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# PLANT WASTES IN WOOD CONCRETE MANUFACTURING

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*The urgency of plant waste application for effective construction materials is proved. It is proposed to manufacture concrete wood with a composite aggregate of a straw and flax boon mixture. Test results of main physical and mechanical characteristics are provided.*

Plants have been used as main components of building materials for hundred years due to their valuable properties: availability, low density, low heat conductivity, application of various technics in processing, their relatively low cost. The named advantages guarantee the need for such materials and a wide range of their application in constructions.

At the turn of XX–XXI centuries the urgency of plant waste application was rethought under the greenness of the materials and high renewability of the raw material. That is why much attention is paid to scientific researches of rational utilization of plant wastes.

The study of qualities and elaboration of compositions of heat-insulating materials used as aggregates of highly tonnage plant wastes in Pensa region took place under the supervision of S.N. Soldatov [1]. Low adhesion strength at the edge of aggregate - binding is one of the main problems in design and production of wood concrete items based on cement. Such an adhesion is caused by numerous humidity deformations of a plant aggregate and the emission of water-soluble sucrose derivatives is harmful to usual hydration of cement. Buckwheat straw was used as the main structure forming component for the production of popcorn heat-insulating wood concrete. Straw is treated with a composite mineralizer of 30 - 40 mm to prevent heat convective transportation of heat in interconnected pores. Oat shell became a fine aggregate. The heat-insulating material is characterized with: density of 544 - 617 kg/m$^3$, ultimate compressive strength of 0,39 - 1,32MPa, heat conductivity rate of 0,06 - 0,084 Watt/m·ºC. The material gained can be named an effective heat insulating material of a low energy intensity and heat conductivity.

Wood concrete based on crushed cotton plant stems technology was worked out in Kazakh scientific, research and design institute of construction materials TOO "NIISTOMPROJECT". A manufacturing scheme of wood concrete items was worked out according to the test results. Portland cement, liquid glass, calcium chloride were used in wood concrete manufacturing. Stems of cotton plant were preliminary crushed to fractions of 1,2 - 10 mm. Moulded items were unbuttoned in 24-hours, then cured for 11 days till their acquisition of handling strength. Wood concrete is characterized with compressive strength of 2,9 MPa, density of 600 kg/m$^3$, heat conductivity of 0,1 Watt/mºC if fractions are 3 - 10 mm. High elastoplastic qualities make it possible to use concrete wood, based on cotton plant stems, as a material for aseismic construction [2].

The studies of concrete wood, based on crushed cotton plant, and cement for African countries were carried out as well [3]. A mineralizer – a water solution of liquid glass – and a hardener – a water solution of calcium chloride – were added. Crushed stems of cotton plant 15 - 20 mm were used for structural concrete wood. The material gained is characterized with ultimate compression strength of 1,8 MPa, average density of 550 kg/m$^3$, heat conductivity rate of 0,09 Watt/m·ºC. To improve its physical and mechanical properties industrial wastes were added to concrete wood: filter cake, slime wastes, fine ash of dry selection. Addition of 5,6 - 8 per cent mass of filter cake improves the amount and plasticity of a cement grout, homogeneousness of the mixture, expansion of the contact area of crushed cotton plant stems with cement stone, strength characteristics of concrete wood items. Concrete wood with filter cake is characterized with: ultimate compressive strength of 2,1 MPa, average density of 540 kg/m$^3$, heat conductivity rate of 0,091 Watt/m·ºC.

The addition of slime wastes of asbestos-cement production improves capillary porosity of cement stone. Ultimate compressive strength makes 3 MPa, average density is 640 kg/m$^3$, heat conductivity rate is 0,1 Watt/m·ºC.

Fine milled ash of dry selection in a heat station was preliminary mixed with Portland cement in proportion of 1:10 - 1:12. 4,3 - 10,8 per cent mass of ash improves the amount of a cement grout and expanses the contact area with the aggregate. Due to ash activity the strength of concrete wood improves and cement consumption becomes lower. Compounds with ash are characterized with ultimate compressive strength of 2,9 MPa, average density of 700 kg/m$^3$, heat conductivity rate of 0,11 Watt/m·ºC.

