Lightweight aggregates for concrete based on vegetable waste

Los áridos ligeros para los hormigones a base de residuos vegetales

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ABSTRACT

Introduction: The increase in the volume of housing construction per capita per year to the level of the eco-nomically developed countries, the tasks of further progressive economic and social develop-ment of the country can be achieved with a corresponding increase in the production of con-struction materials. **Materials and Methods**: The solution of this task is largely connected with the development of resource- and energy-saving technologies for the production of efficient light construction materials based on wastes from various industries, in particular on wastes of plant origin, which contributes to the expansion of the production range of light, smooth granulated aggregates and light insulating concrete based on them with modifying additives that increase and improve the physical and technical characteristics of these materials. **Results and Discussion**: There are known technologies for producing light aggregates, mainly by firing. As energy re-sources became more expensive, there was an urgent need to develop easy-to-fill technology in a cost-effective manner. **Conclusions**: This paper considers a method for producing a light aggregate based on wood processing waste by granulation in a dish granule torus, which is a plate with an inclination angle of 45 0 and the number of mob companies 17-19 rev/min.

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INTRODUCTION

Kazakhstan has accumulated a huge amount of various wastes, including wood processing waste, which is increasing from year to year. The processing of wood waste for the production of building materials contributes to the creation of low- and zero-waste technologies, reduce the cost of production, and reduce the area of land under piles. The main direction of weight reduction of buildings and structures is development of production of light porous aggregates, expansion of manufacture and application of load-bearing structures from light high-strength concrete, enclosing structures from light structural and thermal insulation concrete. Porous aggregates play a leading role in the formation of properties and structural features of light concrete[1]. In this regard, the main indicators of porous aggregate are bulk density and strength of grain.

It is known that the aggregate in concrete occupies up to 80% of its volume. The pro-duction of light concrete with optimal properties depends on the type of artificial porous ag-gregate used[2,3,4].

In the work[5,6,7] it is noted that the ratio of cement to sand (C/S) at the same cement consumption increases, that is, the thickness of cement dough around the sand grains increases. In this regard, the amount of wa-ter needed to produce equal to the consistency of concrete mixtures decreases as the flow rate of ceramics increases. Based on wood processing waste in the form of sawdust and chips, a structural insulation slag-alkaline arbutyl with a compressive strength of MPa was obtained. It is known that wood consists of a complex of various organic substances: 49.5% carbon, 44.1% oxygen, 6.3% hydrogen and 0.1% nitrogen. In addition to organic substances, there are miner-al compounds in wood, giving 0.2-1.7% of ash, which consists of salts of alkaline earth met-als. In order to eliminate the negative influence of water-soluble substances on the cement paste hardening processes, wood is treated with chemical or physical methods[8,9].

A common type of light concrete made from wood waste is wood silicate[10,11]. This material is prepared from a mixture of ground granulated blast furnace slag and caustic sodium (or liquid glass with silicate module M=1...1.45). In the form of a aggregate, structure, sawdust, crushing, etc., are used.

Is of some interest the use of polystyrene in the production of polymeric woody materi-als (PWM) from shredded wood – sawdust opened the possibility of obtaining a new type of PWM with new properties, allowed to find a new non-traditional for wood materials binder, and for thermoplastics - non-traditional processing methods and new uses of the resulting ma-terials. The polymeric woody material was impregnated with styrene monomer sawdust with subsequent thermochemical or radiation polymerization in the presence of sawdust and com-bining the finished polystyrene polymer with the sawdust use of its solution, melt or mechani-cal mixing of crushed polymer with sawdust[12,13,14,15]. In order to increase the strength of the building material a method is proposed for the preparation of vegetable raw materials, in this case sawdust, for the production of xylolite. The sawdust is pre-treated with an aqueous solution of calcium hydroxide (calcareous milk) for 10-15 minutes, after which it is dried at a temperature plus 90-1050C to a residual humidity of 7-9%, and then the sawdust is kept in the atmosphere of car-bon dioxide for 18-1024 hours with relative humidity of carbon dioxide air about 80-90%. By cement stone is formed in concrete by crystallizing structure formation, based on the initial coagulation structure in concentrated suspensions - dispersed mixtures of powder cement and water aggregates[16]. The adhesion of particles of solid phase through thin layers of liquid medium forms coagulation structures.

Some construction materials from sawdust are produced using cement (sawdust con-crete, wood concrete). Meanwhile, it is known that substances contained in wood negatively affect the hardening of cement paste: hemicellulose, starch and extractive substances. This is due to the fact that cement paste, being an alkaline medium (pH=11-12), affects hemicellu-lose, which is hydrolysed alkali and converted into simple sugars, soluble in water and nega-tively influencing the firmness of sawdust products.

