

Influence of pH liquid for mixing gypsum binders on the strength of gypsum composites

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Abstract. The influence of fluid acidity on the processes of hardening, mechanism, kinetics, properties of gypsum stone are of great interest. Studies of these processes for modified composites based on gypsum and heavy high density and basalt additives can improve the modifier's effectiveness. The influence of the pH of a liquid on the processes of structure formation and the properties of composites is determined in this work. It is shown that the pH should be shared by other structure-forming factors. This is the chemical composition of basalt waste, its percentage, the interaction of its oxides with pore fluid and natural minerals are the products of their reaction. The regulation of the material composition of composites can enhance the properties and also lead to degradation of structures.

1 Introduction

From the point of view of the effectiveness of the application, composite materials are significantly superior to conventional materials; therefore, it is precisely their development that is currently being given special attention. Modification of the gypsum binder and the creation of gypsum composite materials allowed at the time to expand its scope and range of manufactured materials and products based on it to impressive volumes: plaster, putty, gypsum board, blocks, plates, screeds. Plaster composite materials have a number of advantages for the consumer, regardless of their purpose and nomenclature. This is fire resistance, chemical resistance, the ability to regulate the humidity in the room, the ability to provide the necessary level of noise and heat insulation. Moreover, such materials are unique not only in terms of environmental safety and creating the optimal microclimate in the premises, but also in terms of their production [1, 2]. Their use in the decoration of residential premises also helps to increase the level of comfort and the ability to implement almost any design decisions.

Together with a gypsum binder, various types of other mineral binders, fillers, chemical additives affecting the setting time, ductility, and strength can be used to obtain composite materials with enhanced performance characteristics. It should be noted that special interest is currently shown in the use of waste as fillers, as well as chemical additives. The prospects for composites thus obtained are also due to the saving of expensive raw materials by replacing parts of it, recycling into actual production waste that is currently

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disposed at landfills [3-5]. So, the authors of [6] studied the possibility of obtaining a composite material - a modified gypsum stone with increased water resistance due to the introduction of various industrial wastes into its composition and proved the effectiveness of this approach.

Improving the characteristics of composite gypsum materials still remains an urgent topic, due to the low strength and water resistance of the gypsum binder. Such work is primarily associated with work on the structure of the resulting composite. The authors of [7-9] note that controlling the process of structuring composite gypsum materials is one of the tasks of modern science. The control of this process is the control of a whole complex of factors: the structure of the gypsum and filler crystals [10], their shape, packing order and size. Optimization of the internal structure of the composite at all levels makes it possible to obtain the maximum number of particle contacts, the densest packing, and, consequently, an increase in strength characteristics [11]. The author of [12] also notes the same, according to the results of studies of the influence of fillers of various structures on gypsum composites.

As noted above, the design of composite gypsum materials takes into account a number of parameters [13]), which are often regulated by the requirements and rules for each type of material obtained [14]. However, not all parameters of composite gypsum materials are regulated, since they do not directly affect the properties of materials, but indirectly, changing other parameters. Among these is the acidity of the mixing solutions, which directly affects the structure formation processes of gypsum stone (crystal distribution, their morphology) and, as a result, the strength indicators, their growth rate, and the quality of the materials obtained [15]. It should be noted that the effect of the pH of the mixing liquid on composites containing anhydrite, α and β modifications of hemihydrates is not the same, due to the different mechanism of their hydration. As a rule, the pH region with minimal activity of calcium ions corresponds to high solubility and increased strength of binders [16-17].

At the moment, the effect of the pH of the mixing fluid on the hardening process, its mechanism and speed, and the strength of the resulting gypsum composite matrix is still not sufficiently studied for applied applications and is of great interest [18-20].

In the framework of this work, the effect of pulverized waste from the production of basalt fibers and lime on the strength of the obtained modified gypsum stone was evaluated in terms of the pH of the mixing fluid of calcium sulfate hemihydrate. Taking into account the fact that the pH value of gypsum solutions is not constant, it constantly changes due to the processes that occur during hydration and structure formation to identify the effect of pH on the hardening processes of gypsum stone. Initially, aqueous solutions of basalt waste and lime were obtained, which were then used to mix gypsum binder. In addition, the pH of pure gypsum mortars is associated with the presence of impurities in gypsum, so conducting research using the described methodology is the most correct.

2 Materials and methods

As a component in the work, we used gypsum binder β -modifications of the G-5 brand with a water demand of 60-70%, setting time - not earlier than 7-8 minutes, setting point - not later than 13 minutes, compressive strength - 5 MPa, bending - 2.0-2.5 MPa. Also, the components used were waste products of basalt fiber production (dust from dust filters) whose chemical composition is presented in Table 1. Slaked lime was characterized by the content of active CaO + MgO - 69%, CaO - 9%.

The content in% by weight of waste from the production of basalt fibers and slaked lime was taken as variable parameters. The waste content varied from 0 to 15% in increments of

7.5, the lime content from 0 to 5% in increments of 2.5. Consistencies were accepted as standard and amounted to 70%.

