

Study of melt amount influence on the expansion degree of expanded clay gravel

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Abstract. The influence of the amount of optimal composition eutectic melt on the expansion degree of expanded clay granules was studied. Expanded clay of the Smyshlyaevskoye field was used as the main raw material. Waste from Togliatti enterprises was used as corrective additives: burnt earth of the steel shop, iron foundry waste, and foundry waste of VAZ. The study applies experimental data on the average density of the studied compositions and a method to calculate the amount and composition of the melt formed in ceramic masses at firing and a software package for evaluating mineral raw materials. The dependence of the average expanded clay gravel density on the amount of the optimal composition formed during the melt firing is established. The obtained data can be used for directional adjustment of the compositions when obtaining the aggregate of the required expansion degree, as well as for plotting the isotherms of expanded clay gravel density on the (R, R_2) O - Al_2O_3 - SiO_2 diagram, which will make it possible to predict the expanded clay density from the location of the raw materials.

1. Introduction

In connection with the changing requirements for the heating technology of building fencing constructions, special attention is paid to its density when choosing aggregates for lightweight concrete. For light structural, heat-insulating and structural concretes of classes B 3.5 - B 20, a filler of grades 300-800 is required, and for each grade of concrete by density [1].

Main artificial aggregate of lightweight concrete is expanded clay gravel. The specificity of expanded clay factories is such that, working on clay from one deposit, at each enterprise there is production of only one brand aggregate: from well-expanded clay - light aggregate, from a badly expanded clay - heavy aggregate. Such a limited assortment does not allow the production of concrete with standardized properties in terms of strength, density, and thermal conductivity.

In practice, concrete of several classes is produced from aggregate of the same quality, while the strength of concrete is regulated by the consumption of binder. The use of a heavier aggregate than is required for the desired concrete grade in terms of density worsens its thermo technical properties. Only different quality aggregates can provide rentable compositions of concrete of the required grades.

There are two possible options for organizing the production of expanded clay of different grades:

- 1) using clays of different deposits with different natural expansion degrees;
- 2) artificial blends based on clay raw materials of one deposit with various additives.



For most regions the first method is not characteristic due to the absence or depletion of well-expanded clays. Even assuming that clays of different qualities are imported to the enterprise, then it is necessary to reconstruct the preparatory department, and first of all, significantly expand the clay reserve [2].

The second approach is the most practical. In this case, the production is based on one, as a rule, nearby field, and the quality of the aggregate should be regulated by additives. This solution will be economical, since additives can be selected among the waste and their proportion is negligible. The main difficulty of this production is in the development of raw materials composition, i.e. in choosing the right type and amount of additives, as well as in the preparation of highly dispersed compositions [3].

2. Materials and methods

The degree of expanded clay gravel expansion depends on many factors [4-7], among which are the quantity and composition of the melt formed during firing. In the work [8], areas for expanded clay blends that provide extremely light expanded clay gravel without establishing patterns of change in properties with distance from the optimal areas theoretically substantiated and graphically determined. This circumstance makes it difficult to predict raw materials qualities that do not fall into the optimal regions, and the choice of corrective additives to obtain aggregates with the required degree of expansion based on the same clay.

To answer these questions, the data of NII Keramzit was used when the clay of the Smyshlyaevskoye field was corrected by waste from Togliatti enterprises: burned earth from the steel shop and waste from the iron foundry of the VZTSM, as well as VAZ foundry waste in an amount of 10 to 70%. The chemical composition of clay and additives is shown in table 1.

