stretching deformation in BO beams was 25…30 per cent higher than that in BN beams. The average deformation of outer compressive fabric (the gauge was 400 mm) almost did not differ in all the beams and at the destruction point of the samples they were not higher than the ultimate compressive index of concrete equal to 0,35 per cent. The fixed stretching deformations in sections with a crack were larger than in the section between cracks. The obtained results prove the Prof. V.I. Murashev's theory where index ψ_S, connecting average and ultimate deformations of reinforcement, was introduced. Tested indices for ψ_S were gained using tested results of average deformations of reinforcement (the gauge was 400mm) and ultimate gauged deformations fixed in the section with a crack, the gauge of 100mm:

$$\psi_S = \varepsilon_{sm}/\varepsilon_s\,, \tag{1}$$

ε_s – relative deformation of a stretching reinforcement in the section with a crack;
ε_{sm} – average relative deformation of a stretching reinforcement.
Theoretical values of ψ_S were gained using method /2/, formulae 2 and 3:

$$\psi_S = 1 - (\sigma_{sr}/\sigma_S)^2, \tag{2}$$

σ_{sr} – tension in stretched reinforcement for a section with a crack at the moment of crack formation, σ_S – tension in stretched reinforcement with a crack at the stage of loading.

$$\psi_S = 1 - (M_{cr}/M_d)^2, \tag{3}$$

M_{cr} – the bending moment corresponding to crack formation, Md –the bending moment corresponding to the loading step.

Having analyzed the results differences in tested and calculated values of ψ_S were found; the average of which is 0,74 (formula 1); 0,62 (formula 2); 0,96 (formula 3).

We came to the conclusions:

1) Fraction formation, regular to longitudinal axis of tested constructions with orthogonal and reversed bars were fixed under equal bending moments.

2) The rate of cracks opening, width and steps, varies considerably. With a larger length between cracks in beams with reversed bars, at the stages close to fraction, large, almost two times large, width characteristics were observed.

3) Deflection of beams with reversed bars under the loading was rather intensive.

4) The rates of average and ultimate deformations of stretched longitudinal reinforcement, which are important for ψ_S when hardness and fracture strength are calculated, turned out to be 1.3…1.5 times higher than those in samples with cross bars.

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WOOD CONCRETE BASED ON CRUSHED BAMBOO

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The test results of wood concrete based on various raw wood materials are analyzed. Wood concrete, used as a coarse aggregate of a crushed bamboo, is described in the article as well as technologies for wood concrete, based on bamboo of high physical and mechanical properties, production.

The use of waste pieces, saving of materials, development of building constructions are becoming urgent today. Gradual depletion of natural resources courses our interest in application of secondary products of proper quality and lower costs. From economical point of view it is important to produce such materials not far from the objects they will be used further on to minimize transport charges and use local raw materials in the production. Plant wastes can be used to get cheap and effective materials. Composite heat-insulating materials, including wood concrete (sawdust concrete, concrete with rush, etc.), fibrolite are manufactured on such a basis. Organic and inorganic elements can be used as a binding material.

Hogged chips, got in the result of woodworking of coniferous or deciduous wood types, fine pulp chips, coarse and fine chips, machinery chips and cuttings can be applied as organic aggregates for wood concrete manufacturing [1].

Coniferous chips with the fraction of 1 - 5 mm are used in wood concrete manufacture. To neutralize sugar concentration in wood, to reduce water absorption of the material, to increase strength and fire resistance of sawdust, to develop binding between organic and inorganic elements sawdust is preliminary treated. Mineralization of wood sawdust can be various: sawdust is saturated with lime water, then it is dried, dipped into a liquid glass solution (1:7 – liquid glass:water) and dried again; sawdust is consecutively treated with water solutions of heavy metals, sodium alginate and barium chloride, after its ageing for 18 - 24 hours the solutions are merged; sawdust is soaked with a ferric sulphate solution for 30 - 120 minutes; treated with lime milk, preserve with 0,3 - 0,5 percent solution of sodium fluoride to keep the material from fungi [2]. To improve heat-insulating qualities of wood concrete we can increase the rate of sawdust to sand.

Avoidance of preliminary soaking and treaty of wood aggregate in water or salt solutions and warp of shrinkage reduction make it possible to use calcic slime, equal to 20 - 25 per cent of the cement mass used instead of calcium chloride or water glass, in wood concrete [3]. Ultimate compression strength makes 1,6 - 3 MPa if average density of wood concrete gained is 590 - 800 kg/m^3. The main disadvantage is its high efficiency of heat-conductivity of 0,2 - 0,31 Watt/m·ºC. This in turn has a negative influence on the competitiveness of wood concrete with similar materials.

Gypsum - and-slab concrete is a variety of wood concrete based on a compound of flooring cement and sawdust. The use of a gypsum binding reduces the time of density gaining and simultaneous strength reduction makes compressive resistance rate higher. Alongside with the advantages observed in application and exploitation of gypsum-and-sawdust concrete there are certain disadvantages and peculiarities. Low frost and water resistance is among them: gypsum stone influenced by humidity lacks its strength, warp of shrinkage appears, heat conductivity rate increases as well. Creep of concrete on gypsum binding at humidification reduces the use of gypsum concrete in bearing structures [4].

Manufacture of fibrolite is based on wood. Usually fibrolite is manufactured in the form of slabs or at construction sites for erection of indistinguishable heat-insulating layers. An inorganic binding, usually cement, makes its composition and woodwool of treated wood in the form of thick bends is applied as an aggregate. To neutralize sugars woodwoool is preliminary treated with a solution of liquid glass, calcium chloride or aluminium sulphate. Slabs are molded under low pressure up to 0,5 MPa. Density of fibrolite slabs makes 250 - 500 kg/m^3, its bending strength is up to 1,1 MPa, heat conductivity rate varies from 0,08 to 0,1 Watt/m·ºC [5]. A raised surface of fibrolite provides its high adhesion to masonry and plaster mortars. Fibrolite varies in density and can be applied in warmth keeping of walls and floors, partitions, stud walls and ceilings. Having low strength fibrolite cannot be applied in bearing walls.

