World Applied Sciences Journal 25 (2): 233-237, 2013
ISSN 1818-4952

DOI: 10.5829/idosi.wasj.2013.25.02.7057

Features of Production of Structural and Heat-Insulating Masonry Mixes

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Submitted: Aug 24, 2013; **Accepted:** Sep 26, 2013; **Published:** Oct 1, 2013

Abstract: The article suggests compositions of structural heat-insulating masonry mixtures with the use of hollow glass microspheres. To extend the range of compositions and the field of use of these mixtures were considered various masonry materials and dense cellular structure on the basis of cement and lime-sand binder: gas-silicate, foam and expanded-clay concrete gravel. It is shown that by varying the ratio of the microspheres and the water-retaining agents we can enhance the degree of uniformity of wall construction by heat-insulation and strain characteristics when using masonry products with a density range of 500-1300 kg/m^3.

Key words: Masonry mortars · Microspheres · Water retention agent · Heat-insulation propertie

INTRODUCTION

The construction of wall structures possessing high strength and insulating properties, is an important aspect in the construction of modern buildings and constructions.

Due to the use of masonry mortars of traditional sand-cement composition, the total thermal insulation of the building is reduced by 30 % compared to a monolithic wall construction, that is caused by the formation of areas with discontinuited insulating sheath and enhanced heat transfer. In addition, the strength and deformation characteristics of the wall construction elements-masonry products and mortars-do not correspond to each other often [1].

Currently, there is a huge amount of materials with different composition and functions, which are used as masonry products for wall constructions and the main criteria of assessing prospects of their application are the strength and insulating characteristics [2-11].

Main Part: One of the effective ways to reduce heat losses in buildings is the use of thermal insulation and structural and heat-insulating building materials and products with low density. However, nowadays there is a shortage of masonry mortars that allow you to obtain the most homogeneous masonry construction in terms of thermal conductivity.

In this regard, it is very actual to develop constractional heat-insulating masonry mixtures (CHIMM) with tailored properties by varying the number of hollow glass microspheres and dosing a stabilizing additive.

Initial raw ingredients for production of CHIMM were: binder, fine aggregate, lightweight aggregate and stabilizing agent. As the binder component for carrying out an investigation the cement CEM I 42,5 N of close corporation“Belgorod cement” was used, sand of Korochansky field with a fineness modulus of 1.2 was used as fine aggregate, Mesellose FMS 24502 and Addiment ST2 were used as stabilizing additives with water-retaining effect, hollow alumino-silicate microspheres (ASM) with alkali content up to 8.4 %, which are the part of the by products of Tom-Usinsk state district power station were used as lightweight aggregate [12].

For development of the mostly wide range of compositions of the masonry mixtures as masonry masonry products we have studied structural and heat-insulating and heat-insulating materials with dense and cell structure on the basis of different types of binders [13]: gas-silicate, foam concrete and expanded clay (Table 1).

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Table 1: Characteristics of wall materials

Type of material	Density, kg/m^3	Crushing strength, MPa	Heat-conduction coefficient, W/(m^2×°C)	Frost-resistance, cycle	Water adsorption, %
Gas silicate	500	2,5	0,14	15	45
Foam concrete	700	3,5	0,18	25	40
Gas silicate	1000	7,5	0,33	50	30

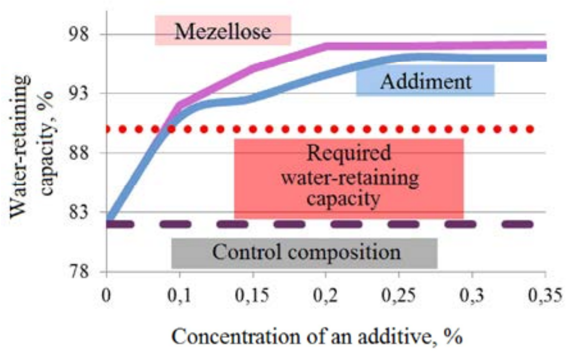

Fig. 1: The relation between the water-retaining capacity of the mortar and the amount of additives