Table 1. Chemical composition of raw materials and additives

Material	Oxides content, mass. %									loss on ignition	organic substances
	SiO ₂	Al ₂ O ₃ +TiO ₂	Fe ₂ O ₃	FeO	CaO	MgO	SO ₃	R ₂ O			
Smyshlyaevka clay	50.15	16.47	6.48	0.84	1.97	3.72	0.37	2.33	17.67		1.42
VAZ foundry waste	90.45	3.57	0.47	-	1.14	0.52	0.47	1.13	2.25		1.65
burned earth											
iron foundry	87.40	6.2	0.96	0.3	1.61	0.45	0.34	1.09	1.63	-	
VZTSM				2							
foundry waste											
VZTSM	87.30	4.12	0.56	1.1	0.62	0.87	0.53	1.62	3.20	-	
				7							

3. Results and discussions

All of the listed wastes are silica-containing additives. The clay of the Smyshlyaevskoye deposit is the reference (optimal) for the production of the lightest expanded clay gravel [8], which is confirmed by the location of this clay in Figure 1, where the optimal areas are shown in the diagram M₁-F₁-R₂-C₁.

When adjusting the clay of the Smyshlyaevskoye deposit with the additives, the proportion of the refractory insoluble residue increases, and the composition of the melt practically does not change. The presence in the charge of the required amount of organic matter and iron oxides provides intensive melt expansion. Knowing the chemical compositions of clay and additives (table 1) and using the developed method for calculating the amount and composition of the melt formed in ceramic masses during firing, using well-known phase diagrams of aluminosilicate systems [9, 10], using a software package for evaluating mineral raw materials, the amount of eutectic melt was determined for the studied charges. The calculated data on the amount of eutectic melt and the average density of expanded clay granules corresponding to the compositions are given in table 2.

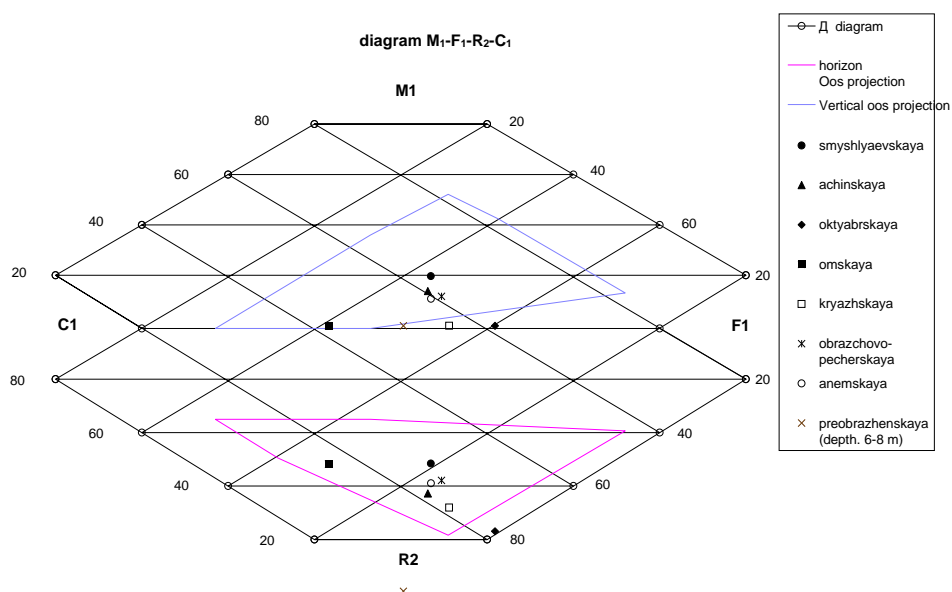


Figure 1. Location of figurative points of expanded clay clays on the diagram

Table 2. Influence of the type and amount of additives on the amount of eutectic melt and the average density of expanded clay granules

Additive type	Additive amount in charges, %							
	0	10	20	30	40	50	60	70
The amount of eutectic melt, %								
The average density of expanded clay granules, g / cm3								
VAZ foundry waste		<u>89.12</u> 0.21	<u>80.44</u> 0.24	<u>72.83</u> 0.29	<u>64.77</u> 0.38	<u>56.82</u> 0.49	<u>48.17</u> 0.63	<u>42.52</u> 1.20
burned earth iron foundry waste	<u>98.02</u> 0.20	<u>89.20</u> 0.22	<u>80.53</u> 0.25	<u>72.89</u> 0.29	<u>64.81</u> 0.37	<u>56.87</u> 0.48	<u>48.20</u> 0.63	<u>42.60</u> 1.18
VZTSM		<u>89.35</u> 0.21	<u>80.67</u> 0.24	<u>72.93</u> 0.28	<u>64.87</u> 0.36	<u>56.95</u> 0.47	<u>48.25</u> 0.61	<u>42.71</u> 1.12