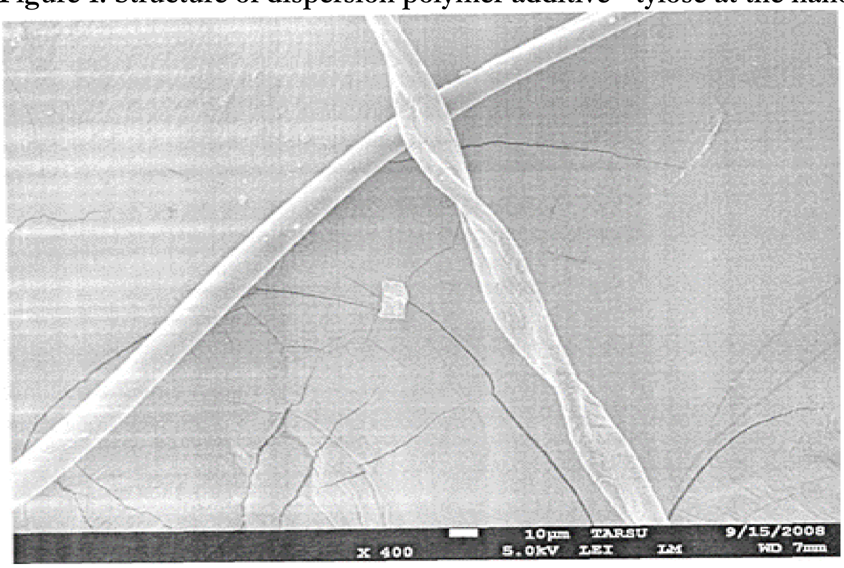
Studies[12,17,18] have shown that the hydration process, which occurs during the preparation of woody cement, produces a hydrate of calcium oxide. The hydrate of calcium oxide with water-soluble sugars present forms calcium sugars and, in particular, the most persistent three-calcium sugars (C12H22O11*3AO*3H2O) are produced with sucrose. He claims that the sugars, by reduc-ing cement paste to lime, because increased extraction of alumina from the total hydrated mineral mass of Portland cement alumina and the formation of aluminosilickel. Aluminosilick-el envelops cement grains with strong, hard-to-soluble films that delay its grip and hardening. In this case, the effect of sugars on grains of Portland cement should be considered as the in-fluence of reactive substances. From the above-mentioned literature on the main properties of light concrete on various aggregates, it is clear that there is insufficient study of concrete based on wood processing waste with modifying additive in the composition, which confirms the relevance of this article[1].

MATERIALS AND METHOD

Supplements Dispersion polymer powders - tylose and mowilith were used as additives. Phys-ico-chemical analyses have shown that they have a complex composition of natural minerals and polymers.

Mowilith DM 2072 is a water reductive synthetic polymer based on homo-, soitrophic polymers of vinyl acetate ($CH_3COOCH=CH_2$). The composition of mowilith – "know-how", has a high adhesive ability. The firm "Clariant" (Germany) produces mowilith of various brands. Tylose MV 5009 R2 - also produced by the firm «Clariant» (Germany). Ethyl cellulose $[C_6H_7O_2(OH)_{3-v}(OC_2H_5)_v]_n$. is thought to be the main component of tylose. Physico-chemical research has shown the presence of C-H, OH and C-O-bonds. But unlike the latter, in the IR spectrum of the tylose, the frequency of the absorption band of the CH_2-groups corresponds to the influence of the double bond ($=CH_2$), and the splitting of the absorption band of the methyl group is characteristic of the isopropyl group $(CH_3)_2CH$(19,20,21,22). Changes in the structure, as well as "know-how" of the firm characterize the tylose as a water-retaining additive. Figure 1 presents the structure of the tylose.

Figure 1. Structure of dispersion polymer additive - tylose at the nanoscale



Wood - the fabric of higher plants, which consists of the following substances:
- organic, high molecular molecules: cellulose, lignin, hemicellulose, 90 to 95%;
-low molecular extraction substances: aliphatic hydrocarbons, acids, resins, essential oils, fats, stearin - from 5 to 2.5%;
-mineral substances: carbonates, silicates, phosphates, oxides of metals - from 0.25 to 1.25%.

The chemical composition of the various wood species is almost unchanged: 50.9% car-bon, 43% oxygen, 6.4% hydrogen, 0.1% nitrogen. Waste generated by wood processing is classified according to its type into three groups: solid (or lump), soft (sawdust, chips) and bark. For the production of building materials and products, sawdust, shavings and lump waste are mainly used. The latter are used both directly for the manufacture of glued construc-tion products, and processing them on technical chips, and then on chips, crushing, fibrous mass, etc.

Sawdust - one of the most massive waste sawing and wood processing. The fractional composition of the sawdust depends on the method of production and is 10-0.2 mm. Particles less than 0.2 mm in size make wood flour. Bulk density and porosity of wood waste depend on the type of wood species and fractional composition (Table 1).

