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Thermal And Technical Parameters Of Especially Lightweight Concretes Based On Secondary Resources Of Agriculture

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Abstract: Heat engineering parameters of boon-straw and straw slabs have been analyzed. The dependence of the change in the coefficient of insulating materials thermal conductivity on the outside temperature has been found out. The changes of the material humidity have been defined by the thickness of the thermal insulation material

Keywords: vegetable wastes, liquid sodium glass, thermal insulating plate, thermal conductivity coefficient.

Introduction

In conditions of shortage of heat-insulating structural materials due to increasing normative requirements for them as well as for ecology of environment and evident necessity of utilization of agricultural production wastes and anthropogenic industry products development of effective technologies of composite materials corresponding to the requirements of modern construction is being activated.

One of such materials are composite materials on the basis of rice hulls-waste of rice processing industry. Advantages of these materials before traditional, for example, on wood chippings, consists in natural reproducibility of rice husk, its low thermal conductivity and bulk density, as well as manufacturability of application, excluding operation of sifting on fractions, and predetermine expediency of its application for building materials, especially in forestless areas, typical for our republic. However, not all the issues associated with its use, have been solved to date. In particular, the influence of various technological factors of production on the properties of composites based on rice hulls in combination with other industrial wastes has not been studied sufficiently, the reserve possibilities of both the aggregate itself and the binder, the intensification of hardening which has almost unlimited possibilities due to a wide range of modern modifying chemical additives, are not realized.

All this restrains the widespread use of rice hulls alone and in combination with other wastes in the production of building materials and products. This situation not only hinders the production and manufacture of thermal insulation and structural products, but also negatively affects the environment due to the accumulation of waste in increasing volumes.

Various researchers suggest using straw, bark, husk, stalks of cotton, hemp, etc. for the production of insulation materials based on plant raw materials. [1 - 4].

In the territory of Uzbekistan in large quantities are formed plant wastes of agricultural production in the form of straw of cereal crops and flax bonfires. Straw in rolls or bales from the fields is delivered to livestock farms, where it is stored in piles and used mainly for bedding cattle. As a rule, some unused straw simply rots away in haystacks.

Rice husk is formed by getting crushed from raw rice. Thus, only in the territory of Kharez region annually about 25 thousand tons of rice husk is formed. As a result of the analysis of the current situation, we can say that the existing technologies for the utilization of plant waste are extremely irrational and require serious scientific approaches to their use with greater benefit for human life. In our opinion, given the current situation on the market of insulation materials, obtaining environmentally friendly heat insulation with high thermal performance based on straw and flax bark is a very promising solution.

Nowadays, Tashkent institute of Architecture and Civil engineeering conducts researches of properties of heat-insulating materials on the basis of chopped straw and flax bark, sodium liquid glass is used as inorganic binder. Thermal insulation boards based on straw and on a mixture of straw and flax bark are obtained. The average density of the straw-based plates is 215-233 kg/m3, compressive strength is 0.31-0.36 MPa, bending strength is 0.75-0.79 MPa, coefficient of thermal conductivity in dry state is 0.056-0.062 W/m2 °C. For castor plates the average density is 240 - 260 kg/m3, compressive strength is 0,65 - 0,83 MPa, bending strength is 1,0 - 1,2 MPa, the coefficient of thermal conductivity in a dry condition is 0,046 - 0,049 W/m2-°Ñ.

After establishing the basic physical and mechanical characteristics of straw and rice straw samples, the study of thermal and technical parameters of thermal insulation materials based on chopped straw and a mixture of chopped straw with flax bark was performed. Under conditions of variable thermal influences, we determined the change in temperature across the cross-section of the samples and the density of heat fluxes. The size of the experimental thermal insulation slabs was taken from the condition of filling the opening between the warm and cold compartments of the climatic chamber and is 300 and 400 mm with a thickness of 100 mm of samples. The average density of the material on the basis of chopped straw in the dry state is 220 kg/m3 and the material on the basis of a mixture of chopped straw and flax bark - 250 kg/m3.

