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SLAG ALKALINE NON-AUTOCLAVED FOAM CONCRETE OF INCREASED CRACK RESISTANCE

Abstract. The paper discusses theoretical and experimental investigation of alkaline activated non-autoclaved foam concrete. It was decided to a use slag binder as a part of non-autoclaved foam concrete. The effect of the silicate module on the rheological and mechanical properties of the slag binder is investigated. It has been established that a decrease in the activator module from 3 to 1 increases the initial and final setting time of the slag alkaline binder 3 times. When the activator module decreases from 3 to 2 compressive strength increases from 27 to 49 MPa, and when it decreases to 1 the strength index changes slightly.

Key words: alkali-activatedn on-autoclaved foam concrete, ground blast furnace slag, fly ash, setting time, compressive strength.

1. INTRODUCTION

Foam concrete is a lightweight material composed of cementitious mortar surrounding disconnected bubbles (more than 50 % by volume) which are a result of physical processes during which air is introduced into the mortar (unfoamed) mixture [1].

Foam concrete is one of the most efficient thermal insulation material. It has a low thermal conductivity and is made from cheap raw materials. Cellular concrete is made product for housing and civil engineering mostly in the form of panels and small wall blocks.

The dry density of foamed concrete is usually between 400 and 1 600 kg/m^3 and its compressive strength, which varies with density, can typically range between 1 N/mm^2 and 25 N/mm^2 at 28 days. Foam concrete has a satisfactory resistance to freeze/thaw and sulfate attack (at least for a short term). The penetrability of the material to various gases and liquids is a function of the constituents and density of the concrete, but it can be dominated by the presence of cracking generated, for example, during curing [2].

The most obvious advantage of foam concrete is its lower density which results in reduction of dead load (additional substantial savings are achieved), reduction of handling and transport costs, faster construction rates (reduction of manpower), good thermal insulation properties (energy conservation advantages, and, thereby, reducing operating costs, heating/air conditioning) and good acoustic properties.

The application of foam concrete can be divided in to three main fields: precast elements (wall and ceiling panels), block production (sewn from big blocks or cast in specified moulds) and cast in situ (flooring system, roof insulation and wall filling) [3].

The main disadvantage of non-autoclaved foam concrete it's high shrinkage deformation. Shrinkage in concrete occurs as a result of changes in the volume of new formation (contractional shrinkage), due to evaporation of chemically unbound water (moisture shrinkage) and carbonization shrinkage, which occurs due to the carbonization of calcium hydroxide and develops gradually from the surface of the concrete into the depth. Of these three factors, moisture shrinkage affects the formation of cracks in concrete in the most degree. The more mixing water is introduced into the concrete mix, the greater the amount of chemically unbound water will remain after hydration with cement. The remaining water evaporates when the product dries, leaving behind itself pores in the structure of the solid phase. In consequence because of this the material begins to shrink. Shrinkage causes stress in the hardened concrete, which exceeds the adhesive force of the particles, resulting in cracks and eventually the destruction of the material [4].

The simplest way to reduce shrinkage is to reduce the amount of free water in a concrete structure by reducing the water-hard ratio. However, with a decrease in water consumption, the workability of the concrete mixture decreases, because of this it is not possible to obtain low indicators of average density and given thermal physical properties. To increase the mobility of the concrete mix plasticizers are introduced into its composition. These chemical additives retain the workability of the mixture while reducing water consumption, creating a film with the same charge on the surface of cement particles, which prevents them from early sticking together.

Another way to improve crack resistance is to use a slag alkaline binder in the composition of foam concrete. Due to the high compressive strength, non-autoclaved foam concrete can be obtained, which is close to autoclave concrete. When using a slag alkaline binder, you can completely abandon the most expensive component in the composition, that is Portland cement, replacing it by man-made raw materials and by ground blast-furnace granulated slag and fly ash from thermal power plants. This will reduce the cost of products and will enable recycle industrial wastes that pollute the environment of our region [5, 6].

Slag alkaline binders are effective clinker-free material with high technological and operational properties.

However, alkaline binders on the main king of slag are characterized by excessively fast setting time as a result of the high reactivity of the slag. The initial and final setting time usually doesn't exceed 10 minutes, which practically excludes their use in concrete.

It is assumed that reducing the silicate module of liquid glass and lowering the percentage of blast furnace slag due to the introduction of a less reactive component in comparison with it fly-ash from a thermal power plant will increase the setting time, but significantly accelerate the set of plastic strength of the raw foam concrete and help achieve high strength properties of non-autoclaved foam concrete [7, 8].

2. EXPERIMENTAL DETAILS

When conducting research, the following materials were used:

– ground blast furnace slag (MDS) fr. < 0.315;

– fly ash (ZU) of the Zuevskaya thermoelectric power station fr < 0.16;

– sodium liquid glass (LS) Diol D-53 (Ms = 3,0; 2,0; 1.0; ρ = 1,25 g / cm^3);

Samples were tested according to standard procedures using certified test equipment and measuring instruments.

3. TEST RESULTS AND DISCUSSION

At this stage, study was carried out on the effect of fly ash from a thermal power plant and a ground granulated slag on the setting time and compressive strength of a slag-alkaline binder, which hardened under various conditions.

As it can be seen in the figure 1, reducing the activator modulus from 3 to 1 increases the setting time by 3 times.

