СТРОИТЕЛЬНЫЕ МАТЕРИАЛЫ

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POROUS WALL CERAMICS WITH BURNOUT ADDITIVE FROM FLAX BOON

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Advantages and technologies of porous ceramics production are considered. The experience of using burnout additives of different origin for wall ceramics is analyzed. In the work it is proposed to use a flax boon fraction of not more than 2 mm as a burnout additive. Density and strength of ceramic samples were determined. The dependence of the average density and strength of the ceramic shard on the consumption of flax boon, including the use of superplasticizer S-3. The positive effect of the use of superplasticizer S-3 on the compressive strength of porous ceramic samples was established. The data on frost resistance and thermal conductivity of porous wall ceramics samples obtained by using flax boon as a burnout additive are presented.

Keywords: *porous ceramics, flax boon, burnout additive, strength, density.*

Introduction

Economy resources are the major economic and environmental problem all over the world. Modern construction demands the raise of efficiency of building materials. The solution of this problem is connected with creation of materials for non-load-bearing constructions of the buildings providing decrease of power consumption and specific consumption of materials in manufacturing, raising of their heat-shielding properties and decrease of loadings on the basic load-bearing walls of buildings.

It is possible to provide requirements of the building complex in such materials partially at the expense of working out of composes and production technique of ceramic items with porous structure.

Porous ceramic possesses a number of advantages as compared well other building materials, including hollow and solid brick. These are high heat-shielding, fireproof and sound-proof properties, chemical durability, low sorption moisture.

Porous structure of ceramic materials can be made by buckling of a charge in process of formation or foaming, chemical pore-formation, using of monofractional composits of initial raw materials, raising moisture of raw mass, introducting burning additives, adding in mass porous aggregates into foaming.

Obtaining of a high-porous ceramic by a pressing method is known. Using the property of clay (plastic property), corpuscles tapes-zhgutik of the lengthened form are made, at chaotic, disorder placement and pressing obtain. This method allows to obtain porous ceramic items with density 800…1300 kg/m^3 [1].

Using a high-speed high-temperature buckling and caking raw-clay porous ceramic small blocks with density 400…800 kg/m^3 are obtained. It allows to reduce the thickness of walls in 1,3…1,5 times in comparison with a traditional brick [2].

Adding burning out additives in a charge is optimal in manufacturing wall ceramic materials by the method of plastic formation. In the process of roasting the uniform warming up of products is observed, reducing medium improving process of formation of a ceramic crock is created. These additives are the sawdust which application is known since XVIII century [4], various sorts of bituminous coal, a waste coal dressing plants, ash TEC, lignin, peat, straw, leaves of trees, peel buckwheat, polystyrenen packings wastes, papers, board, any other combustible materials having low bulk density [3–5].

Application of extraction and enrichment of coals waste of the Western Donbass, the Lvovsko-Volynsk coal field is known. It provides more uniform distribution of combustible mass in burned items and is economically and technologically favourable. A coal output and enrichment wastes considerably reduce sensitivity of the raw to drying, provide temperature reduction of brick roasting on 50…70 °C and allows obtain crock of the lower density.

Adding in ceramic mass the coal residual materials besides formation the porous structure allows to lower fuel consumption, necessary for roasting of items.

Having the unburned carbon (not burnt out coke) it is possible to use ash TEC as a combustible additive. Ash in quantity to 50% that allows to gain a stoneware in density to 1250 kg/m^3 induct into a charge wall ceramics. However disadvantages of ash TEC are connected with the restriction of the content CaO + MgO (no more than 5%)

and an unequal chemical compound of ash is noted at burning of the same fuel on one power station. It leads to differences of physic-mechanical properties of a ceramic brick [3].

Perspectiv composites for wall ceramics are composites on the basis of riding clay with the additive of ash or cindery microspheres in quantity of 10…20% from the clay mass, allowing to obtain ceramic items with average density 1120…1450 kg/m^3 [4].

Use of complex mineral (pulverous fractions of argillites) and organic additives (levigated stalks of cotton) are known. Average diameter of stalks of cotton is 5…10 mm. Thanks to porous-fibrous structure of stalks drying of products is considerably sped up. The additive in clay raw materials of argillites of the completed lubricant-coolant and levigated stalks of cotton allows to obtain the stoneware with average density 1385 kg/m^3 and the brand with strength of M 100.