Table 1. Fractional composition and properties of sawdust

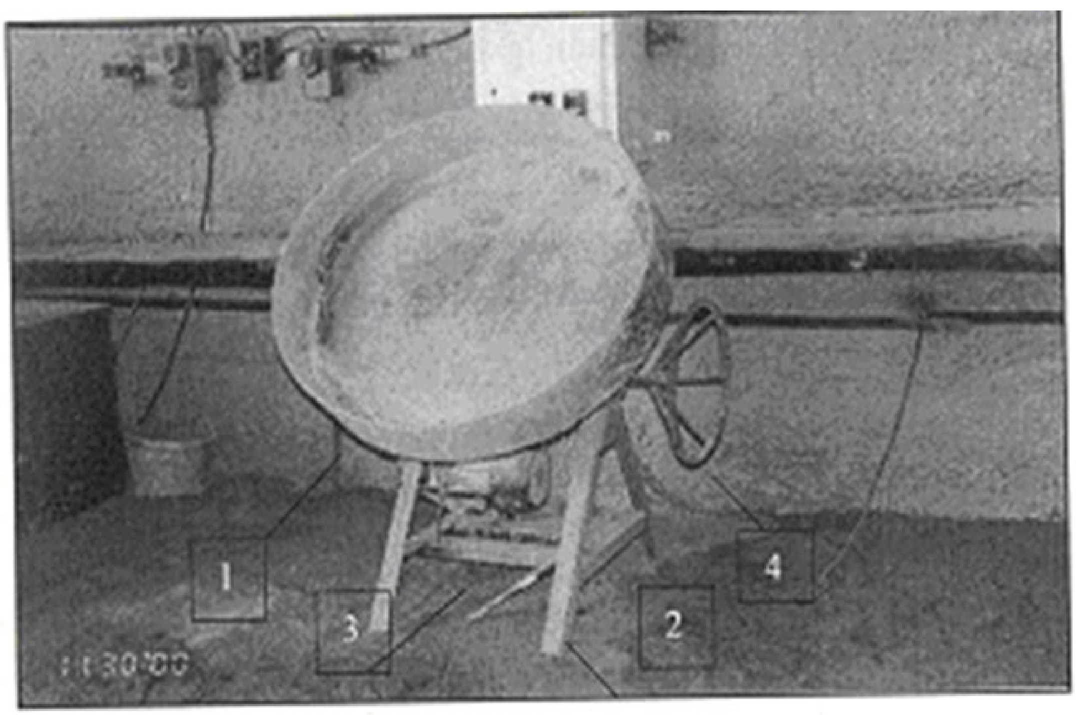
Fractional composition, %, particles with dimensions, mm			Bulk density in dry condition, kg/m³	Volume porosity, %
20-10	10-5	5-2,5		
-	100	-	200.0	75.3
40	40	20	175.0	72.0
25	25	50	220.0	72.0
35	35	30	230.0	71.0

Both softwood and hardwood waste are used in the production of building materials. For the production of most materials, coniferous rocks are preferable, as they contain less wa-ter-soluble extractive substances, as well as various sugars, tannins and resin substances that adversely affect cement-hardening processes.
The chemical and mineralogical composition of raw materials, as well as the influence of additives and aggregates on the hydration and hardening processes of cement were investigat-ed using physico-chemical methods of analysis.
The study of morphology, phase composition, contact zones and phase relationships, distribution of elements over an area was carried out using analytical scanning electron mi-croscopy (ASEM). They used the X-ray machine DRON-3M, a derivative machine M-1500, infrared spectrophotometer Specord M-80, microscope MIN-8.
One of the methods of physical action is treatment of wood particles with water (soak-ing in a special basin). Water-soluble substances treated in wood are significantly less than those normally shipped by rail or stored under sheds. Knowing the wood content (1.54) and the bulk weight of sawdust in a completely dry state ($\gamma 0$, kg/l), it is possible to determine the porosity P (%) by the formula:

$$P= 100(1- \gamma 0 / 1,54), \qquad (1)$$

Wood particle mass is also characterized by elasticity. The elasticity of wood particles[18,19,20] depends on the size and duration of the applied pressure, the particle size and the hy-drothermal treatment of the particles. The property of elasticity is manifested now of pressing from sawdust products and materials. In long-term humidification of wood particles with hot steam or water, particle elasticity is less than in low moisture mass. The pressing of sawdust materials and products eliminates the lateral displacement that occurs when other types of waste are used.
The method for producing artificial aggregate by granulation is one of the promising ways of reducing the cost of light materials. This paper considers a method for producing a light aggregate based on wood processing waste by granulation in a plate granulator, which is a plate with an inclination angle of 45 0 and a speed of 17-19 rev/min (Figure 2).