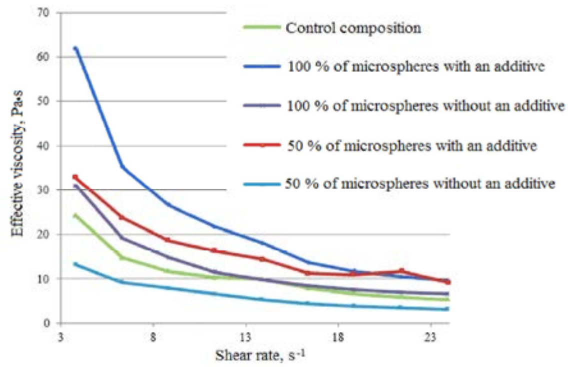

Fig. 2: The dependence of mortar viscosity from the composition

Calculation of the required characteristics of masonry mortars was based on preset physical and mechanical properties of masonry products. The required compressive strength of mortar stone is defined for each type of material and varies in the range 3,5-11 MPa. Choice of the range of the strength was driven by the calculation of the stresses in the mortar stone and rated stress in masonry product, taking into account the deformation modulus of both composites and the requirements of construction rules and regulations (SNIP II-22-81).

Structural and heat-insulating wall materials have high water absorption (Table 1) and that results in necessity of application of masonry mortars with high water-holding capacity, which is achieved through the use of various water-retaining additives. Furthermore, the use of stabilizing additives leads to the increase in the shrinkage of mortar because of enlarged water-cement ratio with the same mobility without additional application of plasticizing agents, that provides the effect of crimping that occurs during hardening of masonry mortar in wall construction. This reduces the vertical loads due to horizontal compressive forces and that can be explained by the differences in modulus of deformation of walling material and mortar stone.

In the framework of the research as a water-retaining additive we have used Mesellose FMS 24502 and Addiment ST2. Their selection was carried out under the condition of the same water/cement ratio. By varying the concentration and type of water-retaining additive we have obtained mortars with water-holding capacity by 5-7 % higher than the desired stipulated by State Standard 28013-98 (Fig. 1). Application of Addiment ST2 in a content of 0.25 % leads to increase of water retention by 14 %, but the strength of mortar stone is reduced by 2 % compared to the control cement-sand mortar. Introduction of 0.2 % Mecellose FMS 24502 enhances both water retention and strength by 15 %. However, such additives while keeping the water-cement ratio leads to increase in viscosity, which is undesirable for masonry mortars [14]. In this regard, we have studied the effect of water-retaining additives and microspheres on rheotechnological characteristics of mortars with static and dynamic tension and after partial dehydration with cellular surface of wall materials.

The increase of viscosity at state of rest is caused by introduction of Mesellose and happens due to physical binding of water (Fig. 2). This interaction is of coagulatory type and is based on weak hydrogen bonding and that leads to high sedimentation stability of the system. Due to the possible applied loads on mortar (mixing, laying) a temporary disruption of the structure to the clusters happens and that causes liquefaction of the system. This effect is positive from the viewpoint of homogenization and workability [15, 16]. However, the complete destructuring of the system doesn't happen because water is partly connected with an additive and that reduces the amount of moisture evaporated from the solution under stirring and laying and prevents splitting.

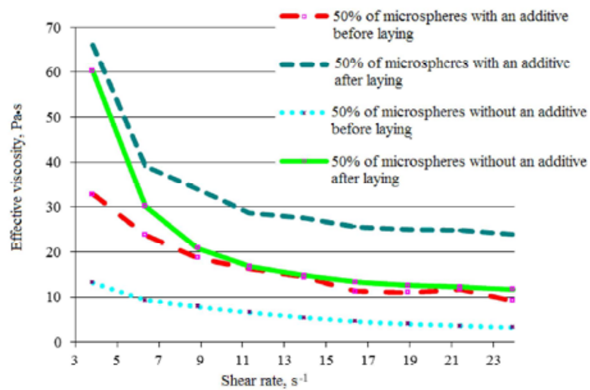

Fig. 3: Dependence of the effective viscosity from the presence of additive before and after laying on the cellular surface of walling materials[1].

