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FORMATION OF STRUCTURE MAGNESIUM FOAMED CONCRETE

MIRYUK OLGA

Professor, Doctor of Technical Sciences, Rudny Industrial Institute, Republic of Kazakhstan

ABSTRACT

The investigations are carried out to study the formation of cellular of compositions on the base magnesium binder. The comparative characteristic of the cellular materials received by various methods are given within the investigations. Influence of the method of preparation on properties of magnesium compositions is investigated during study. Possibility of additional formations of cellular of a foam-mass is shown at the expense of a gas-forming additive and hollow granules. Efficiency of separate preparation of concrete mix is shown in a detail. By investigations detected particularities of cellular were the base for technologies of magnesium concrete of variable density.

KEYWORDS: Magnesium Binder, Formation of a Cell, Foam-Mass, Structure

INTRODUCTION

Magnesium binders are effective materials for modern construction. Magnesium binders are characterized by low energy intensity of production and use, intensive hardening, high strength characteristics. The main reason for holding back widespread magnesia binders is a limitation of the developed deposits of natural magnesite and, as a consequence, the lack of caustic magnesite. Magnesia materials with valuable properties are not widely used because of the low water resistance and shrinkage deformation hardening.

High-activating ability of caustic magnesite in relation to various materials is the basis for the preparation of mixed binders. The combination of caustic magnesite of natural and man-made materials expands the range and increased the volume of magnesia binders. The advantages of mixed binders are to improve the physical and mechanical properties while saving caustic magnesite and rational use of natural and technogenic silicate [1 – 8].

A promising area of use mixed magnesia binders is cellular concrete. Improving the efficiency of cellular concrete is connected with improved strength and thermal properties due to the optimization of the structure. The solution to this complex technological problem considers involvement the production of materials, ensuring the formation of small closed porosity and the formation of a durable frame interporous partitions. Synthesis of cementless compositions is expedient which thanks to its special nature and the hardening phase composition hydrate formations provide a highly porous structure, exceeding the strength cement counterparts. Among uncemented materials special places occupy astringents, which are used for mixing salt solutions, activating curing of the powder composition. Development of porous compositions of the mixed magnesia binders provides resource-saving production, allows the use of a wide range of methods of formation cellular structure [7].

For magnesia composites are used salt solutions as a mixing component exceeding the density of the water – a traditional mixing component of cement foam concretes. There is a few information on concerning porization of magnesia porous concrete.

Variatropic concrete is characterized by variables values of average density and strength at the forming section of the array, the possibility of obtaining the differential porosity of the honeycomb, and in the product - a smooth transition in the insulating structural properties. Transition to variatropic structure increases the carrying capacity, reduces the thickness of the plates and decreases the deflection under load, cuts down the reinforcement flow [7, 9].

Forming structure with variable density is realized mainly in the aerated concrete technology of traditional binders. Variatropic structure for foam is technologically difficult. Information about variatropic structure of magnesia cellular concrete is not available.

Objective of researc – to investigate magnesia porous concrete of variable density

METHEDOLOGY

On the first phase of experiments were explored various options for the preparation of magnesia foammass characterized by a sequence of making the components in the total weight, the primary contact components, the nature of the impact on the processed material. Magnesium foam mass prepared by one-step process (Table 1) is favorably different by faultless fine porosity.

Table 1: Influence of Preparation Method of the Raw Mass on the Properties of Foam Concrete

Method of Preparation Foam Mass	The Diameter of the Face Breaking Mass, mm	Multiplicity of Foam Mass	Density of Foam Concrete, kg/m^3	Compressive Strength, MPa	Porosity
Three-stage	110	4,3	330	2,1	Average
Premixing suspension	120	2,5	590	7,3	Small
One-stage	150	2,1	610	7,5	Very small

The next step was to study the possibility of reducing the density of magnesia foam concrete through additional porization receptions.

The raw materials which were used: mixed magnesia binder slag containing 50% caustic magnesite; foaming agent; polystyrene; hydrogen peroxide; a mixing - magnesium chloride solution.