Figure 2. Disc Laboratory Granulator



(1-plate, 2- support, 3 – electric motor, 4 – plate tilt stop)

Wood processing waste - sawdust fraction of 1.25 mm or less was used to produce a granulated light aggregate. The sawdust fraction of 1.25 mm to obtain a granulated aggregate was pre-crushed into smaller particles. The 0.63 mm fraction waste was also used for granula-tion.

Consider a method for producing a granulated aggregate by granulation in a disc granulator.
Granulation method – The mixer is loaded with 50% crushed waste of a fraction of 1.25 mm and 50% of a fraction of 0.63 mm, after careful mixing, 2...3 parts of cement are added, 0.5% of the polymer additive from the amount of dry mixture and re-thoroughly mixed. Water is added to the mixture with constant mixing and until the humidity of 30... 35%. Prepared raw material mixture in the amount of 4...5 kg is fed to the disc laboratory granulator to produce pellets and then to powder them with cement. The polymer additive used was Mowilith and Tylose.
Granulation depends on the following factors: the humidity of the mixture, the inclina-tion of the granulator, the degree of filling of the plate and the time of pelletizing. Therefore, along with the change in the granulometry of the mixture, the time of granulation varied with-in 7...9 min. When a small amount of cement was introduced, the strength of the granules was low in all cases, so when choosing the optimal composition, the consumption of cement varied within 40 ... 60%. The amount of wood and water waste, respectively, fluctuated between 35... 25% and 35... 25%. The content of polymer additives varied in quantity: Mowilith - 1.5... 3% of dry mass; Tylose - 0.5... 1.0% of dry mass. The compositions of the mixtures and their densities are shown in Table 2.

Table 2. Content of components in raw mixtures

	Number of components, mass. %						
	cement	water	polymer additives		fraction wood processing waste, mm		
			mowilith	tylose	1.25	0.63	crushed
1	40	35	0.9	0.3	60	-	-
2	45	30	0.75	0.27	-	20	35
3	60	27	0.4	0.21	-	-	40
4	50	32	0.5	0.18	25	-	25
5	40	25	0.7	0.13	20	20	20

RESULTS

When 60% of the cement was injected into the mixture, the raw density of the granules was 780 g/gran. The presence of a polymer additive in the composition of the mixture contributes to an increase in the strength of the pellets, which explains the increase in strength of the granulated aggregate. The particulates of wood processing waste are wetted with aqueous solution, forming films. Water films are combined under the influence of surface tension, bringing together the waste particles[23].
As a result of repeated impacts, the particles are compacted and there is excess water on their surface, which attracts new particles and, at the same time, cement grain. When crushed waste is constantly rolled in the granulator with cement grains, the granules are increased in size and compacted. The main physical and technical characteristics of raw granules are given in Table 3.

Table 3. Influence of cement and water content on strength and bulk density of granulated aggregate

Composition No.	Raw density, g/cm^3	Bulk density, kg/m^3	Tensile strength when compressed in cylinder, MPa
1	650	700	2.1
2	650	850	2.9
3	780	850	3.5
4	750	800	3.8
5	680	750	4.1

At 35% humidity, the raw density of the pellets was 650 g/cm^3 and at 25% humidity was 680 g/cm^3, which is acceptable. When injected into the mixture 60-45% of cement ob-served the same pattern. Increasing the amount of cement to a certain limit (60%) improves the granulability of the mixture by increasing the mass dispersion and the interaction of the cement with the crushed waste constituents. Increasing the amount of water to 35% when cement is reduced to 40% leads to an increase in granule size, and reducing the amount of water below 25% when cement is higher than 60% results in sand and the mass is not granulated.
As the time of granulation increases, the granules decrease in size and the bulk density increases. High granule strength is obtained at a pelletizing time of 7-9 min. and this time is taken as optimal for all compositions. Increasing the time above the optimal results in cracks. Table 4 shows the dependence of raw granule density and final product strength

on the time of pelletizing. When granulating a cement-wood mixture within 3-5 minutes, the pellets are large and less durable.

Table 4. Influence of mixture granulation time on gravel properties

Granulation time, min	Raw density, g/cm³	Bulk density, kg/m³	Tensile strength when compressed in cylinder, MPa
3	500	800	1.1
5	450	630	1.5
7	700	880	2.9
9	650	800	2.5
12	750	810	2.1

The use of modified cement as a binder has resulted in higher crude density granules, which vary between 650-800 g/cm3. The optimal composition of the granulated aggregate is the content of the following components in the amount of: cement – 40-60%, Mowilith 0.4-0.9%, Tylose 0.13-0.3%, Water 25-32%. The most effective use of crushed wood waste frac-tion is 1.25 in 20-40%. The effective modifying agent in the composition of the binder is a complex containing substances Mowilith and Tylose in the amount of: 0.4-0.7% and 0.21-0.13%. The resulting aggregate had a bulk density of 550-900 kg/m 3 with a pellet tensile strength of 1.7 in the cylinder – 4.1 MPa.