For all charges during firing, a melt of optimal composition is formed. The melt percentage decreases with an increase in the number of additives, which affects the density of expanded clay (Fig. 2). The influence of the type of additive is insignificant; the amount of the additive is decisive.

The mathematical dependence of the average density of expanded clay granules on the amount of melt of optimal composition is determined:

$$Y = 12.46 / (X - 29.02) \quad (1)$$

here: Y - expanded clay granite density, g / cm³;
X - the amount of melt of the optimal composition, %.

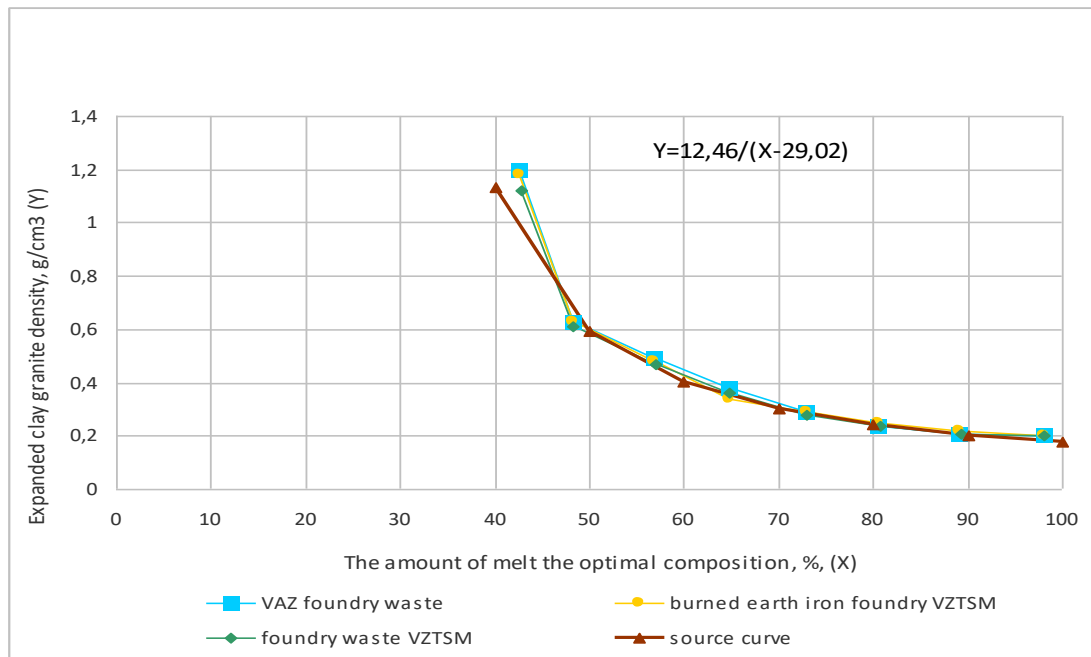


Figure 2. Dependence of the average density of expanded clay granules on the amount of melt of optimal composition

The established pattern provides wide opportunities in terms of developing compositions of the blends with the desired expansion degree:

- on the basis of Smyshlyaevsky clay, compositions for producing expanded clay of different grades are recommended;
- necessary amount of melt of optimal composition in artificial blends to obtain aggregate of a certain grade by density is determined.

4. Conclusion

1. The dependence of the average density of expanded clay gravel on the amount of the optimum composition formed during firing of the melt is established.
2. The processed material can be used to collect data bank when plotting the (R, R₂) O - Al₂O₃ - SiO₂ density isotherms, which will make it possible to predict the expanded clay density from the raw materials location.

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