Introduction of microspheres, by virtue of their dispersion and morphology, has dual effect on the mobility of the mortar. On the one hand, the introduction of microspheres in an amount of 100 %, due to their high specific surface (96 m^2/kg) compared to the sand and shortage of disperse medium in the system leads to the increase of viscosity. On the other hand, due to the spherical shape and glass-lined smooth surface of the aggregate, while loading there is an increase in the mobility of the mortar, which is associated with a reduced coefficient of friction.

This effect is supported by the dependence of viscosity changing upon the application of dynamic stress from the amount of microspheres. If we reduce the content of ASM to 50 % with the same water-cement ratio the amount of the dispersion medium will be sufficient and that explains the increase in the mobility of the system.

The introduction of water-retaining agent with the complete replacement of sand on the microspheres on a static tension gives maximum viscosity to the mortar. At the same time, on a dynamic tension the system reaches the viscosity comparable to that of the control composition. In this case, sedimentation stability of the composition with 100 % ASM and the water-retaining additive is maximal.

Analysis of rheotechnological characteristics of mortars before and after the laying (Figure 3) on the cellular surface of walling materials showed that the composition with the use of additive Mesellose has a higher sedimentation stability. Use of a complex “Additive-ASM” allows obtaining of mortars that retain workability when applied to a masonry material with increased viscosity.

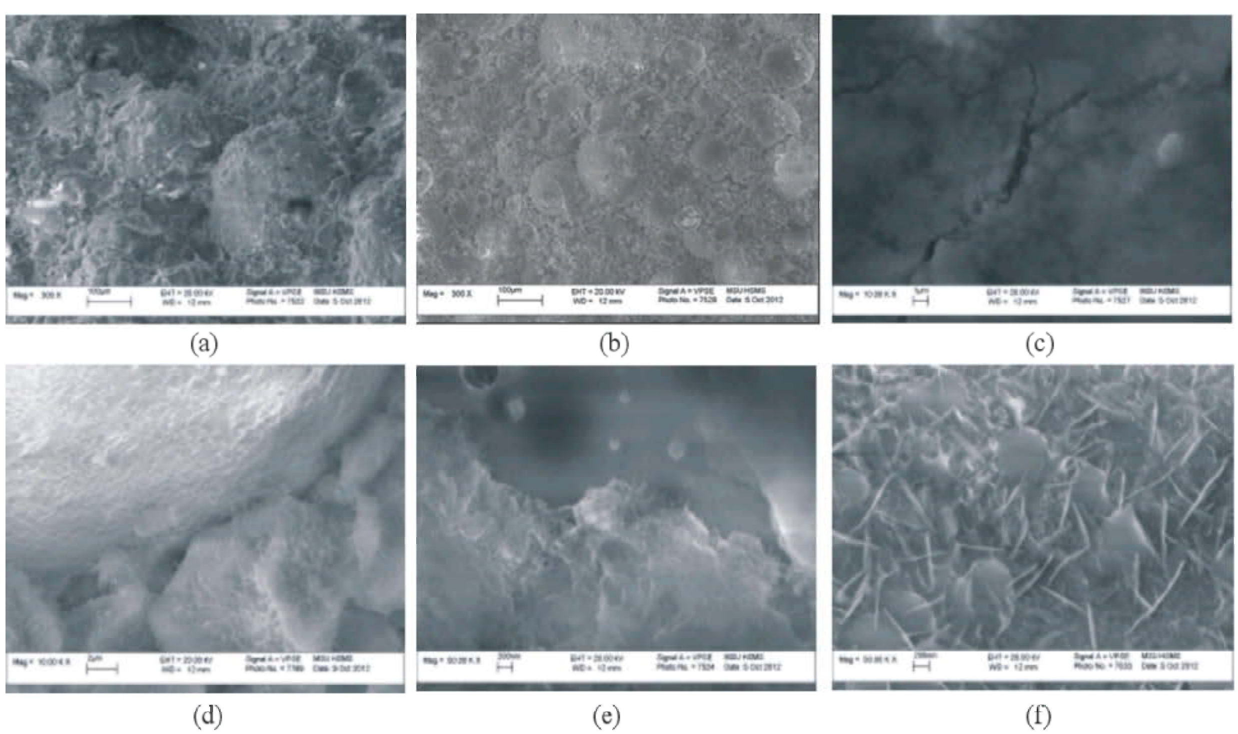

Fig. 4: Microstructure of masonry mortar with microspheres: a, b, c-without stabilizing additive; d, e, f-with an additive