Following optimum production parameters, a granulated aggregate was obtained on the modified cement of the next grain composition (Table 5). Test results showed that mainly 5-10 mm granules dominate the aggregator.

Table 5. Grain composition of granulated aggregate

Composition, No.	Sieve residue, mass. %, fractions, мм								Sieve passage 0.14, mass. %	
	10		5.0		2.5		1.25 and less			
	part.	full.	part.	full.	part.	full.	part.	full.	part.	full.
3	19.81	19.81	47.79	67.9	26.81	94.41	4.19	98.6	1.4	100
4	17.23	17.23	45.82	63.05	28.63	91.68	7.42	99.1	0.9	100
5	18.51	18.51	46.19	64.70	28.01	92.71	6.09	98.8	1.2	100

Table 6 presents the main physico-technical characteristics of the 3-5 granulated aggre-gate. The granulated aggregate of the formulation 5, containing the complex additive of mow-ilith in the amount of 0.4% and the tylose – 0.21% on the basis of crushed waste, has a higher bulk density of 850 kg/m3 than the composition 1 obtained on the cement binder. Therefore, the grade of the granulated aggregate on the modified cement (900-750) is correspondingly higher than on the cement (500,600), the strength of the granules in the former varies within 2,5-4.1 MPa, and in the second one is almost twice as low (1.7 and 1.6 MPa), the water re-sistance rate of the first is 0.86-0.77. The low water resistance of the 3-5 granulated aggregate is due to the content of the binder complex dispersion polymer additive, which forms a kind of film on the surface of the cement grains and wood processing waste.

The granulated aggregate on the modified aggregate has frost resistance within F35-F50. All this generally determines the choice of the granulated aggregate on modified cement as the most effective aggregate for light concrete.

Table 6. Physical and technical properties of the aggregate

Main indicators	Granulated fraction aggregate, mm, compositions (No.)					
	3		4		5	
	5-10	10-20	5-10	10-20	5-10	10-20
Bulk density, kg/m³	850	800	850	800	750	700
Pellet strength during compression (MPa) in the condition of:						
dry	3.5	3.2	3.8	3.4	4.1	3.9
water-saturated	3.0	2.6	3.2	2.9	3.3	3.0
Water resistance coefficient	0.86	0.81	0.84	0.85	0.8	0.77
Water absorption, %	18.0	19.5	13.7	14.9	16.1	16.0
Inter-grain void, %	33.3	41.2	36.2	39.8	37.4	38.2
Frost resistance, cycles	40	35	45	50	50	45
Thermal conductivity, W/m*degree	0.11	0.10	0.09	0.09	0.091	0.092

Therefore, the optimal composition of the granulated aggregate on modified cement provides 40-60% of wood processing waste, 60-40% cement, 25-32% water and pelletizing time – 7-9 minutes. With this composition, the bulk density of the obtained aggregate corresponds to 850-750 kg/m3, the tensile strength of the pellets in the cylinder is 3.5-4.1 MPa. The optimum content of the polymer additive in the binder is within the limits of: mowilith – 0.4-0.7% and tylose – 0.21-0.13%.

One of the ways to increase the strength and resistance of concrete on waste wood processing to various aggressive media, Alternating humidification and drying is the convergence of the deformations of cement stone and organic aggregate by increasing the elasticity of cement stone when modified by polymers(24,25,26). For concrete modification, the choice of dispersion polymer powders is because they form films with a high adhesive capacity in relation to extractive substances of wood (ESD). The granulated aggregate, unlike porous aggregates s in light concrete, absorbs very little water. Therefore, the water cement ratio was calculated and the required usability was determined.

The mechanical properties of modified concrete depend mainly on the average density. Concrete with an average density of 1000 kg/m^3 has marks M25, at 1200 kg/m^3 – M35, at 1300 kg/m^3 – M50, at 1500 kg/m^3 – M75. The strength characteristics of the modified con-crete meet the requirements of the regulations for light concrete. The ground and bending ten-sile strength for the above-mentioned grades ranges from 2.7 to 7.0 MPa and 0.79 to 1.8 MPa respectively and increases with the average density of the modified concrete (Tables 7). How-ever, the strength coefficients decrease with increased compressive strength of concrete.