Before testing, the samples were in a climatic chamber for three weeks under specified conditions (Table 1).

From the conditions given in the table, it follows that samples 3, 4 by the beginning of the experiment had higher humidity than samples 1, 2.

Table 1 - Initial parameters of temperature-humidity regime of samples

№ of sample	Filler composition	Air temperature in the climate chamber compartments, °C	Humidity of air in the climatic chamber, φ %	
			warm room	cold department
1	straw	18	50 - 60	50 - 60
2	mixture of straw and flax bark	18	50 - 60	50 - 60
3	straw	18	50 - 60	90 - 95
4	mixture of straw and flax bark	18	50 - 60	90 - 95

During the tests in the warm compartment of the climatic chamber, the calculated parameters for a residential building were maintained: the air temperature tB = 18 °C and the relative humidity φ = 50 - 60% [5].

In the cold compartment of the climatic chamber the air temperature tn was changing in time in the following sequence:

1. tn = 10 °C; 2. tn = 5 °C; 3. tn = 0 °C; 4. tn = -5 °C; 5. tn = -10 °C; 6. tn = -15 °C; 7. tn = -20 °C.

At each value of temperature tn the samples were kept for 120 hours. After 3 weeks of keeping the samples in the chamber, the stationary state in the studied area corresponding to tn = 10 °C and tn = 18 °C was taken as the initial temperature distribution. To determine the temperature values across the sample cross section, the insulating plate is divided into 4 zones of 25 mm width each. Values of temperatures and densities of heat flows were fixed by information-measuring complex RTP-1-16T in 1.5 minutes.

On the basis of research data the temperature distributions over the thickness of samples in the form of lines of temperature drop were obtained (Figures 1 - 4).

Using the obtained dependences, there were determined thermal conductivity coefficients and thermal resistance of samples at given values of outside air temperatures. The results of experimental and calculated data are presented in Table 2.

The analysis of the obtained results shows that with the decrease of temperature of air in the cold compartment of the chamber, the heat flux density and thermal resistance to heat transfer increase and the heat transfer coefficient of the material decreases.

The heat transfer resistance efficiency of the insulating material in relation to heat transfer resistance of the sample 2 in comparison with the sample 1 is 27 % at temperature t = -20 °C and the efficiency of the sample 4 in comparison with the sample 3 is 31 % at the same air temperature.

The heat flux density of sample 2 is 21 % less than that of sample 1 and sample 4 is 24 % less than that of sample 3 at air temperature tB = -20 °C in the cold compartment of the chamber.

When comparing samples similar in composition, it is seen that the material based on the mixture of chopped straw and flax bark the value of heat flux density of sample 4 is higher than that of sample 2 by 11 %, and the material based on chopped straw the value of heat flux density of sample 3 exceeds the index of sample 1 by 13 %.

The heat transfer coefficient of sample 1 decreases with decreasing temperature by 39 % and that of sample 2 by 64 %. For samples 3 and 4, the values of thermal conductivity decreased by 24 % and by 56 % respectively.

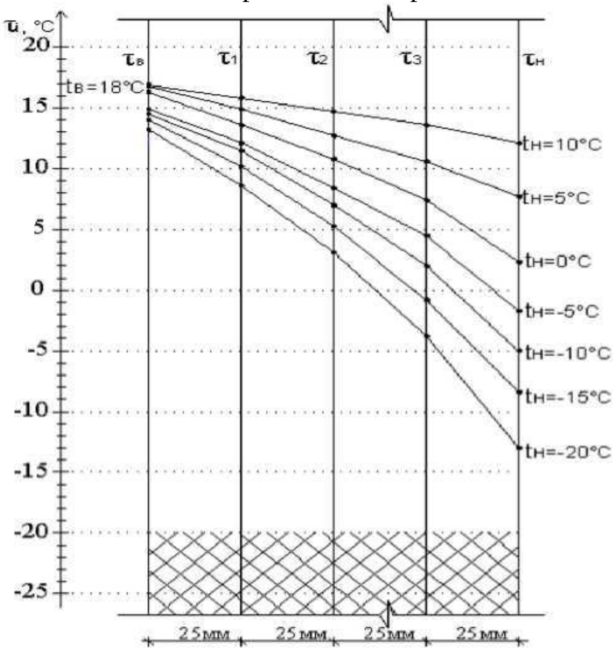

Fig. 1 - Temperature distribution over the thickness of the thermal insulation material based on a mixture of chopped straw (sample 1)