Is perspectiv use of zeolitic mucks. Zeolit-containing siliceous mucks and zeolit-containing clays are effective technological additives in manufacturing ceramic brick. Pustotno-porous brick hollowness of 41%, a brand on strength of M 75…100, average density 930…980 kg/m^3 and a coefficient of thermal conductivity no more than 0,3 W/(m·°C) is gained from raw masses on the basis of polymineral clay and the given technological additives [5].

It is possible to create a highly porous structure of a ceramic material by applying the high-temperature porisation of a clay charge, as well as by supplementing the granules of a ceramic semi-finished product during firing. As a fine additive, the author [6] proposed to use fine porous highly dispersed zeolite in an amount of 10…15%. The average density of such a ceramic brick is 520…700 kg/m^3 with a compressive strength of 1,5…2,5 MPa.

One of the ways of solution the problem of decreasing average density is useing raw materials for wall ceramics siliceous opalcrystalbolide rocks. Argillous minerals flask are presented mainly by hydromicas which promote lower sintering temperatures. The least average density of samples on the basis of carbonate flask is 1180…1330 kg/m^3, the greatest on the basis of argillous is 1380…1540 kg/m^3. It allows to obtain hollow structural products of average density 800…1200 kg/m^3 [7]. Average density of the crock on the basis of flask is 15…35% lower then the same parameter of the products made from traditional clay raw materials.

Only as burning out additives, but also as a plasticizer lignine is used being waste product of wood alcohol. Besides, the additive improves drying and forming properties of clay mass. Lignine is inducted in number of 4…15%, combining with other combustible additives, for example, sawdust, coal [8].

It is necessary to induct in charges great volume of burning out additives of phytogenesis (peel buckwheat, wood dust) for raising heat efficiency of wall materials. For the purpose of exclusion of strength reduction of the porous crock. Na- and Al-containing additives are recommended to introduce simultaneously into charge of additives of multifunctional acting consumption. It is at the expense that power- and resource effect and raise of strength of hollow-porous ceramics is attained of mehano-chemical activation: mechanical – at flour milling of the basic raw materials; chemical – in introducing in the composition of mehanoactivated clay, Na- and Al-containing additives and combustible additions, including processed by these chemical additives. Products having the brand with strength of M 75…100 and average density 684…973 kg/m^3 and hollowness 20…55 % [9] are obtained.

Now the sawdust inducted in number of 8…28% by volume is widely applied for martempering drying properties of raw [3]. Application of sawdust as a blowing agent gives economy of fuel and energy resources and allows to obtain the ceramic material with the improved heat-shielding properties. Properties of the charred products are influenced by the size and structure of sawdust. When using a circular saw coarse and fibrous sawdust are obtained, and when using at the belt saw more thin sawdust of the cubic form are obtained. The greatest effect is attained in introducing of the sawdust obtained by means of the belt saw.

Researchers at Kazan State Architectural and Construction University have developed a method for producing ceramic foam products, which includes the joint mixing of all components of the charge (clay, aggregate, burnable, stabilizing, fluxing additives, liquid glass, plasticizer, water and a foaming agent). Sawdust with a fraction of 0,25…0,315 mm is used as a burnable additive. The compressive strength of the samples is 3,7…4,0 MPa with an average density of 580…630 kg/m^3 [10]. In addition, this university is developing in the field of production of porous-hollow bricks and stones with a density of 750 - 950 kg/m^3 with a strength of 75…150 MPa and thermal conductivity of 0,145…0,185 W/(m·°C). Burning supplement is buckwheat husk in the amount of 20… 56% of the volume of the mixture.

A large number of scientific papers [11–16] are devoted to the use of organic waste from the agro-industrial complex: rice husk, raw cotton waste, sugar cane, tea production.

According to the results of a number of studies, it is proposed to use waste from the production of olive oil as burnable additives [17–21].

The introduction of cake into the charge as a pore-forming additive [19] made it possible to obtain a ceramic brick with a reduced density and thermal conductivity while maintaining the strength characteristics.

French researchers [20] added milled olive pits and wheat straw to the mixture to obtain porous ceramics.

Belarusian colleagues studied composition containing various pore-forming additives [22], such as sawdust and wood ash, pulp and paper and sugar production in an amount of up to 10% to produce wall ceramic materials with improved thermal insulation characteristics.