Table 7. Physical and mechanical properties of mowilith-containing concrete

Mark	Average density, kg/m^3	Strength limit, MPa, at:		
		compression R_{comp}	Pristine, R_{pr}	bending R_{bend}
M25	1000	3.5	2.7	0.79
M35	1200	5.0	3.8	1.15
M50	1300	7.5	5.5	1.65
M75	1500	10.0	7.0	1.80

An important characteristic of the deformation properties of concrete is the elasticity module, which depends to a large extent on the strength of concrete and the type of aggregate (Table 8). The initial modulus of resistance of the concrete corresponding to the voltage of 0.2 Rpr is generally accepted in the calculations.

Table 8. Deformation and strength characteristics of mowilith-containing concrete

Basic characteristics, unit of measurement.	Indicators	
	1	2
Section, A•10^4 m^2	98.6	96,96
Destructive pressure, kn	36	40
Average density, kg/m^3	1243	1239
Average	1241	
Prismatic strength, MPa	3.65	4,12
average	3.88	
Modulus of elasticity, MPa	5.27	5,50
Average	5.39	

Comparative Table 9 shows that modified concrete is approaching ceramic polystyrene concrete.

Table 9. Modulus of elasticity of some light concrete

Type of concrete	Average density, kg/m^3	Modulus of elasticity, MPa
Ceramsite concrete	1430	12.0
Ceramic polystyrene concrete	1220	10.8
Modified concrete	1240	9.87

The resulting modified concrete has a low thermal conductivity. Depending on the aver-age density (1000-1500 kg/m3), the coefficients of thermal conductivity are given in Table 10.

Table 10. Thermal conductivity of modified concrete

Average density, kg/m^3	Thermal conductivity coefficient, W /m * ^{0}C
300	0.064
400	0.070
500	0.075
1000	0.082
1200	0. 094
1500	0.1

DISCUSSION

The cement hydration processes in the sugar solution in the presence of the polymer additive were observed on the microscope MIN-8 with an increase of *1000 times in passing light. The test sample of cement interacted with excess water. When cement was closed with water after 5 minutes, the appearance of a slightly visible film of hydrates on the surface and the beginning of needle formations. After 15 minutes, the grain swells noticeably, forming a dense shell of needle-like crystals. Further hydration of cement (40-60 min) is accompanied by an in-crease in grain size, promotes the formation of many needle-like, small crystals and the appearance of rounded transparent grains. Changes in cement hydration in the sugar solution are also visible from the moment of mixing. This process begins with the formation of faint, thin light films along the edges of crystals. After 5-7 minutes, the film of neoplasms is noticed and the size of large cement grains is reduced. The interaction of cement with the sugar solution after 5-5.5 hours. leads to the formation of large clusters of small grains and reduce the number of large ones. No other formations were found during this period.

The presence of a polymer additive in the composition of the astringent, when hydrated in a sugar solution in the first minutes of plating does not give much change. The interaction of the modified astringent is accompanied by the appearance of subtle light films of hydrates and the first needle formations (0-5min). 10-15 minutes later are observed formation of a film of neoplasms on the surface of the cement grains and spontaneous splitting of large grains into small particles occurs. At the same time, the first clusters of small particles appeared. Changes at hydration after 1-1.5 hours. accompanied by the appearance of rounded transparent grains, and from small needle-shaped crystals formed the first large formations.

The production of Ca(OH)2 crystals by water on cement takes 3.5-4.5 hours that is manifested by the appearance of light film, grain lengthens and increases the number of grain rounded shape. On the surface of grain crystals there are needle-like formation and accumulation of needle-like crystals, similar to polyhedra. Cement hydration five hours later. is characterized by an increase in the number of accumulations of hexagonal form of needle-shaped crystals and an increase in the thickness of light films along the edges of crystals.

When cement is hydrated in a sugar solution within 24 hours, there is also a slight in-crease in the thickness of the film of neoplasms. In the phase grains the manifestation of «channels» in crystals is noticeable. Large grains break into smaller ones and accumulate small particles in their place. After 29 hours on individual cement grains there are new formation of noticeable thickness, phase «channels» are clearly expressed and there are already single fully progestated crystals. When hydrating modified cement in a sugar solution after 7-8 hours, a marked decrease in the number of large grains and the appearance of barely noticeable outlines of the polymeric film are detected. After 26 hours of interaction, the polymer film is stronger, which envelops neoplasms, and the thickness of hydrate films is increased. The field under study is covered with a large number of small grains of the new phase. After 3 days of cement hydration, $Ca(OH)_2$ crystals were observed in the water. Also, there was re-crystallization of needle- and hexagonal crystals. After 48 hours of hydration, accumulations of small grains were detected in the sugar solution. The formation of shapeless neoplasms and the appearance of cracking of large crystals (2-5 days). And the three-day hydration leads to the destruction of the grains into smaller particles and at the same time there is a further interaction of the so-lution on the newly exposed surfaces of crystals.