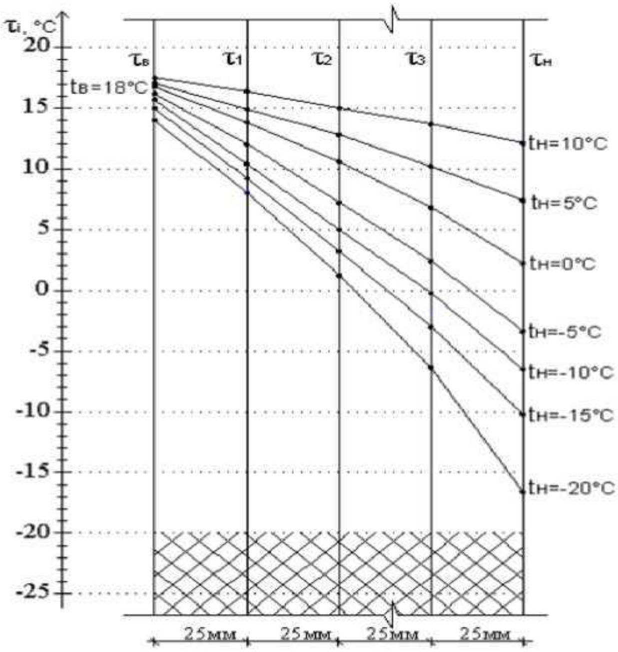

Fig. 2 - Temperature distribution over the thickness of the thermal insulation material based on a mixture of chopped straw and flax bark (sample 2)

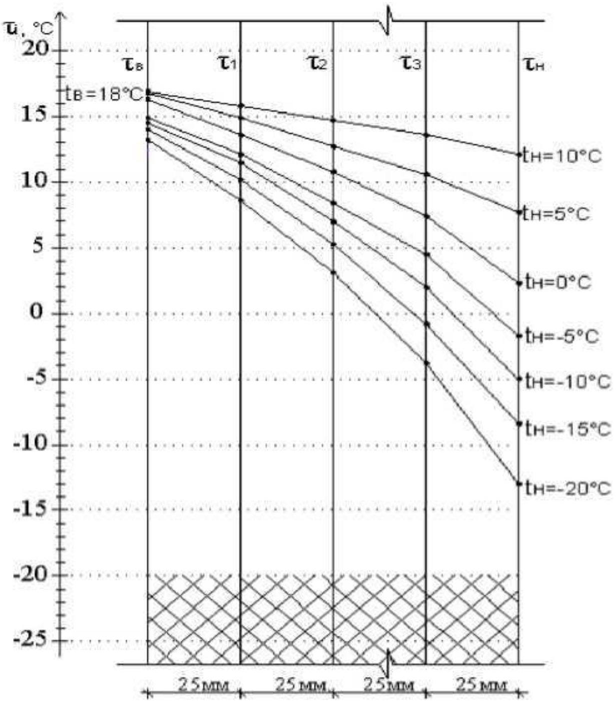

Fig. 3 - Temperature distribution over the thickness of the thermal insulation material based on chopped straw mixture (sample 3)

