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EFFECT OF MODIFICATION OF SAND-LIME PRODUCTS ON THEIR BASIC FUNCTIONAL PROPERTIES

WPŁYW MODYFIKACJI ELEMENTÓW WAPIENNO--PIASKOWYCH NA ICH PODSTAWOWE WŁAŚCIWOŚCI UŻYTKOWE

A b s t r a c t

This paper describes a proposal for the modification of traditional sand-lime products using the granulate of foamed glass and lithium polysilicate. These fillers are intended to reduce gross density in a dry state and retain the highest possible compressive strength of the obtained material in comparison to the starting material. Basic functional property tests were thus performed on blocks made from the terminal material, i.e. compressive strength, gross density in the dry state, water absorption. The results of this research are discussed and presented in tabular and graphic form of this paper.

Keywords: sand-lime products, silcate bricks, modification, properties, additives, admixture, foam glass aggregate, lithium polysilicate

S t r e s z c z e n i e

W artykule przedstawiono propozycję modyfikacji tradycyjnego wyrobu wapienno-piaskowego granulatem spienionego szkła i polikrzemianem litu. Wypełniacze te mają na celu zmniejszenie gęstości brutto w stanie suchym oraz zachowanie możliwie wysokiej wytrzymałości na ściskanie otrzymanego materiału w stosunku do materiału wyjściowego. Na otrzymanych bloczkach wykonano badania podstawowych właściwości użytkowych modyfikowanych wyrobów, tj. wytrzymałość na ściskanie, gęstość brutto w stanie suchym, absorpcja wody. Wyniki badań zostały omówione i przedstawione w formie tabelarycznej oraz graficznej niniejszego opracowania.

Słowa kluczowe: produkty wapienno-piaskowe, silikaty, modyfikacja, właściwości użytkowe, dodatki, domieszki, granulat spienionego szkła, polikrzemianu litu

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1. Introduction

Silicate elements are a commonly applied material used in the construction industry. Currently, they are among the main group of products used for the construction of masonry structures, therefore they are suitable for building walls loaded both horizontally and vertically [1]. Their main advantage is undoubtedly high compressive strength. In addition, only natural materials are used in their construction – sand, lime and water. With the many advantages of sand-lime products, attention is paid to the large gross mass in the dry state of these elements, which is perceived as a drawback in the transport and implementation.

The modification of silicate products is not widely described in the literature, however, in recent years attempts to modify these products with basalt aggregate or LDPE granulate have been recorded. Basalt aggregate with the fraction of 2–4 mm used in the share of 25–40% relative to the weight of the product, has a positive effect on the physical properties – reduces absorb-ability and water absorption while increasing compressive strength. Modification with this aggregate, however, leads to an increase in weight. [2, 3]. Additives in the form of low density polyethylene LDPE reduces water absorption and the weight of the product while lowering it compressive strength. As a result of the last mentioned feature, relevant products may only be those which contain up to 9% of the filler in their composition by the weight of the product [4].

The aim of the study is to obtain a sand-lime product of low weight, which retains a high compressive strength.

The wide product palette offered on the market provides many opportunities for using additives which could reduce the gross density of silicate elements in the dry state. Foam glass aggregate, which is the main raw material for preparing glass cullet, is a granulate characterized by among other things, low density, high compressive strength and excellent sound absorption [5]. Because of these characteristics it was decided to use it as a filler in silicate mass.

From a practical point of view, the chosen silicate product would require a compressive strength greater than 5 MPa (this compressive strength corresponds to the lowest class of compressive strength according to the EN 771-2:2003 + A1: 2005 standard [6]). Due to the goal of the research, a lithium polysilicate admixture was applied. Its use is to increase the compressive strength of the resulting products. The methodology and the results of preliminary investigation are shown below.

2. Research methodology

The test procedure consisted of experiments aimed at determining compressive strength, gross density in the dry state and water absorption. Tests were performed in two series, on traditional samples and those modified by the addition of granulated foam glass. In the first series granules of fraction 0.04–0.1 mm were used, while 0.05–1 mm were used in the second one. The content of the additive in modified elements was respectively 10, 20 and 30% of the weight of the product. The mass was formed into rectangular blocks with dimensions of 4 × 4 × 16 cm, and then subjected to compaction and autoclaving at a temperature of 203°C. Thus the prepared samples were subjected to determination of the gross density in the dry state and compressive strength test.

The experiments were designated for a further phase of research, in which samples containing foam glass granulate with the fraction of 0.05–1 mm were enriched by a lithium polysilicate admixture. Samples were then subjected to the same tests as the samples described above.

A water absorption test was also conducted to establish the quantity of water absorption in thr modified products. This feature is particularly important for elements intended for use in layers resistant to moisture penetration or external elements of buildings with exposed facings. The study was performed according to recommendations of PN-EN 771-2 [6].

