деформированного состояния этой конструкции, разработке приближенного метода расчета прочности и деформативности ЦСП на упругом основании.

Ключевые слова: строительство, композитные материалы, энергоэффективные технологии, древесные отходы, промышленные технологии.