RESULTS AND DISCUSSIONS

When using the foam concentrate (FC) cell structure is formed by a mechanical engagement and uniform air distribution with stirring mass in a mixer. The porosity is homogeneous, closed, small with cells diameter of 0.1 - 1 mm (Figure 1, Table 2).

The effectiveness of foaming agent - hydrogen peroxide H_2O_2 depends on the consistency of the molding material (Figure 1, Table 2). Gas escapes from highly mobile mass. The volume of the gas is limited in extremely viscous mass, gaps and slit-like pores are formed here.

To make effective use of expanded polystyrene (EPS) is needed plastic viscous mass enveloping the beads (Figure 1, Table 2).

We showed the expediency of combination of FC and H_2O_2. In foam mass are created conditions for allocation, distribution and retention of small oxygen bubbles. When combining FC and EPS was prepared foam mass, then added granules and mixed.

To reduce the density of composites is suitable a complex porization: created by using hydrogen peroxide and foam concentrate cellular mass of concreted polystyrene pellets.

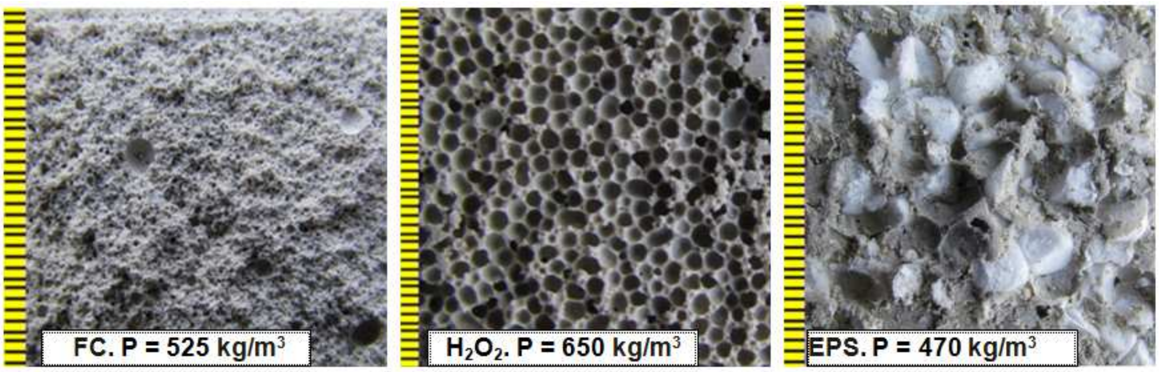


Figure 1: The Impact of the Type of Blowing Agent on Composites Structure

Table 2: Properties of Porous Magnesia Composites

The Pore-Forming Component	The Diameter of the Face Breaking Mass, mm	Concrete Density, kg/m^3	Concrete Compressive Strength, MPa
No	108	2050	50,0
No	250	1500	22,5
FC	230	525	4,0
H_2O_2	240	650	4,6
EPS granules	150	470	2,0
FC + EPS	108	335	1,0
FC + H_2O_2	230	290	1,2
FC + H_2O_2 + EPS	108	220	0,8

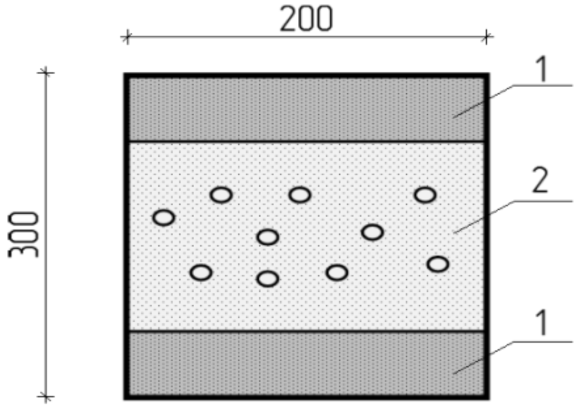
Variatropic cellular concrete has aimed product heterogeneity in section of product and characterized by average values of variable density and strength at the section of the forming array, the possibility of obtaining differential porosity honeycomb. In the product with variatropic structure achieved a smooth transition of the construction properties to the insulating one. Cellular concrete strength is enhanced by improving the structure of interporous partitions [1].