In Belarus researches on use of sawdust as burning out additive by specialists "NIISM" is carred out. The obtained experimental data allowed to development technological parameters of clay moulding, drying and roasting at Radoshkovichsky ceramic plant [23]. Products with general density 850…1100 kg/m^3, having the brand on strength of M 75…175, the brand on frost resistance F 50…75 are obtained. The coefficient of thermal conductivity in dry state is 0,18…0,29 W/(m·°C).

At the Obolsky ceramic plant in cooperation with Polotsk State University the manufacturing methods of producing of structural clay tiles with the peat and fuel oil additives are completed. The control composition has the density of 1850 kg/m^3 at strength 29 MPa. Use of the complex additive of peat and fuel oil allows to lower the density to 1150 kg/m^3 at the brand of products with strength M 75 and the brand on frost resistance F 15, and to lower heat conductivity from 0,64 to 0,52 W/(m·°C) [24]. However for last years peat and fuel oil cost has considerably raised and application of these additives is economically unprofitable.

Theoretical and practical development on influencing of surface active substances as additives on properties of the clay brick testify of possibility of improving of structural characteristics of ceramic items. Use of surface active substances on the basis of lignosulphonates increases the number of plastic properties of clays, raises mould ability, reduces forming moisture and doubles the strength of the raw brick and the strength of the brick. The optimal proportion is 1…1,5% of mass of clay.

Practically all observed above additives are by-products or production wastes. As practice shows application of those or other additives has regional character, as it is, as a rule, the waste of manufacture.

Use of secondary resources in manufacturing of building materials is a considerable reserve of raising building efficiency. Among such resources it is possible to gate out a farming industry with drawal – the flax boon. Using the boon as an organic burnout additive allows to lower average density of a ceramic crock, to create the framing of ceramic mass preventing the shrinkage of samples and, promotes materials recycling of processing of flax.

Materials and methods

The density of the ceramic crock was determined according to GOST 7025. The compressive strength of the ceramic crock was studied according to the method given in GOST 8462. Frost resistance of ceramic samples was determined in accordance with GOST 7025. With the help of the device ITP-MG4 in accordance with the requirements of STB 1618 set the values of the thermal conductivity of the porous ceramics.

Clay of medium plasticity of deposit «Zapolie» was used for researches. The control composition (clay 90% + chamotte 10%) has the average density of a ceramic crock 1810 kg/m^3 with the strength 31 MPa. In experimental compositions, flax boon fraction of 0,5…1 mm, 1…2 mm and 2-3 mm was administered in an amount of 3…10%.

Surface-active substance (surfactant) based on naphthaleneformaldehyde was used to increase the strength of the experimental samples. Superplasticizer S-3 according to specifications 6-36-020429-625 as the surface active substances was applied.

Main part, discussion

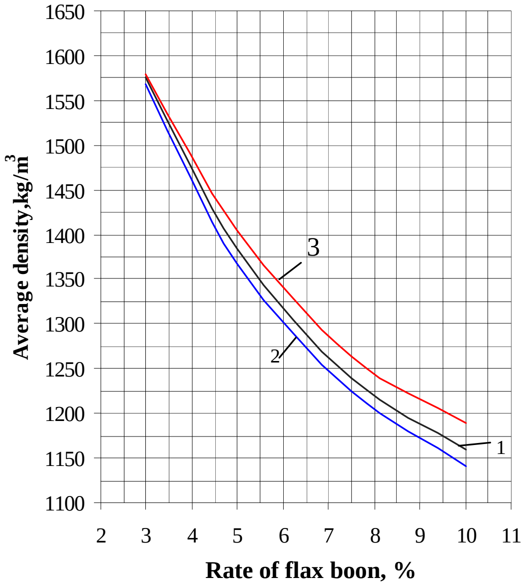
The raw mass should possess certain forming properties. Using the high plasticity of charge leads to reject, increasing shrinkage; poor plasticity raw mass, – to breakage of the tape press. In order to avoid defects and breakdowns in the process of brick production, we must consider the humidity of the flax boon with the introduction of the raw mass. After a number of studies, we found that the best rate of plasticity of ceramic mass is achieved at a moisture content of flax boon 44…87%.