The production of heat-insulating materials of both high mechanical properties and heat-and-technical characteristics is possible if a lightweight aggregate of plant raw materials making voids and a cellular binding, filling the voids, are applied. Thus, A.Yu. Schibrya suggests using of an equal amount of rice peeling to sawdust to reduce a water flow of a cement wood mixture by 7 - 9 per cent, density by 3 - 5 per cent and cement use by 4 percent. To make cement grout porous wood saponified resin with lime paste as a stabilizing agent is added. Clay can be used as well (40 - 60 kg/1 m^3 of cement wood) to improve capillary-porous structure of the binding and to reduce the heat-insulating rate and warp of shrinkage of porous cement wood [6].

The studies of optimization of cement wood structure based on coniferous and deciduous chips took place at Polotsk State University. A chip 40 mm long is used as a coarse aggregate, sawdust (up to 20 per cent) is used as a fine aggregate. To make sawdust of a proper structure horizontal vibro compaction with the span of 10 cm and a verticle one of 50 Hz were applied. Thus a directed laying of chip in cement wood was observed and physical-and-mechanical properties of the material were improved as well. The application of a worked out technology provides the density of cement wood equal to 550 - 600 kg/m^3 , compression resistance of 3,5 - 4 MPa and heat-conductivity 0,12 - 0,14 Watt/m·ºC [7].

Crushed bamboo can be used as an alternative material. It is a fast renewable material (grow up to 10 cm/24 hours) in Asian and African countries. Bamboo stems are traditionally used as bearing building elements in frames of houses up to 3 floors in countries with a warm climate [8].

Today the studies of using bamboo stems as an alternative to steel reinforcement are held in Singapore [9]. Still certain disadvantages were observed: weak adhesion of a cement stone with a smooth surface of a bamboo stem, the change of bamboo sizes under water absorption and drying.

The use of bamboo in wall building materials is studied in the laboratory at the Department of Construction Industry. At the preliminary, bamboo stems, 10 - 25 mm diameter, were treated with an abrasive to make it rough. Then it was crushed into parts to obtain coarse and fine fractions. Crushed bamboo was used in tested compounds as a coarse aggregate and sawdust was used to fill the voids. Cement is a binding element. An accelerator of hardening $CaCl_2$ (25 per cent of cement mass) was used in the compounds to make the hardening faster and neutralize harmful influence of sugars on the binding elements. The results are fixed in Table.

Physical and mechanical characteristics of cement wood

Composition No.	Components consumption per 1 m^3 (fraction from a unit)							Density, kg/m^3	Strength, MPa	Heat conduction coefficient, Watt/ m·°C
	Bamboo				Sawdust	Cement	Water			
	Coarse fraction		Fine fraction							
	Rough surface	Fine surface	Rough surface	Fine surface						
1	–	0,36	–	–	–	0,41	0,23	660	0,8	0,16
2	0,36	–	–	–	–	0,41	0,23	660	1,2	0,16
3	–	0,24	–	–	0,12	0,29	0,35	800	1,4	0,13
4	0,24	–	–	–	0,12	0,29	0,35	800	1,6	0,13
5	–	–	–	0,35	–	0,4	0,25	660	1,2	0,16
6	–	–	0,35	–	–	0,4	0,25	660	1,7	0,16
7	–	–	–	0,25	0,11	0,29	0,35	800	1,9	0,13
8	–	–	0,25	–	0,11	0,29	0,35	800	2,3	0,13

Having compared test results of samples 1 and 2 that of a coarse bamboo fraction we came to a conclusion that compressive resistance of sample 2 increased by 44 per cent. Strength increase is characterized by a cement stone improving of adhesiveness to a bamboo surface. The use of a fine bamboo fraction with a rough surface (sample 6) makes it possible to improve compressive resistance at 39 per cent in comparison with that of sample 5 where a fine bamboo fraction with a smooth surface was used. Comparative analysis of samples 1 and 5 prove that due to crushed bamboo the strength increased by 53 per cent, despite of bamboo's smooth surface. Strength improvement takes place due to expansion of sides area (sides are with rough surface), which appears under the longitudinal splitting of fibres during bamboo crushing. Similar relation can be observed in samples 2, 6 with a rough surface. Thus the strength of sample 6 increased by 48 per cent in comparison with that of sample 2.

Wood sawdust of high heat insulating quality was used to fill the void frames of a crushed bamboo. Despite the improvement of cement wood density due to sawdust from 660 to 800 kg/m^3 heat conductivity coefficient lowed from 0,15 to 0,13 Watt/ m·°C. Sawdust improved binding characteristics of a composite material, which also influenced its compressive resistance. Data analysis of samples 1 – 4 with a coarse bamboo fraction proved that sawdust use improves cement wood strength by 33 – 75 per cent irrespective of aggregate's surface. The same is true to samples 5 – 8, where strength is improved by 35 – 58 per cent.

A set of sawdust technologies as a fine aggregate application stems surfacing and fine bamboo fraction application influences physical and mechanical properties of cement wood greatly. Density increases by 21 per cent, compressive resistance becomes 2,9 times higher and heat conductivity coefficient is lowered by 0,03Watt/m·°C. The main sphere of bamboo based cement wood is manufacturing of building blocks for blockwork of supporting walls 3 m high. Cement wood blocks are used as walls, for example in frame constructions, and provide exterior walls with high insulating qualities, that is also equally important for countries with a warm climate.

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