3. Results of research

The experiments conducted in the first stage of the study on the modified silicate elements showed that even a small amount of foamed glass granulate causes a significant decrease in the compressive strength, as can be seen on Fig. 1. The strength of the traditional silicate product was equal to 20.51 MPa. Even a 5% share of granules of diameter 0.04–0.1 mm caused the value to drop to 16.94 MPa, and the same share of granules but with larger diameter (0.5–1 mm) resulted in decreased compressive strength of almost four times, achieving only 5.86 MPa.

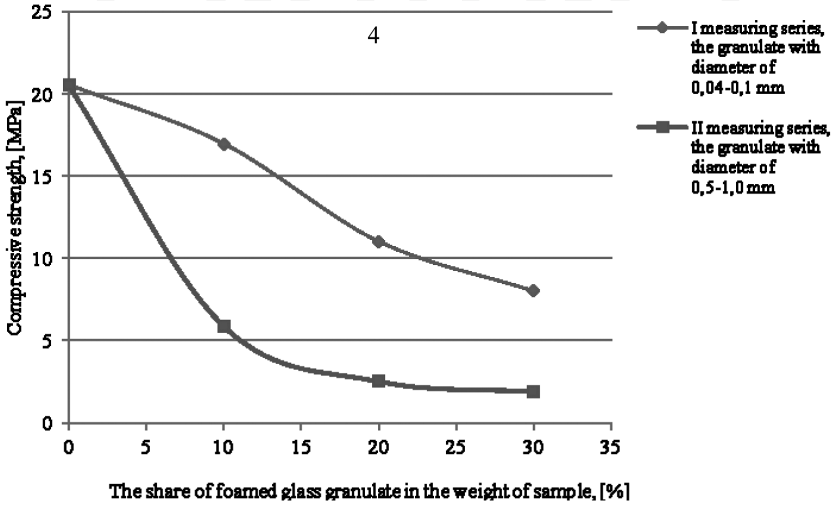

Fig. 1. Effect of granulate on the compressive strength of modified silicate products

From a practical point of view, only those products in which compressive strength is greater than 5 Mpa are relevant, therefore the content of glass granules with diameter 0.5–1.0 mm higher than approximately 11.0% becomes unreasonable. The determined compressive strength value was not obtained when applied were granules of diameter 0.04–1 mm were applied. It is noted, however, that a small amount of granulate with larger diameter gives the same results as a quadrupled greater share of smaller granules. This relationship is clearly seen on Fig. 1.

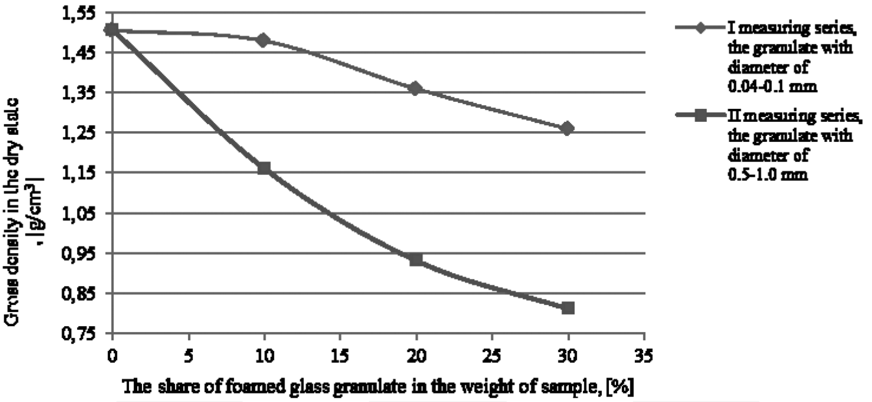

Fig. 2. Effect of granulate on gross density of modified silicates

When searching for applicable silicate products, it can be noted that a significant decrease in gross density in the dry state occurs only with the involvement of foam glass granulate (having a diameter of 0.04–1 mm) above 12%, and a small addition of granulate with larger diameter shows a distinct change (Fig. 2) – 5% of the additive causes a decrease in gross density value to 1.32 g/cm^3.

Considering the results above, further studies were conducted using granulate with the diameter of 0.5–1.0 mm. In order to improve strength properties, to both traditional and modified samples added was lithium polysilicate, in amounts equal to 5% of the product weight.

The presence of lithium polysilicate in the sample contributed to the increase in compressive strength of a traditional product by 3.51 MPa. Analogously, an increase in compressive strength is visible in the samples with the addition of foamed glass granulate, but with growing share of the additive the gradient decreases. In the samples containing 30% of the granulate and 5% of lithium admixture, compressive strength grew by only 0.67 MPa, as shown in Fig. 3.