The use of flax boon as a burnout additive reduces the density of experimental samples from 1810 kg/m^3 to 1140…1580 kg/m^3. At the same time, the compressive strength of the samples decreased by 2 or more times to 5,5…15,8 MPa. On the basis of experimental data dependences of density and strength of the ceramic crock from the charge flax boon (Figures 1, 2) are obtained.

The obtained dependences allow us to conclude that the introduction of flax boon in the amount of 3…10% reduces the average density of the ceramic crock by 13…37%. Introducing the burnout additive in quantity to 3% from clay mass does not provide essential decrease of average density, and introducing more than 10% from clay mass considerable strength reduction of a ceramic crock occurs.

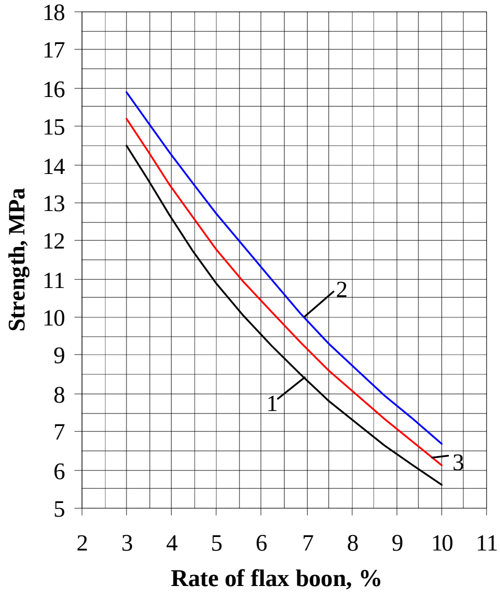
Thus, the allowable amount of added flax boon is in the range from 3 to 10% by weight of clay. At the same time, the best strength characteristics are demonstrated by samples with the addition of flax boon with a fraction of 0,5…1 mm and 1…2 mm (Figure 2).

With a view to ensuring the regulatory requirements of the brand porous bricks shall conform to M75, M100, M125. From these dependencies in Figure 2 it follows that for the M75 brand, the consumption of flax boon with a fraction of 1…2 mm is 9,1% with a density of 1170 kg/m^3. To ensure the brand M125 input flax boon fraction of 1…2 mm should be no more than 5,2%, and the density should be at least 1360 kg/m^3.



1 – fraction of 2…3 mm; 2 – fraction of 1…2 mm; 3 – fraction of 0,5…1 mm

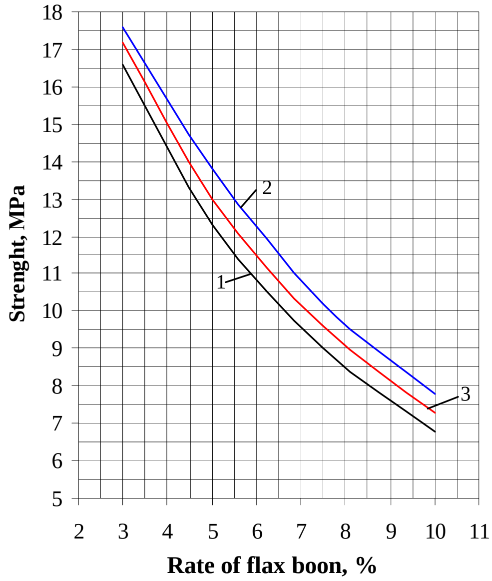
Figure 1. – Dependence of average density of ceramic crock on the rate of flax boon



1 – fraction of 2…3 mm; 2 – fraction of 1…2 mm; 3 – fraction of 0,5…1 mm

Figure 2. – Dependence of strength of a ceramic crock on the rate of flax boon

Experimental data allow us to conclude that it is possible to obtain ceramic wall products with the strength of the crock from 6,8 to 17,6 MPa when adding a superplasticizer S-3 to the raw material mass. Dependences of the strength of a ceramic crock from the rate of flax boon in acting of superplasticizers S-3 are obtained (Figure 3).



1 – fraction of 2…3 mm; 2 – fraction of 1…2 mm; 3 – fraction of 0,5…1 mm

Figure 3. – Dependence of strength of a ceramic crock on the rate of flax boon with the introduction of superplasticizer S-3

The introduction of plasticizer S-3 provided an increase in strength by 11…24% of porous ceramic samples compared with compositions without additives. While maintaining the strength at the level of compositions without additives, it is possible to increase the number of introduced flax boon by 1…1,5%, which will reduce the density of ceramic bricks to 10%.