Variatropic structure of cellular concrete is forming by techniques: stitching crusts, forming the hydraulically open forms; changing in temperature in the various layers of gas concrete mass; introducing passivating gas formation in the lower layers of the mass; degassing the local area of the molding composition; autofrettaging [9, 10].

As results of the experiments were proposed methods of forming variatropic magnesia structure of cellular concrete:

- Filling the forms by horizontal layers of mixtures of differing porosity;
- Filling the mold with mixtures vertical layers having different porosity and density; to avoid «face breaking» of the masses of different composition is expected short-term installation of removable partitions;
- Installation the cover on the form filled gas foam concrete mixture that will generate the upper packed layer.

During the investigation was substantiated rational method of forming variatropic structure of magnesia foam concrete, providing a consistent placement of foam mass with different average density. For the core layer of foam concrete blocks was matched molding composition with expanded polystyrene beads (Figure 2). Changing the ratio of the thickness of the individual layers allows to adjust the performance of average density of the product. In forming variatropic structure is formed multimodal porosity, creating a thermal insulation barrier.



1 – Layers of Foam Concrete with a Density of 500 kg/m^3,
2 – A Highly Porous Foam Layer with Density of 150 kg/m^3 with Granules
Figure 2: Variatropic Structure of Foam Concrete Block

Variatropic magnesia concrete is characterized by a reliable adhesion with polystyrene beads, smooth transition zones of different porosity. Magnesium cellular concrete is characterized by little defective structure, increased porosity at the highest strength values (Figure 3).

Possible use of variatropic structure blocks – dome house (Figure 4). Currently, the construction of the dome is popularized as such housing meets important criteria – environmental safety and energy efficiency, is not contrary to the basic tasks of construction.

The walls of the first floor of dome houses are made of foam concrete blocks with dimensions 200 × 300 × 400 mm. Foam concrete block has variatropic structure, which system consists of three layers of different density and thermal conductivity; central layer – the foam density ρ = 150 kg/m^3, outer layers that serve as permanent formwork with a density ρ = 500 kg/m^3.

To justify the possibility of using units with variable density were studied the properties of variatropic product, behavior of the individual layers under the loads, also was made graphical analysis of the block model. Design scheme and model of loadings are presented in Figure 5.