To determine the normal density of the gypsum dough, a clean container was filled with the required amount of distilled water, a weighed portion of the dry mixture in the amount of 300 g was poured into it. The dough was mixed with a hand mixer until it became homogeneous and poured into a Suttard viscometer. After 15 seconds from the moment of filling the test, the viscometer rose vertically. If the spreading diameter of the formed gypsum pellet was 180 ± 5 mm, the value of the water-solid ratio was taken as normal density, otherwise the tests were repeated.

Studies of the basic physical and mechanical properties of gypsum composites were carried out in accordance with GOST 23789 79, GOST 8462 - 85, GOST 7025 - 91. To prepare gypsum dough and a mixture based on it, the required amount of a portion of the waste from the production of basalt fibers and / or lime was measured, mixed into for 3 seconds, closed with distilled water, measured pH and the same solution closed the dry mixture of pre-weighed gypsum binder. Samples of 20x20x20 mm in size were prepared from the solution prepared in this way. Samples were injection molded.

Table 1.The chemical composition of the waste production of basalt fibers.

| Element(Oxide) | % |
|--------------------------------|--------|
| SiO ₂ | 41.13 |
| MgO | 14.66 |
| CaO | 13.81 |
| Fe ₂ O ₃ | 7.34 |
| Na ₂ O | 6.59 |
| Cl | 4.29 |
| K ₂ O | 4.14 |
| Al ₂ O ₂ | 3.99 |
| S | 1.57 |
| ZnO | 1.11 |
| MnO | 0.428 |
| F | 0.320 |
| TiO ₂ | 0.262 |
| P | 0.191 |
| CuO | 0.0904 |
| SrO | 0.0323 |
| Cr ₂ O ₃ | 0.0207 |
| Co ₃ O ₄ | 0.0117 |
| NiO | 0.0106 |

3 Results and discussion

The studies found that the hydrogen indicator of distilled water from 7 rises to 9 when managing waste production of basalt fibers in an amount of 7.5% and up to 10 with an amount of 15%. With the introduction of lime (2.5%), together with the waste (7.5%), the pH increases to 13 (Fig. 1).

On the 7th day of hardening of the samples, samples containing 2.5% of lime in the composition gained maximum compressive strength, the pH being 12. The strength of samples containing 2.5% of lime and 7.5% of the waste from basalt fiber production exceeded the strength of control samples by 10% (Fig. 2,3), the pH was 13.

Thus, the optimum pH of the gypsum binder mixing fluid is between 12-13. Apparently, an increase in pH to these parameters leads to a sharp increase in the activity of Ca^{2+} ions, an increase in solubility, and an increase in the strength of the composite gypsum stone.

However, it is not correct to consider the processes that take place during hardening of a composite gypsum binder system containing lime as an alkaline component, only from the influence of pH, because lime in clinker-free composite gypsum binders in the long-term hardening causes the formation of ettringite. It was his formation that caused the decrease in strength on the 28th day of hardening of the resulting stone due to the occurrence of high internal deformations (Fig. 2, 4).

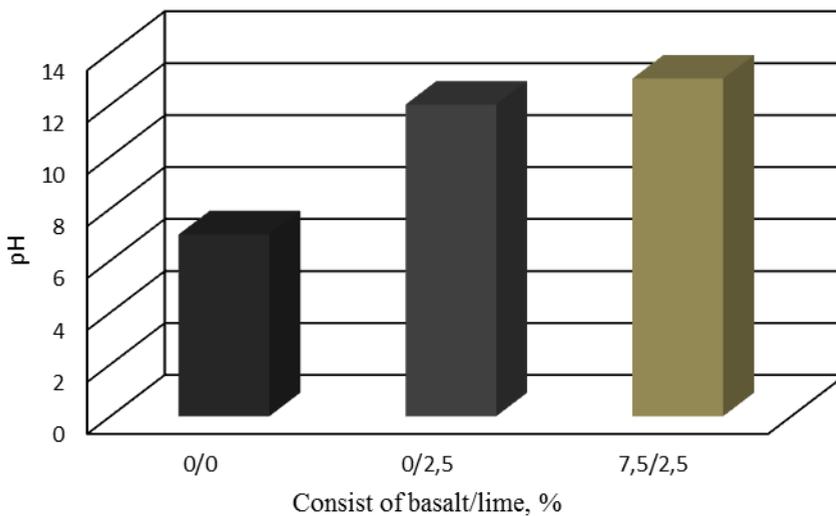


Fig. 1.Effect of lime content and waste of basalt fiber production on pH of solutions.