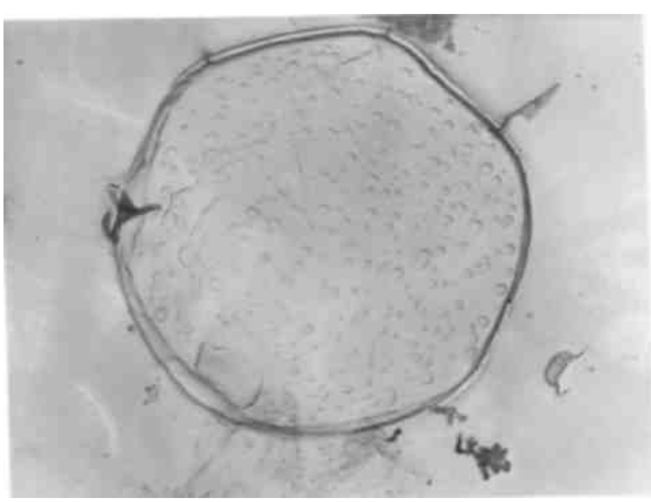
Hydration of modified cement for 36-48 hours is characterized by the appearance of a polymer film on the surface of hydrates located on cement grains, at the same time there is an increase in the thickness of the polymer film. At the same time, the formation of gel and shapeless neoplasms was detected. After 5 days of hydration, small grains of elongated shape appear in the water. Dark crystals are visible in the field of view. Large grain phases are sur-rounded by fine grains and resemble the folds of smaller ones. Cement hydration over a peri-od of 7-10 days is characterized by a large number of reacted grains, although there are some grains only partially affected by hydration. The stratification of the lesions becomes well visible.

In the sugar solution, when cement is hydrated, large grains are destroyed into smaller ones and the interaction is already taking place on newly exposed surfaces (3 days). After 4-5 days, there are shapeless, loosely visible formations, the crushing of large grains into small ones and the flow of reaction continues. The interaction of modified cement with the sugar solution occurs with the destruction of large grains and the formation of reaction products on newly formed surfaces. Polymer films (3 days) appear around these products and surfaces. Further hydration (4-5 days) is accompanied by an increase in the thickness of the polymer film, which envelops the surface of the neoplasms in the form of a blanket, and 7 days of hydration leads to the intensive appearance of the polymer phase.
The hydration of cement in the water continues with the formation of short needle-like crystals and spontaneous grain crushing (20 days). The observed cement interaction after 28 days represented spontaneous dispersion of most grains. The total interaction of cement with the sugar solution lasts for 14 days, and there may be accumulations of small, dotted, faintly visible neoplasms. At this time of hydration of the modified cement with a sugar solution, the formation of a monolithic grating from the polymeric phase penetrating through the hydrate phase of cement can be observed, which can be concluded that the above cement is sufficient-ly fully hydrated. Figures 6 to 8 show the products produced by the cement hydration process in different environments.

Figure 6. The polygon-block microstructure of calcium hydrosilicates when cement is solidified in an aquatic environment

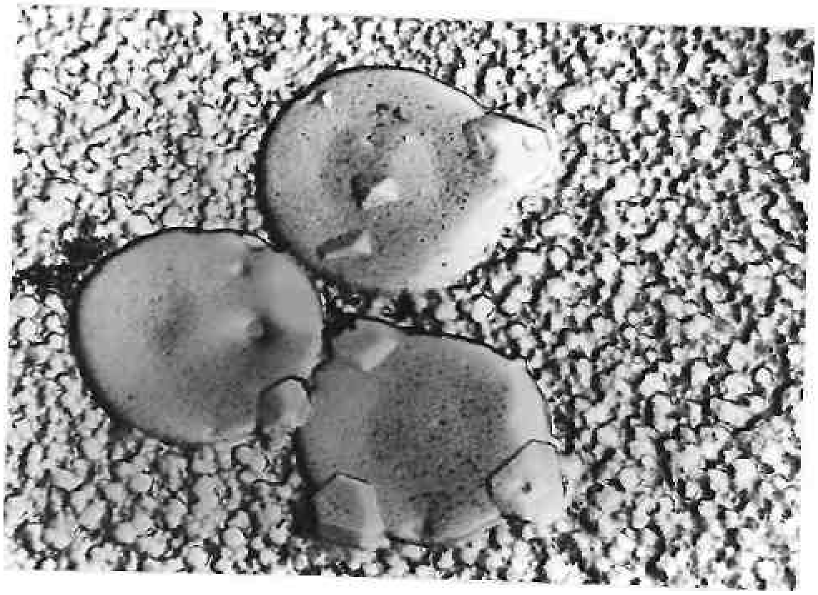
Figures 6 shows platinum-carbon replica at lumen, 14000* increase, chemical separation.