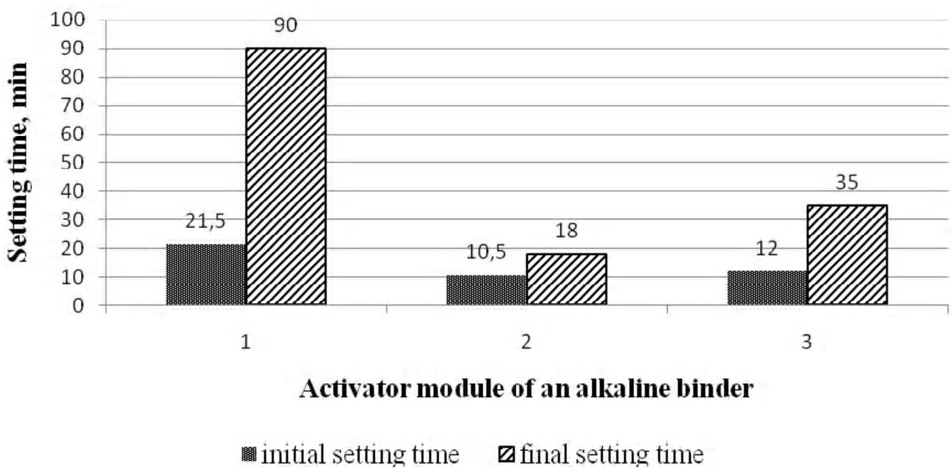

Figure 1 – Influence of the activator module on the setting time.

For instance, the sample with activator module 3 shows an initial setting time of 12 mins, while this value increases to 21 mins in the sample with activator module 1; and the final setting time also increases from 35 mins to 90 mins.

The compressive strength of samples with activator module 1–3 is shown on fig. 2.

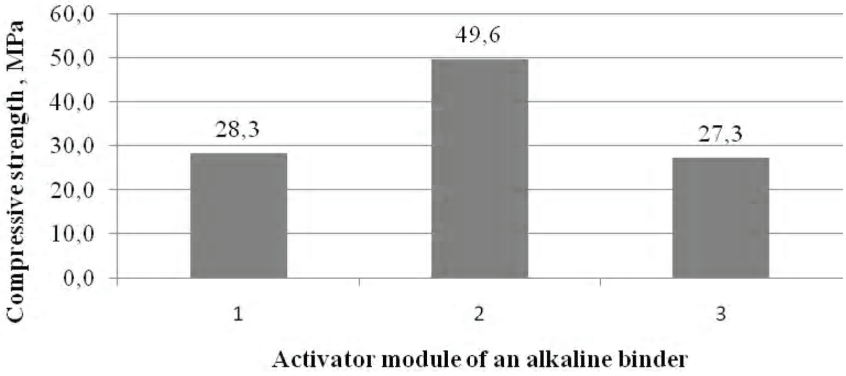

Figure 2 – Influence of the activator module on the compressive strength.

For mixes with activator module 3, the compressive strength is 27 MPa after curing when steaming; and it increases to 49 MPa with activator module 2 and to 28 MPa with activator module 1 (fig. 2).

And the results in this study show that satisfying strength that is suitable for structural applications can be obtained in ambient-temperature-cured-slag-fly-ash blends on liquid glass.

Early setting time reduces the ripening time of foam concrete before heat treatment, which increases the performance of this technology.

4. CONCLUSIONS

1. It is theoretically substantiated that the use of a slag alkaline binder with the addition of fly ash from thermal power plants improves the technological and operational properties of non-autoclaved foam concrete.
2. It has been established that reducing the silicate module of liquid glass makes it possible to achieve optimum setting time for a non-autoclaved foam concrete technology.
3. Reducing the silicate module of liquid glass from 3 to 1, allows to achieve the strength characteristics of an alkaline binder, acceptable for use in structural thermal insulation foam concrete of non-autoclave hardening.

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ШЛАКОЩЕЛОЧНОЙ НЕАВТОКЛАВНЫЙ ПЕНОБЕТОН ПОВЫШЕННОЙ ТРЕЩИНОСТОЙКОСТИ

ГОУ ВПО «Донбасская национальная академия строительства и архитектуры»

Аннотация. В статье представлены теоретические и экспериментальные исследования щлакощелочного неавтоклавного пенобетона. Исследовано влияние силикатного модуля на реологические и механические свойства золошлакового вяжущего. Установлено, что уменьшение модуля активатора с 3 до 1 увеличивает начальное и конечное время схватывания золошлакового вяжущего в 3 раза. При уменьшении модуля активатора с 3 до 2 прочность на сжатие увеличивается с 27 до 49 МПа, а при уменьшении до 1 показатель прочности изменяется незначительно.
Ключевые слова: шлакощелочной неавтоклавный пенобетон, молотый гранулированный доменный шлак, зола-унос, сроки схватывания, прочность при сжатии.

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ШЛАКОЛУЖНИЙ НЕАВТОКЛАВНИЙ ПІНОБЕТОН ПІДВИЩЕНОЇ ТРІЩИНОСТІЙКОСТІ

ДОУ ВПО «Донбаська національна академія будівництва і архітектури»

Анотація. У статті представлені теоретичні і експериментальні дослідження щлаколужного неавтоклавного пінобетону. Досліджено вплив силікатного модуля на реологічні і механічні властивості золошлакового в'яжучого. Встановлено, що зменшення модуля активатора з 3 до 1 збільшує початковий і кінцевий час схоплювання золошлакового в'яжучого в 3 рази. При зменшенні модуля активатора з 3 до 2 міцність на стиск збільшується з 27 до 49 МПа, а при зменшенні до 1 показник міцності змінюється незначно.
Ключові слова: шлаколужний неавтоклавний пінобетон, мелений гранульований доменний шлак,- зола-винесення, терміни схоплювання, міцність при стисненні.

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