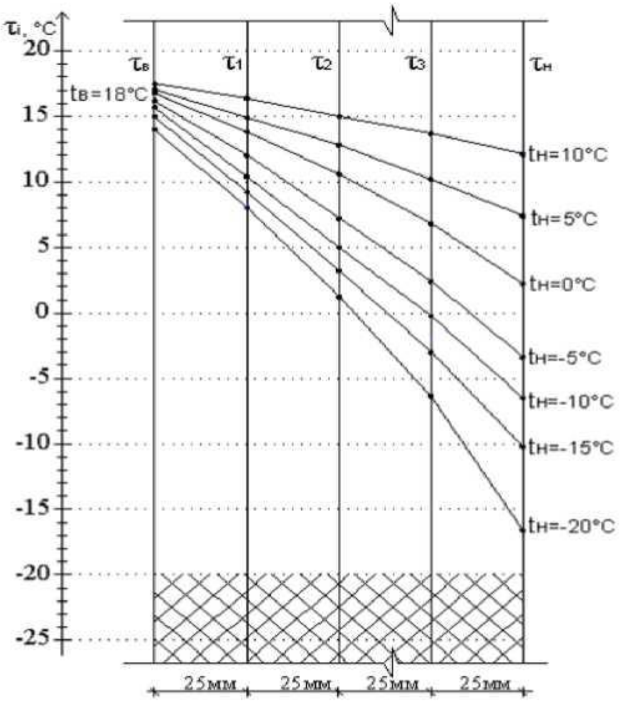

Fig. 4 - Temperature distribution over the thickness of the thermal insulation material based on a mixture of chopped straw and flax bark (sample 4)

Table 2 - Thermal characteristics of materials according to the study

Temperature outdoor air temperature, °C	Heat flux density q, W/m2				Thermal resistance to heat transfer R, m2-°C/W				Thermal conductivity coefficient λ, W/m2-°C			
	sample 1	sample 2	sample 3	sample 4	sample 1	sample 2	sample 3	sample 4	sample 1	sample 2	sample 3	sample 4
+10	5,56	5,71	6,2	6,05	0,9	1,05	0,769	0,893	0,111	0,095	0,13	0,112
+5	1,3	8,87	1,56	0,37	0,917	1,23	0,787	0,935	0,109	0,081	0,127	0,107
0	4,6	12,4	5,1	4,6	0,971	1,27	0,826	1,0	0,103	0,079	0,121	0,1
-5	8,6	16,2	9,6	8,03	1,0	1,29	0,847	1,087	0,1	0,077	0,118	0,092
-10	0,11	16,9	2,23	9,1	1,064	1,45	0,877	1,163	0,094	0,069	0,114	0,086
-15	1,57	17,99	4,64	9,9	1,136	1,59	0,909	1,266	0,088	0,063	0,110	0,079
-20	3,92	19,7	7,52	2,17	1,25	1,72	0,952	1,38	0,08	0,058	0,105	0,072

Comparing indices of thermal conductivity of materials on the basis of straw, we can conclude that at air temperature t = 10 °C thermal conductivity coefficient of sample 3 exceeds the value of thermal conductivity of sample 1 by 15 %, and at tB = -20 °C by 24 %. For materials on the basis of a mix of straw and flax bark a similar dependence is traced, but with less intensity. Thus, heat conductivity coefficient of sample 4 increases by 15 % relative to the value of sample 2 at tB = 10 °C and by 19 % at minimum temperature tB = -20 °C.

At the maximum positive air temperature in the cold compartment of the chamber tn = 10 °C the thermal conductivity of sample 2 was 17 % lower than that of sample 1 and 38 % lower at the maximum negative temperature tn = -20 °C. For more humid materials, the thermal conductivity coefficient of sample 4 was 16 % lower than that of sample 3 and 46 % lower at the same temperature values, respectively.

At the end of the experiment in a climatic chamber, humidity values of samples were determined in accordance with [6]. Moisture changes according to material thickness are shown in figure 5. Moisture values at a thickness of 100 mm correspond to the surfaces of the samples from the warm compartment side of the chamber.

From the obtained dependencies it follows that the average moisture content value of sample 1 based on straw is 19.1 % and exceeds by 20 % the moisture content value of sample 2 based on a mixture of straw and flax bark equal to 15.2 %.