Cane and straw in the form of granular aggregate can be applied in light weight concrete. The use of cane granules provides density of 780 kg/m$^3$, ultimate compressive strength of 4,9 MPa, heat conductivity rate of 0,21 Watt/m·ºC. The use of straw granules provides the material gained with such physical and mechanical properties as: density of 810 kg/m$^3$, ultimate compressive strength of 5,2 MPa, heat conductivity rate of 0,28 Watt/m·ºC. As a result, shrinkage and compressibility properties of light weight concrete, based on granular plant aggregate, are similar to those of ordinary light concrete, based on claydite gravel and ash lime mixtures; as

well as a sufficient potential for load in comparison with concrete wood. Softening effect influences the perception of operating effect and loads without crack formation [4].

Production technology of boon concrete for low rise cast building constructions is worked out. Gypsum and cement binding material, boon and water were the main components. The laying time of boon concrete is limited by the viability of the mixture. To solve the problem we increased a water binding rate and added an air-entraining additive to improve mixture's movement. This technology makes it possible to obtain boon concrete with density of 630 - 980 kg/m$^3$, ultimate compressive strength of 0,8 - 4,4 MPa. As a result boon concrete, containing gypsum, of a great range of strength properties, was gained. This, in turn, makes it possible to apply such concrete in various constructions [5].

The development of concrete wood with coarse and fine straw aggregate 20 - 40 mm and 10 mm flax boon is being studied at the Department of Industrial Construction. Cement and lime composition is used as a complex binding material. Compounds with straw or a mixture of straw and flax boon aggregate are being studied. Moulding of samples is carried out under pressure. The curing takes from 1 to 4 days. The results are fixed in the table below.

Physical and mechanical characteristics of concrete wood

| Sample | Components consumption per 1 m$^3$ (fraction from a unit) | | | | | Density, kg/m$^3$ | Strength, MPa | Heat conductiorate, Watt/ m·ºC | Curing time, 24 hours |
|---|---|---|---|---|---|---|---|---|---|
| | straw | boon | cementт | lime | water | | | | |
| 1 | 0,2 | 0,14 | 0,17 | 0,17 | 0,32 | 755 | 3,1 | 0,12 | 4 |
| 2 | 0,17 | 0,13 | 0,18 | 0,18 | 0,34 | 686 | 2,9 | 0,076 | 3 |
| 3 | 0,16 | 0,11 | 0,19 | 0,19 | 0,35 | 646 | 2,7 | 0,084 | 2 |
| 4 | 0,27 | – | 0,19 | 0,19 | 0,35 | 646 | 2,2 | 0,095 | 2 |
| 5 | 0,14 | 0,1 | 0,21 | 0,21 | 0,35 | 602 | 2,4 | 0,09 | 1 |
| 6 | 0,11 | 0,09 | 0,23 | 0,23 | 0,34 | 547 | 2 | 0,08 | 1 |
| 7 | 0,2 | – | 0,23 | 0,23 | 0,34 | 547 | 1,6 | 0,09 | 1 |

Test results of samples 6 and 7 showed that commuting of some straw to boon under similar density of concrete wood makes it possible to improve the density to 25 per cent and decrease heat conductivity rate to 0,01 Watt/m·ºC. Density improves to 23 per cent and heat conductivity rate lowers to 0,011 Watt/m·ºC in sample 3 in comparison with those in sample 4. Having compared samples 6, 7 with 3, 4 correspondently we observed the improvement of density to 18 per cent, ultimate compression strength to 35 - 38 per cent, heat conductivity rate to 5 - 6 per cent, curing time reaches two days. The efficiency of boon application is caused by the moulding of two interpenetrative structural systems making a firm structure known as "a frame in a frame" (the systems are made of coarse and fine aggregate). Boon fills the voids in the frame and makes the second frame, preventing the air movement in the composition and thus decreasing heat conductivity of the material.

Considerable changes of physical and mechanical characteristics are observed in the comparison of samples 1 and 6. Density improved to 38 per cent, ultimate compressive strength – to 55 per cent, heat conductivity rate – to 50 per cent, curing time made four days in sample 1. The higher density of concrete wood, the longer curing time is. This in turn lessens the cycles of the mould reuse. If the mould is removed before the set time there will be deformation of the sample in volume, i.e. concrete wood will lose its density caused by elastic deformation of straw and the lack of binding. Lime makes it possible decrease negative influence of sugars on the moulding of cement stone structure. Lime also influences the amount of the binding material and the expansion of the contact area of cement stone with straw and boon, which improves adhesions between the aggregate and the binding.

According to the data gained, requirements to physical and mechanical properties, time of the mould reuse samples 5 and 6 are the most suitable. Concrete wood wall blocks (samples 5, 6) are firm enough for non-bearing outside walls up to 3 m high in frame constructions and 300 mm thick providing required thermal resistance.

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