For samples with a compressive strength of at least 10 MPa at a density of 1250 kg/m^3, frost resistance and thermal conductivity were determined. Frost resistance of experimental porous ceramics was 84 cycles of alternating freezing and thawing, which corresponds to the brand F75. The thermal conductivity of the samples in the dry state (operating conditions A) is 0,22 W/(m·℃).

Conclusion

1. The possibility of using flax boon as a burnout additive in the manufacture of wall ceramics is proved. The best levels of density and strength are achieved by using the flax boon fraction 0,5…1 mm and 1…2 mm.

2. With the introduction of flax boon in an amount of 5…9% in the raw material mass, it is possible to obtain wall ceramics with a compressive strength of 7,5…12,5 MPa at a density of 1170…1360 kg/m^3.

3. Application of the surface active substances based on naphthalene formaldehyde improves the molding properties of the ceramic mass and reduces water consumption. Due to the decrease in the moisture content of the ceramic mass, the drying process is accelerated, which reduces energy consumption and increases the strength of the experimental samples by 11…24%.

LITERATURE

1. Akberov, A.A. Tekhnologiya i svoystva vysokoporistogo keramicheskogo materiala : avtoref. dis. … kand. tekhn. nauk : 05.23.05 / A.A. Akberov ; Sankt-Peterburgskiy arkhitekturno-stroitelnyy universitet. – Sankt-Peterburg, 2005. – 21 s.
2. Tammov, M.Ch. Energoeffektivnyye poristokeramicheskiye materialy i izdeliya : avtoref. dis. … doktora tekhn. nauk : 05.23.05 / M.Ch. Tammov ; Nauchno-issledovatelskiy proyektno-konstruktorskiy i tekhnologicheskiy institut betona i zhelezobetona. – Moskva, 2006. – 39 s.
3. Rogovoy, M.I. Tekhnologiya iskusstvennykh poristykh zapolniteley i keramiki / M.I. Rogovoy. – M. : Stroyizdat, 1974. – 315 s.
4. Revva, I.B. Stroitelnaya keramika na osnove kompozitsiy legkoplavkikh glin s neplastichnymi prirodnymi i tekhnogennymi komponentami : avtoref. dis. … kand. tekhn. nauk : 05.17.11 / I.B. Revva ; Tomskiy politekhnicheskiy universitet. – Tomsk, 2005. – 23 s.
5. Kornilov, A.V. Netraditsionnyye vidy nerudnogo syria dlya proizvodstva stroitelnoy keramiki / A.V. Kornilov // Stroitelnyye materialy. – 2005. – № 2. – S. 50–51.
6. Putro, N.B. Porizovannaya stroitelnaya keramika (sostav, tekhnologiya, svoystva) : avtoref. dis. … kand. tekhn. nauk : 05.23.05 / N.B. Putro ; Novosibirskiy gosudarstvennyy arkhitekturno-stroitelnyy universitet (Sibstrin). – Novosibirsk, 2004. – 24 s.
7. Kotlyar, V.D. Opoki – perspektivnoye syrye dlya stenovoy keramiki / V.D. Kotlyar, B.V. Talpa // Stroitelnyye materialy. – 2007. – № 2. – S. 31–33.
8. Zolotarskiy, A.Z. Proizvodstvo stroitelnogo kirpicha / A.Z. Zolotarskiy. – M. : Stroyizdat, 1989. – 264 s.
9. Gabidullin, M.G. Nauchnyye i tekhnologicheskiye osnovy upravleniya strukturoy i svoystvami energo- i resursosberegayushchey stroitelnoy keramiki : avtoref. dis. … doktora tekhn. nauk : 05.23.05 / M.G. Gabidullin ; Kazanskiy arkhitekturno-stroitelnyy universtitet. – Kazan, 2006. – 51 s.
10. Dmitriyev, K.S. Poristaya keramika: sovremennoye sostoyaniye i perspektivy / K.S. Dmitriyev // Mezhdunarodnyy zhurnal eksperimentalnogo obrazovaniya. – 2016. – № 7. – S. 152–154.
11. Prospects for using industrial waste in production of ceramic building materials / D.V. Makarov [et. al.] // Gornyy informatsionno-analiticheskiy byulleten'. – 2016. – No. 5. – P. 254–281.
12. Raut, S.P. Development of sustainable construction material using industrial and agricultural solid waste: A review of waste-create bricks / S.P. Raut, R.V. Ralegaonkar, S.A. Mandavgane // Construction and Building Materials. – 2011. – V. 25. – P. 4037–4042.
13. Fired clay bricks manufactured by adding wastes as sustainable construction material – A review / P. Muñoz [et. al.] // Construction and Building Materials. – 2014. – V. 63. – P. 97–107.
14. Monteiro, S.N. On the production of fired clay bricks from waste materials: A critical update / S.N. Monteiro, C.M. Fontes Vieira // Construction and Building Materials. – 2014. – V. 68. – P. 599–610.
15. Halil, M.A. Cotton and limestone powder waste as brick material / M.A. Halil, P. Turgut // Construction and Building Materials. – 2008. – V. 22. – P. 1074–1080.
16. Demir, I. An investigation on the production of construction brick with processed waste tea // Building and Environment. – 2006. – V. 41. – P. 1274–1278.
17. Assessment of olive mill solid residue (pomace) as an additive in lightweight brick production / M. Dolores La Rubia-Garcнa [et. al.] // Construction and Building Materials. – 2012. – V. 36. – P. 395–500.