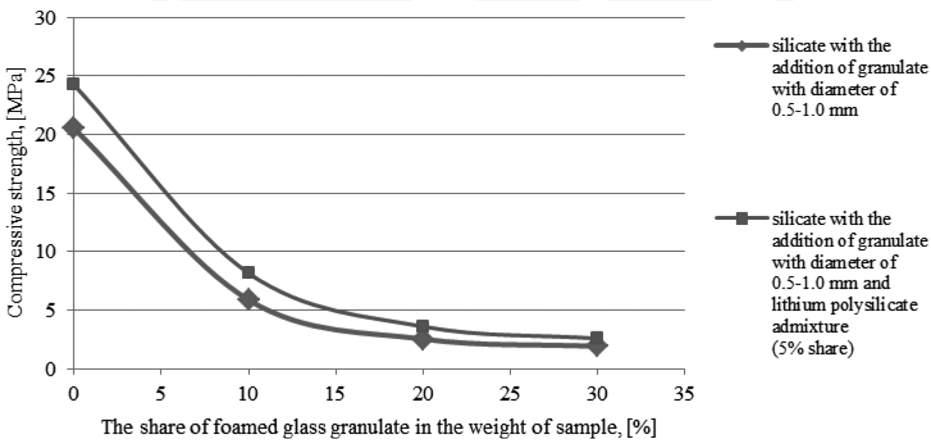

Fig. 3. Effect of polysilicate admixture on compressive strength of silicate products with foamed glass granules with a diameter of 0.5–1.0 mm

In addition, the presence of lithium polysilicate in the sample with foamed glass granulate contributed to a change in the weight of the silicate product. A shown in Fig. 4, gross density in the dry state slightly decreased. This means that the admixture in the form of lithium polysilicate allows for a reduction in the weight of silicate products, on average by 0.14 g/cm^3. The weight difference decreases with the share of granulate in the sample. This relationship is shown in Fig. 5 (dotted line indicates the limit of assumed correct compressive strength).

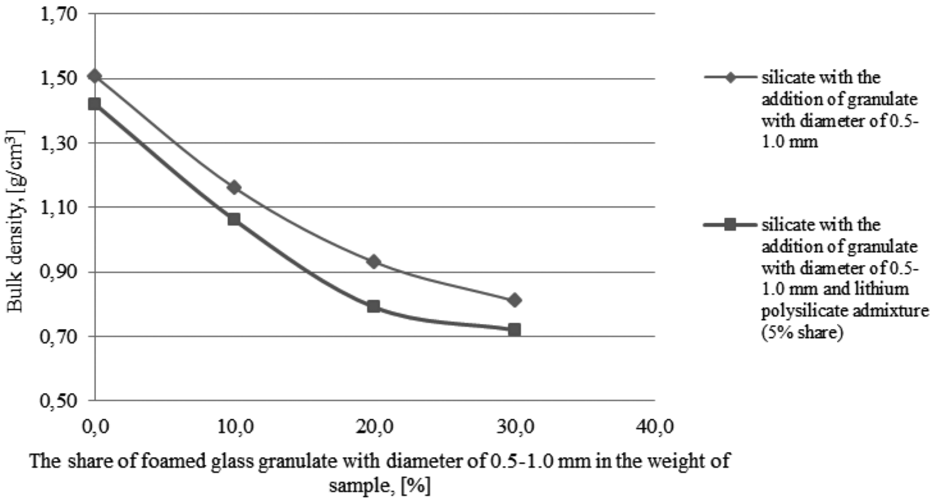

Fig. 4. Effect of polysilicate admixture on gross density of silicate products with foamed glass granules with a diameter of 0.5–1.0 mm

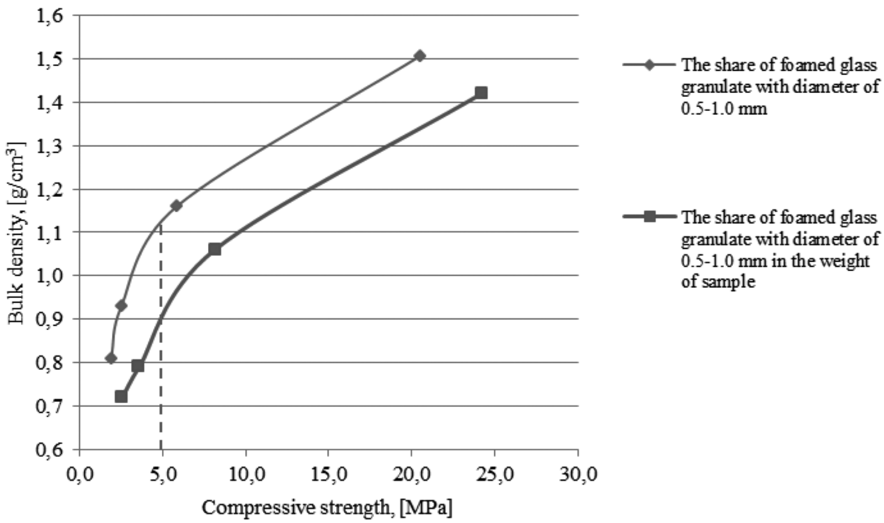

Fig. 5. Impact of gross density on the compressive strength of resulting silicate product