For heat-insulating materials of the second stage of researches average moisture content of sample 3 is 24.8 % that is 26 % higher than the value of moisture content of sample 4 equal to 18.7 %.

When comparing materials of the same composition, it is found that the average moisture content of sample 1 is 30 % less than that of sample 3, and the average moisture content of sample 2 decreases by 23 % in relation to the moisture content of sample 4.

On the warm compartment side of the chamber, an increase in the moisture content of samples 1 and 3 relative to the moisture content of samples 2 and 4 by 23 % and 28 %, respectively, is observed.

Similar dependence is traced and on the side of the cold compartment of the chamber. The excess of humidity values of samples 1 and 3 over humidity values of samples 2 and 4 is 19 % and 23 % accordingly.

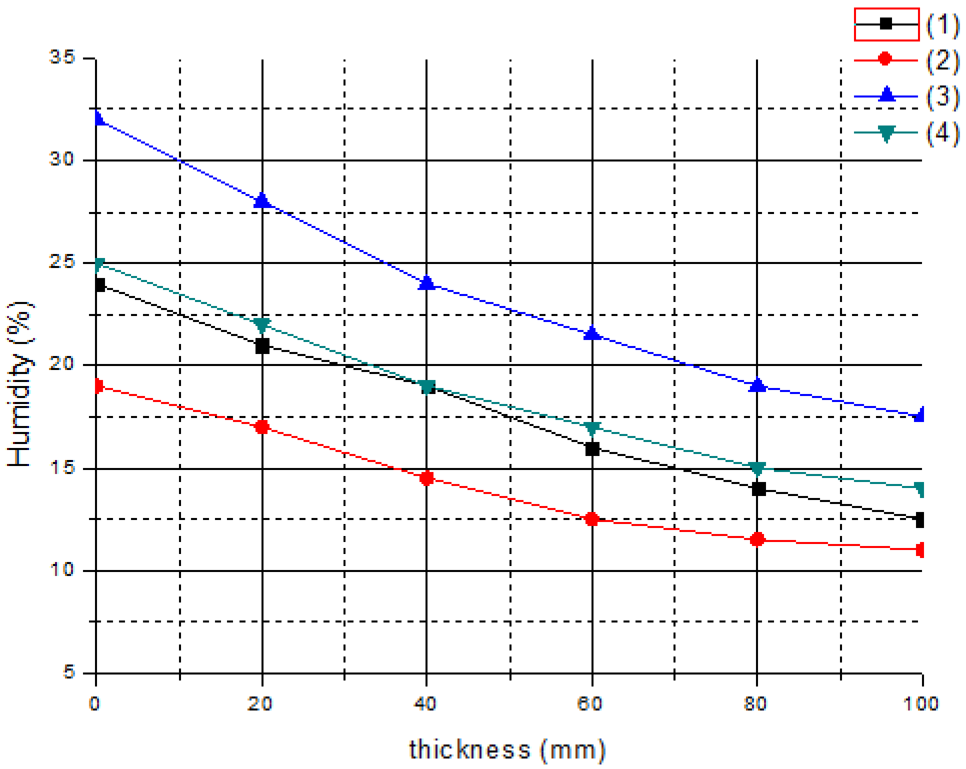

Fig. 5 - Moisture distribution over the thickness of the insulation material after the tests in the climatic chamber: 1 - Material based on chopped straw (sample 1), 2 - material based on a mixture of chopped straw and flax bark (sample 2), 3 - material based on chopped straw (sample 3), 4 - material based on a mixture of chopped straw and flax bark (sample 4)

Based on the obtained thermophysical indices, it was found that the most effective experimental thermal insulation materials work at temperatures below -5 °C. In conditions of increased air humidity, heat-insulating material on the basis of a mix of straw and flax bark has higher thermal-technical characteristics in comparison with a straw heat insulator.

The results of tests in climatic chamber make it possible to assume, that the heat-insulating material from straw and flax bark, taking into account ecological purity of components and low combustibility, can compete seriously with widely spread materials from foamed polystyrene and mineral wool.

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