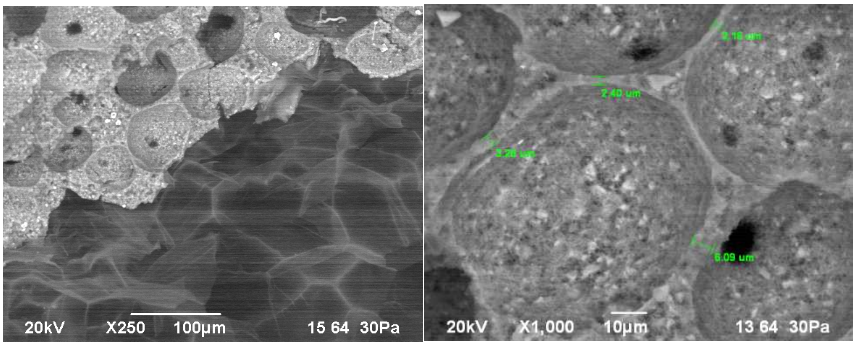


Figure 3: The Microstructure of Variatropic Concrete

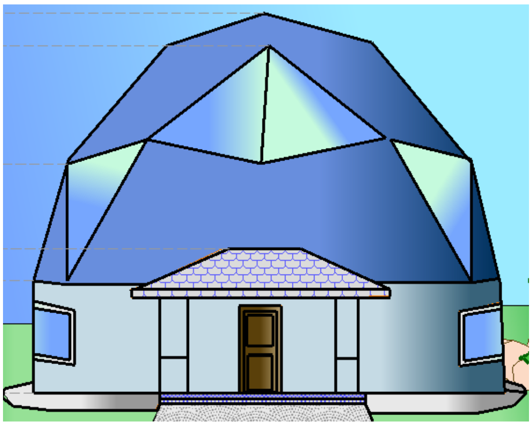


Figure 4: View of Dome Construction House

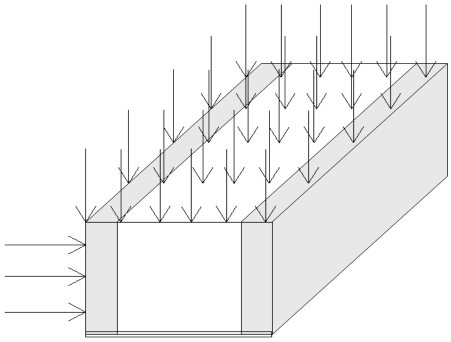


Figure 5: Calculated Block Diagram and Loading Model

On the first stage of the investigation were made a number of variational parameters of block (Table 3) according to the thermal calculations, which varies the thickness of the outer layers and selected parameters of warming layer. The total amount of heat transfer for a given thickness should satisfy the thermal resistance value $R_{0тр}$ = 1,46 m^2 (^{0}C/W). Thermal characteristics of walls' layers with different structures are shown in Table 4

Table 3: Variation Range of the Block Parameters in $R_{0тр}$ = 1, 46 m^2 (^{0}C /W)

Wall Variant	Layer Thickness, mm		Total Block Thickness, δ, mm
	External, δ_1	Central, δ_2	
1	30	170	230
2	50	140	240
3	70	100	240
4	100	60	260
5	120	30	270
6	150	–	300

Table 4: Thermal Characteristics of Walls

Variant of Wall	Density, kg/m ^{3}	Thermal Conductivity, W/(m^{0}c)	Layer Thickness, m	Thermal Resistance, m^2 (^{0}C/W).
1	600	0,12	0,03	0,25
	300	0,09	*x*	1,18
	600	0,12	0,03	0,25
2	600	0,12	0,05	0,42
	300	0,09	*x*	1,47
	600	0,12	0,05	0,42
3	600	0,12	0,07	0,58

	300	0,09	*x*	1,11
	600	0,12	0,07	0,58
4	600	0,12	0,1	0,83
	300	0,09	*x*	0,65
	600	0,12	0,1	0,83
5	600	0,12	0,120	1
	300	0,09	*x*	0,3
	600	0,12	0,120	1
6	600	0,12	0,15	1,25
	300	0,09	*x*	-
	600	0,12	0,15	1,25

Thus, the most efficient blocks from the standpoint of resource saving are those with calculated thickness of 240 mm, which is recommended to consider an option with a greater thickness of the outer layers of low porosity, that theoretically increase the carrying capacity of blocks.

Calculation of the block unit on the bearing capacity to function as a self-supporting wall element was held on the effect of static loads from its own weight of the block and considering the effect of wind loads.

The calculation was performed using the software package "LIRA". The calculation is based on the method of finite elements in displacements. As basic unknowns were taken move nodes: X is linear in the X axis; Y is linear in the Y-axis; Z is linear in axis Z.

For a graphical analysis was selected block of 240 mm thickness. In constructing the model was received block with dimensions 200×300×400 mm. The average density of variatropic unit structure is 350 – 400 kg/m^3. The created block model with variatropic structure is a solid voxel, divided in increments of 10 cm in the basic components of volumetric modules. Then in layers were assigned stiffness and density of layers. In the constructed model is made stepwise vertical load of Pi = 0, 03 t/m^2.

Since the variation model of change of load and the dependence of the stresses and destruction are linear, it decided to stop the election on the first loading stage. Wind load is taken into account in the amount of 10% of the core loading. The block is rigidly attached on the lower surface and the space available on the sides.

The main problem for the prospective analysis of the block work in a self-supporting wall: identify areas of critical stress; definition block structure risk stratification along the lines of the diffusion mixing layers; risk assessment by the destruction of the central unit a porous layer under a static load distribution.