Traditional silicate products are characterized by water absorption of about 16%. Introducing a sand-lime mass lithium polysilicate admixture contributed to a significant increase in water absorption by up to about 21.0%. Analogously, this value is considerably higher in products containing 30% foamed glass granulate additive and 5% content of lithium polysilicate, which results in a threefold increase in water absorption. These changes are shown in the Fig. 6.

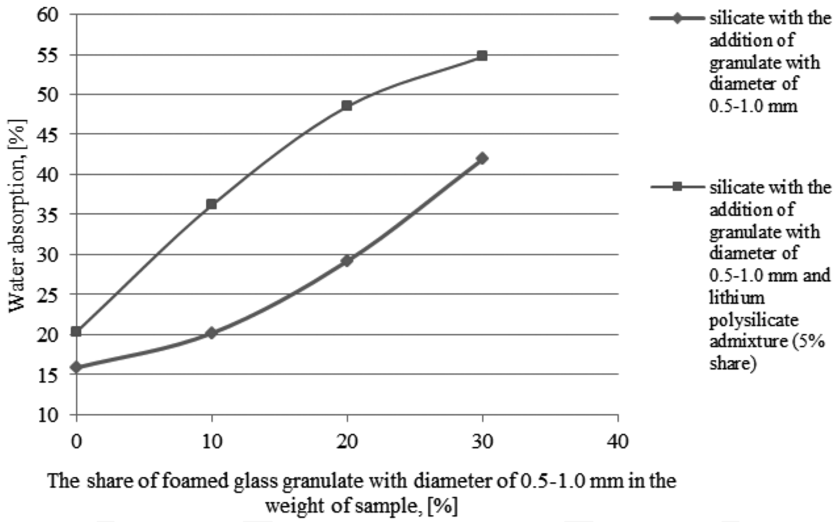

Fig. 6. Water absorption of modified silicate products

4. Conclusions

The purpose of preliminary investigation conducted was to find a silicate product characterized by a low gross density in the dry state with a high compressive strength, not less than 5 MPa. The study led to the following conclusions:

1. The share of granulated foam glass with a diameter of 0.5–1.0 mm is more economically significant in the production of the product than the granulate having smaller diameter (0.04–0.1), due to obtaining the same strength characteristics with a smaller amount of the additive.
2. Sufficient strength of the modified silicate product can be obtained with the share of granulate with diameter 0.5–1.0 mm not greater than 11.0%.
3. The use of lithium polysilicate admixture contributes to an increase in compressive strength and reduces gross density in the dry state in comparison to the traditional product.
4. Changes in the composition of the modified silicate product containing foam glass granulate and lithium polyslicate admixture significantly increased water absorption.
5. With a lithium polysilicate share equal to 5%, the proper compressive strength will be maintained when the content of foamed glass granulate is not greater than 8.5%

6. The proposed additive and admixture presence in the sample, while maintaining the proper compressive strength, causes a decrease in gross density in the dry state extremely to 0.91 g/cm^3 and increase in water absorption to 37%.

References

[1] Sawicki J., *Silikaty w budownictwie*, Izolacje, nr 1, 2009.
[2] Dachowski R., Stępień A., *Research on sand-lime products regarding their physical and mechanical features*, Structure and Environment, No. 1/2010, Vol. 2, Wydawnictwo Politechniki Świętokrzyskiej, Kielce 2010, 5-8.
[3] Stępień A., *Wpływ kruszywa bazaltowego na porowatość i wytrzymałość wyrobów silikatowych*, [w:] *Zagadnienia materiałowe w Budownictwie i Inżynierii Środowiska*, Wydawnictwo Politechniki Świętokrzyskiej, Kielce 2012, 37-46.
[4] Raźny J., *PORAVER – nowe spojrzenie na szkło*, Izolacje, nr 1, 2011.
[5] Linczowski Cz., Dachowski R., *Porównanie najpopularniejszych ściennych materiałów budowlanych stosowanych w budownictwie jednorodzinnym*, Wyd. Przemiana, Kielce 1998.
[6] PN-EN 771-2:2006+A1:2005: Wymagania dotyczące elementów murowych. Część 2: Elementy murowe silikatowe.