Figure 7. Weakly crystallized calcium hydrosilicates formation on the surface of clinker min-erals when hydrated in a sugar solution



Figures 8 shows platinum-carbon replica at lumen, 14000 increase*, chemical separation.

Figure 8. Homonolisation of the microstructure of the polymeric phase on the granule surface by the growth of octahedral hydrosilicate crystals



Therefore, under the influence of the sugar solution, all phases of the cement are subject to dispersion. This is due to the adsorption of sucrose, that is, chemosorption on the surface of the crystals; it weakens and then breaks the bonds in the mineral, causing the destruction of phase crystals. The presence of a polymer additive helps to inhibit the adsorption of sucrose by enveloping the crystals with a polymeric film, reducing the number of destroyed phase crystals. The formation of a monolithic grating from the polymer phase increases the strength of the contact zone, adhesion, fracture resistance and durability of the material based on a polymer cement mixture under the influence of a sugar solution.

CONCLUSIONS

Effective method for producing a granulated aggregate based on a modified cement binder with an optimal composition: 40-60% crushed wood waste, 40-60% cement, 25-32% water and pelletizing time – 7-9 minutes. A granulated aggregate with a bulk density of 550-900 kg/m3, with a pellet tensile strength of 1.7-4.1 MPa, frost resistance F35-F50.

The mechanism for forming the modified active layer on the pellets of the light aggregate from wood waste is as follows:

- the result of the implementation of the mechanism provides the creation of a protective hydrophobic polymer film on the basis of a complex additive of mowilith and tylose, each of which has a double action, regulating the water-holding capacity and creating a surface of phase separation;
- the formation of cement hydration products takes place on film surfaces in the form of nano-sized non-functional nano-crystals of hydrosilicates providing surface film strength;
- the water-holding capacity of the dispersion polymer additive of tylose is regulated by the microstructure of the cellulosic fibre in its composition.

Modified structural insulation concrete has the following characteristics: M25-M75; co-efficient of thermal conductivity – 0,082-0.1 W / m*0C; frost resistance – F25-F35; sulfate resistance coefficient – 0.72-0.83. Thermal insulation concrete has the following characteristics: M5-M15; coefficient of thermal conductivity – 0.064-0.075 W / m*0C. Under the influence of the sugar solution, all phases of cement are subject to dispersion, which is explained by the adsorption of sucrose, which leads to the destruction of phase crystals. The formation of a monolithic grating from the polymer phase increases the strength of the contact zone, adhesion, fracture resistance and durability of the material on the basis of a polymer cement mixture under the influence of a sugar solution.

The process of formation of calcium hydrosilicate crystals in the cement stone micro-structure can be divided into the following stages: the formation of clusters of cubic crystals in the inter-grain space of cement stone; separation of crystalline hydrosilicate strands on the surface of granules; fusion of parallel-directed crystals into plate and prismatic crystallogens. The increased compressive strength of concrete is achieved by the presence of water-soluble polymer powders. The strength in the contact zone of concrete is increased and is explained by the fact that the liquid phase of cement stone, containing polymer particles, calcium ions, aluminate and silicon-hydrode anions, penetrates into the pores of the material and ongoing hydration and polymerization processes firmly connect contacting materials (cement stone and aggregate). Increasing the concentration of polymer powders in modified concrete helps to reduce the shrinkage by an average of 30-40%. In the presence of additives, studies show that the water absorption of concrete is reduced. The polymeric phase in the cement stone has a microheterogeneous structure containing inorganic inclusions of hydrate phases, non-hydrated cement particles or thin fractions of aggregates. Reinforcing the polymer component improves the properties of the component itself and the system as a whole.

The mechanism for forming the modified active layer on the pellets of the light aggregate from wood waste is as follow:

- the result of the implementation of the mechanism is the creation of a protective hydrophobic polymer film on the basis of a complex additive of mowilith and tylose, each of which has a double action, regulating the water-holding capacity and creating a surface of phase separation;
- the formation of cement hydration products takes place on film surfaces in the form of nano-sized non-functional nano-crystals of hydrosilicates providing surface film strength;
- it has been determined that the water-holding capacity of the dispersion polymer additive of tylose is regulated by the microstructure of cellulosic fibre, which is included in its composition.

Physico-chemical studies have shown that when hardening modified concrete based on:

• the waste of wood from the hydration process follows the traditional mechanism, which is explained by the influence of the polymer additive, which forms a dense polymer film around the neoplasms, preventing the interaction of sugars with cement hydration products;

• on the granular aggregates that the modifying agent is mowilith and it is established that the hydrosilicates during the hydration of cement mixtures are formed through the aqueous medium and are products of topchemical reactions, i.e. dissolved and recrystallized lick, which causes a state of dynamic equilibrium in the system.

Therefore, the resulting granulated aggregate based on the waste of wood processing and the modified binder is effective in producing structural-thermal modified concrete.

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