[1]Mortar was taken from the surface of gas silicate in 1 minute after laying

Table 2: Composition and characteristics of mortar and mortar stone

	Composition of mixture, kgкг/m^3			Characteristics of mortar and mortar stone							
						Strength,Mpa					
#	Cement	Quartz sand	Microspheres	Water-retention capacity	Water-cement ratio	Compressive strength	Bending strength	Adhesion, MPa	Density, kg/m^3	Heat-conduction coefficient, W/(m^2×°C)	Frost-resistance, cycle
1	230	0	400	97	1,24	2,8	0,46	0,26	745	0,16	25
2	270	350	300	97	1,06	3,9	0,65	0,5	1055	0,2	35
3	328	700	200	97	0,98	8.4	2,04	1,98	1392	0,32	50

Thus, visualization of the dual effect of the implementation of complex influence of introduced lightweight components and additive Mecellose FMS 24502 is caused by a total positive complementary effect of plasticizing factor (due to the introduction of microspheres) and structuring factor (when using water-retaining additive Mecellose FMS 24502). Herein this applies both to the initial conditions of the system and the conditions of the structural and mechanical influence on the system.

Microstructure of mortar stone with application of stabilizing additive is characterized by a dense matrix (Fig. 4, d) with lots of tumors (Fig. 4, e, f) compared to the mortar stone without additives (Fig. 4, a, b, c). The growth of tumors on the walls of the microspheres is promoted by a well-developed surface with traces of corrosion, which determines the best bonding of cement with aggregate and increases the strength of the composite.

To create a wall construction from expanded clay, foam concrete and gas silicate (Table 1) we have chosen rational compositions of mixtures for each walling material according to their characteristics and designed characteristics (Table 2).

The use of wall products and masonry mortar with appropriate heat insulation and deformation characteristics can improve the degree of homogeneity of the wall structure by reducing the density of the mortar and balanced values of the transverse extension of stone mortar and walling material.

CONCLUSION

Application of rational composition of CHIMM with lightweight aggregate provides generation of masonry mortars with density of 745-1400 kg/m^3 and strength of 2,5-8,4 MPa, which allows the selection of CHIMM, depending on the characteristics of the walling material.

Conclusions: The character of the complex influence of the microspheres and water retention additive on the characteristics of CHIMM and structure formation of mortar stone that consists in increased sedimentation stability and as a result, ability of rheotechnological control of the system at the early stages of hardening. Mobility of masonry mortar increases by 15 %, there are observed expressed thixotropic properties, while the strength of the developed masonry composite increases compared to the material without the stabilizing additive. Application of the stabilizing agent without plasticizer permits to increase processing characteristics and physical-mechanical properties of the mortar and mortar stone while maintaining a stone mortar with unchanged mobility and that provides strong adhesion to masonry materials resulting in effective collaboration of mortar and material of the wall construction.

Compositions of structural heat-insulating masonry mixes on the basis of hollow aluminosilicate microspheres of Tom-Usinsk state district power station using stabilizing additives (Mesellose FMS 24502)makes it possible to obtain masonry composites with strength from 2.5 to 8.4 MPa, density from 745 to 1400 kg/m^3, thermal conductivity coefficient from 0.16 to 0.32 (W/(m^2×°C).

ACKNOWLEDGMENTS

This work was financially supported by the Ministry of Education and Science of the Russian Federation, the strategic development program of BSTU named after V.G. Shoukhov, state task 3.4601.2011.

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