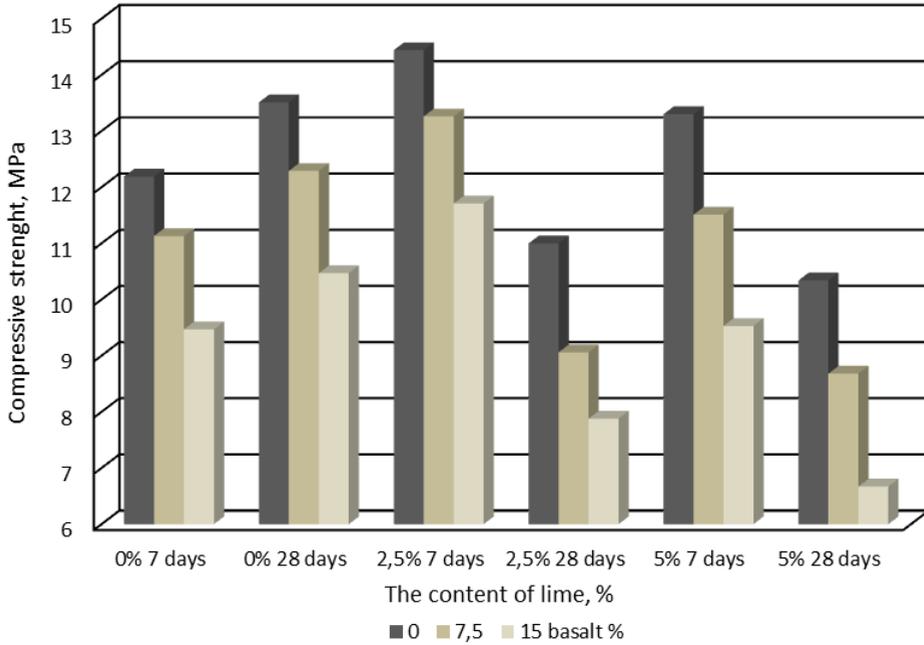


Fig. 2.Effect of lime content and waste of basalt fiber production on the strength of gypsum composites on days 7 and 28.

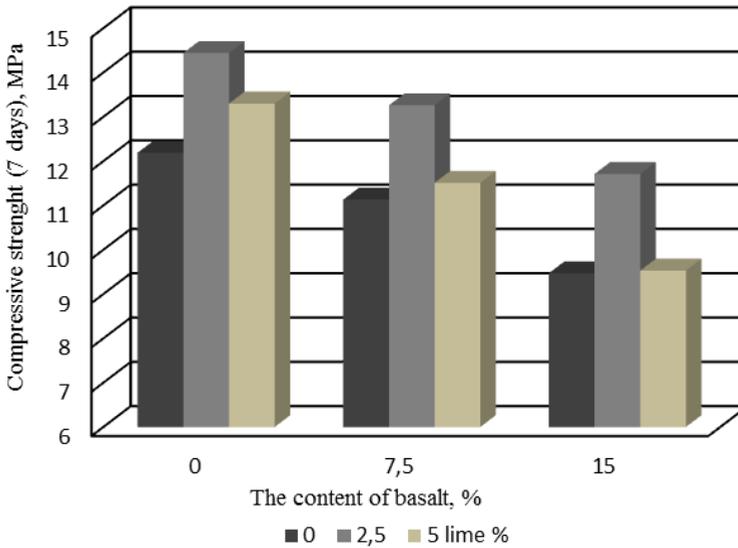


Fig.3.Effect of lime content and waste of basalt fiber production on the strength of gypsum composites on the 7th day of hardening.

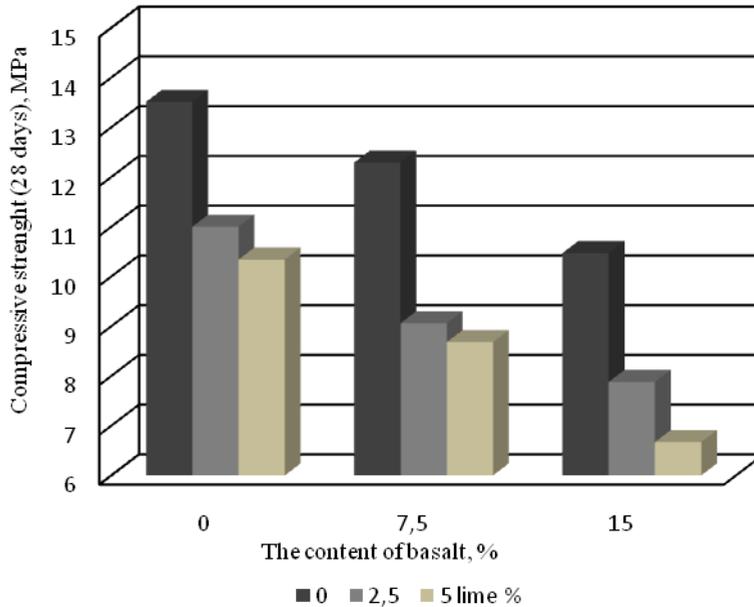


Fig. 4.Effect of lime content and waste of basalt fiber production on the strength of gypsum composites on day 28 of hardening.

4 Conclusion

Thus, the pH of the gypsum mixing fluids affects the strength properties of composite gypsum. Increasing the pH to 12-13 leads to an increase in solubility and an increase in the strength of gypsum stone. However, the use of lime as an alkaline component in gypsum composite systems is impractical due to the formation of ettringite, which was observed on day 28 of hardening.

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