Mosaic voltages for different movements are shown in Figures 6 – 9.

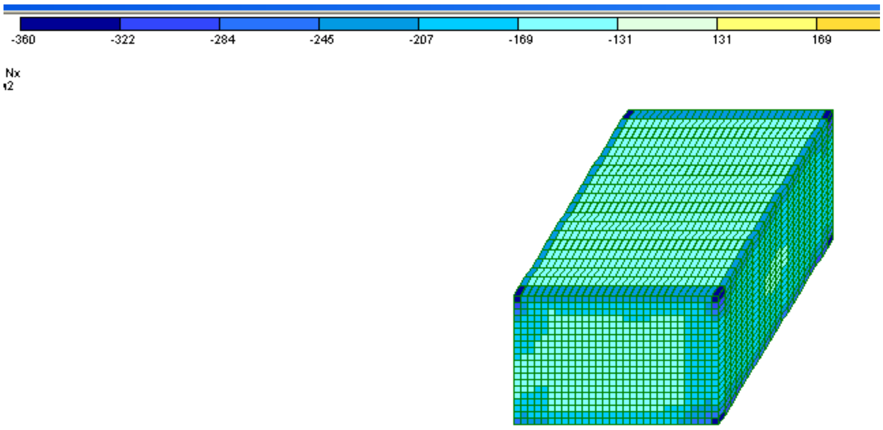


Figure 6: Mosaic Stress on N_x, t / m^2

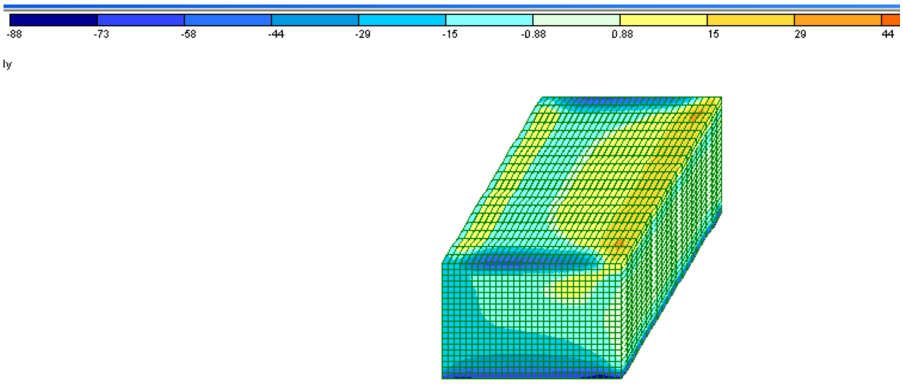


Figure 7: Mosaic Stress on N_y, t/m^2

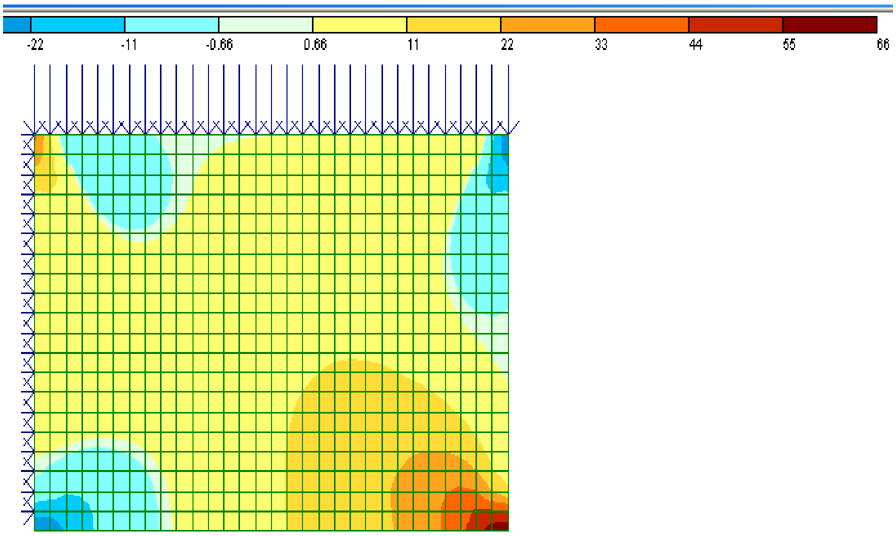


Figure 8: Mosaic Stress on T_{yx}, t/m^2

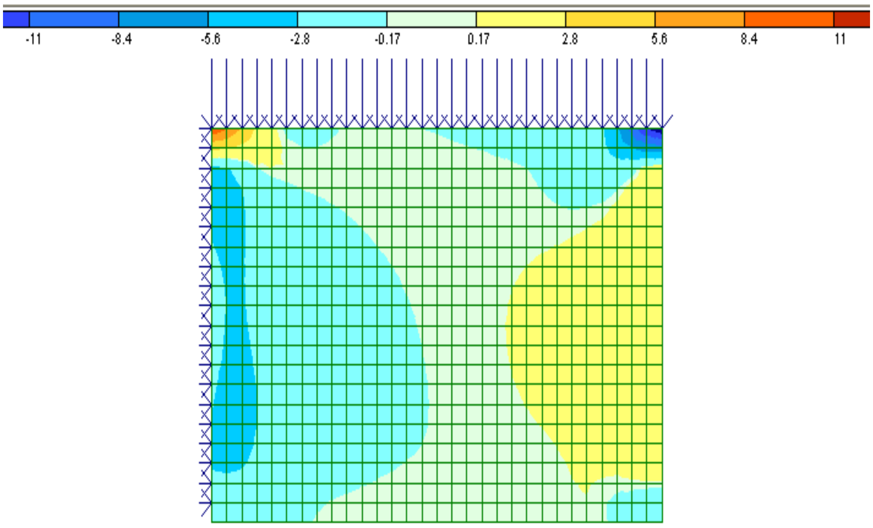


Figure 9: Mosaic Stress on T_{yz}, t/m^2

The analysis of the stress distribution mosaics of axis "X" shows that at the compression unit the critical stress primarily arises on denser carrier layers: critical stress concentrate at the corners of the block. It is assumed that destruction will begin to block and bypass block corners on all surfaces of the edges.

The analysis of the stress distribution mosaics of axis "Y" indicates that the unit is working in tension in planes opposite to those which are affected by the wind loads. Stretching zone is small, the maximum voltage values reach 20 t/m^2 in a strictly localized areas. This confirms the fact that serious threat of loss of stability and spatial rigidity when the unit is in tension do not arise.

Mosaic stress of the following two voltage in the cross section unit show that the maximum stresses occur in the dense layers, in more porous layer there are no destructive forces.

Comparison of graphic illustrations stresses in the block operation in a self-supporting wall allows us to state the following.

Areas of critical stress is strictly localized and concentrated mainly in the more dense layers, which are designed to withstand the loads, subjected block to normal operating conditions. The most dangerous sections of the loss of rigidity of the spatial unit – are the corners. The proposed way to reduce the danger of destruction - the inception of wire mesh between several layers of masonry blocks, which will redistribute load attached.

Analysis of stress graphics field on the body block indicates that the bundle on the diffusion junctions is unlikely, since the load inside the body uniform and minimal compared with the external faces of the block. The destruction of a central porous layer under a static load distribution is unlikely.

CONCLUSIONS

The investigation is proposed a method for complex porization of magnesia composites by combining techniques and subsequent swelling volume grouting porous mass of foam beads.

Investigations determined the possibility of the formation of variatropic structure of magnesia foam concrete. Here was proposed stratified vertical and horizontal formation of masses differing by material composition, and porosity.

The test results indicate a secure contact for the various layers of the structure of cellular concrete of variable density.

Magnesium blocks of variatropic structure are energy efficient building material. Magnesium blocks of variatropic structures should be recommended to use in low-rise building with erecting self-supporting walls up to 5 floors in the considered parametric characteristics

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