18. De la Casab, J.A. Recycling of washed olive pomace ash for fired clay brick manufacturing / J.A. De la Casab, E. Castro // Construction and Building Materials. – 2014. – V. 61. – P. 320–326.
19. Replacement of the mixing fresh water by wastewater olive oil extraction in the extrusion of ceramic bricks / D. Eliche-Quesada [et. al.] // Construction and Building Materials. – 2014. – V. 68. – P. 659–666.
20. Eliche-Quesada, D. Effect of sludge from oil refining industry or sludge from pomace oil extraction industry addition to clay ceramics / D. Eliche-Quesada, R. Azevedo-Da Cunha, F.A. Corpas-Iglesias // Applied Clay Science. – 2015. – V. 114. – P. 202–211.
21. Properties of fired clay bricks with incorporated biomasses: cases of olive stone flour and wheat straw residues / L. Aouba [et. al.] // Construction and Building Materials. – 2016. – V. 102. – P. 7–13.
22. Cvoystva keramicheskikh stenovykh materialov pri vvedenii razlichnykh vygorayushchikh komponentov / I.V. Pishch [et. al.] // Steklo i keramika. – 2015. – № 2. – S. 19–23.
23. Rusak, G. Keramika dlya teplykh sten. Perspektivy proizvodstva i primeneniya porizovannoy keramiki v respublike Belarus / G. Rusak // Masterskaya. – 2007. – № 1–2. – S. 84–89.
24. Ivanenko, A.M. Svoystva stenovykh keramicheskikh materialov, poluchayemykh s ispolzovaniyem vygorayushchikh dobavok na osnove mestnogo Syria / A.M. Ivanenko, V.V. Bozylev, A.A. Bakatovich // Vestnik Polotskogo gosudarstvennogo universiteta. Seriya F, Prikladnyye nauki. – 2005. – № 9. – S. 121–127.

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ПОРИСТАЯ СТЕНОВАЯ КЕРАМИКА С ВЫГОРАЮЩЕЙ ДОБАВКОЙ ИЗ КОСТРЫ ЛЬНА

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Рассмотрены преимущества и технологии производства стеновой пористой керамики. Проанализирован опыт применения выгорающих добавок растительного происхождения для стеновой керамики. Предлагается использовать костру льна фракцией не более 2 мм в качестве выгорающей добавки. Определены плотность и прочность керамических образцов. Установлена зависимость средней плотности и прочности керамического черепка от расхода костры льна, в том числе при использовании суперпластификатора С-3. Установлено положительное влияние применения суперпластификатора С-3 на прочность при сжатии пористых керамических образцов. Приведены данные по морозостойкости и теплопроводности образцов пористой стеновой керамики, полученных с использованием костры льна в качестве выгорающей добавки.

Ключевые слова: *пористая керамика, костра льна, выгорающая добавка, прочность, плотность.*