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Evaluation of the Effect of Additives on the Workability of Concrete Mix as Part of a Study of a Modified Wall Block

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Abstract
The article presents the results of an experimental investigation into the effect of modifying additives on the workability and setting times of a concrete mix used in the production of a two-component wall block. The block structure consists of an external façade layer and an internal structural–thermal insulation layer, which requires precise control of the rheological and technological parameters of the concrete mix during sequential casting. Lignin and soapstock, which are by-products of the wood-processing and fat-processing industries, were used as modifying components. The experimental program included the determination of concrete mix flowability and cement paste setting times at various additive dosages. The results showed that the incorporation of lignin and soapstock increased the workability of the concrete mix compared to the reference composition: the maximum increase in flowability reached up to 6.4% for lignin and up to 9.5% for soapstock. Their combined application produced a pronounced synergistic effect, resulting in an increase in workability of up to 16% in linear terms and up to 35% in terms of spread area, as well as a reduction in data dispersion. The setting time tests revealed opposite effects of the additives: lignin contributed to a reduction in both initial and final setting times, whereas soapstock, due to its hydrophobic properties, led to their extension. The obtained results can be used to optimize the technological regulations for manufacturing two-component wall blocks and to improve the quality and stability of the final products.

Keywords: wall block, additive, workability, setting time, lignin, soapstock.

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Introduction

The relevance of wall enclosing structures and products is beyond doubt, as the majority of existing and ongoing construction projects are, in one way or another, carried out using artificial stone.

Traditionally, heavy wall structures include brick masonry and concrete walls made from high-density concretes [[1], [2], [3], [4]]. In contrast, lightweight wall systems are formed using aerated concrete and foam concrete [5]. The key distinction between these two groups of materials lies in their intended purpose and structural role: heavy, high-strength concrete is primarily used for load-bearing elements such as columns, foundations, and walls (including panel walls) of multi-storey buildings [6]. The drawbacks of using heavy wall structures include low economic efficiency due to high production costs, the complexity of the construction process (in the case of brick walls), and the need for additional insulation measures (for heavy concrete) [[7], [8], [9]].

Lightweight concretes, on the other hand, are primarily intended for external enclosures and internal partitions [[10], [11], [12]]. Their porous structure provides enhanced thermal and sound insulation properties, while reduced density decreases the load on the foundation, which is a significant structural advantage. The disadvantages of using lightweight wall structures include their relatively low performance compared to heavy ones, which is associated with lower load-bearing capacity, higher hygroscopicity (in the case of aerated concrete), low frost resistance, high brittleness, and so on [[13], [14], [15], [16], [17], [18], [19]].

The construction product proposed in this project—a two-component multi-purpose wall block—offers novelty both in the technological solution of the wall structure and in its composition and production technology. The novelty also includes the development of a modifying additive derived from industrial waste, whose use is aimed at targeted improvements of the operational characteristics of the wall block composite material (water repellency, frost resistance, and strength). The proposed product differs in composition from existing analogues, and the proposed technological solution is distinct from previously known production technologies (analogues are presented below).

This article presents research on the workability of the concrete mixture used to manufacture the wall block. Studying the workability of the mixture provides essential information for the production process of the wall block. This is particularly relevant because the block consists of two parts: the external façade part and the internal structural-thermal insulation part (Figure 1).

Both parts of the block constitute a monolithic, unified structure; however, they differ in their technological composition as well as their functional purpose. Therefore, the workability of the concrete mixture, as well as the setting time, plays an important role in the production process, since manufacturing involves the sequential pouring into molds—first the heavy façade part, followed by the internal lightweight part of the block. The workability (workability) of the concrete mixture is also particularly important during the production of the façade part, as decorative elements (e.g., imitating brickwork or patterns) may be incorporated into the mold.

Based on the above, the research objectives were defined as follows:

1) To determine the effect of additives on the workability of the concrete mix.
2) To determine the effect of additives on the setting times of the concrete mix.

These indicators will be key for adjusting the placement time of each block layer to ensure a high-quality building product.

Experimental part

Figures 2 and 3 show the technological schemes for the production of the external and internal parts of the blocks. The production of the wall block involves the use of the following components: cement (C), sand (S), lignin (Lg), soapstock (Sp), basalt waste (Bs), aluminum powder (Al), caustic soda (N), and the remainder being water (W).

Lignin in concrete mixtures is used predominantly in the form of lignosulfonates, which are by-products of the sulfite pulping of wood. These compounds act as industrial chemical additives, the performance of which is determined by their interactions with cement particles at the molecular level. Due to their negative charge, lignosulfonate molecules are adsorbed onto the surface of cement grains, imparting a negative charge to the particles themselves. Hydrated shells are formed on their surfaces, which reduce the tendency of particles to coagulate and form aggregates. This effect improves cement dispersion and increases the workability of the concrete mixture [[20], [21]].

Soapstock, which represents a complex of fatty acids, exhibits activity in cement systems mainly due to its surface-active and ion-exchange properties. Its action is associated with a number of characteristic chemical processes. Soapstock components with an amphiphilic structure contain both hydrophilic groups that interact with the aqueous phase and hydrophobic hydrocarbon chains that orient toward air voids or outward from the system. Such molecular orientation contributes to a reduction in surface tension, improves the wetting of cement grains, and ensures the formation of a stable dispersed system [[22], [23]].

To improve the durability of the façade layer against environmental exposure, lignin (a by-product of the wood industry) and soapstock (a waste product of the fat-processing industry) are incorporated into the mixture. The hydrophobicity of soapstock, as well as its resistance to certain acids and alkalis, enhances the durability of the façade layer exposed to the environment. Additional hydrophobization is achieved through lignin, which promotes polymerization within the façade layer structure.

Because both lignin and soapstock affect mix workability, quantitative evaluation was necessary for developing a technological regulation for two-component block production.

Tests were conducted on series with varying contents of modifying components, compared to reference samples (RS).

For the outer layer, the mass fraction of lignin relative to cement was 0.015; 0.020; 0.025; 0.030; 0.035%. The soapstock fractions were identical—0.015; 0.020; 0.025; 0.030; 0.035%.

For the inner layer, lignin contents were 0.02; 0.025; 0.03; 0.035; 0.04%, and the basalt filler content varied from 0.5 to 0.9% of sand mass.

Table 1 presents the mix proportions, indicating the masses of the components required to prepare 1 cubic meter of concrete. Sample preparation and testing were carried out under laboratory conditions at an air temperature of 21–23 °C and a relative humidity of 60–65%.

The following laboratory methods were used:

1) Concrete mix workability — GOST 7473-2010 [24].
2) Setting times — GOST 310.3-76 [25].

Table 1 – Proportions of components for concrete preparation

Additives, %	Cement (C)	Lingin (Lg),	Soapstock (Sp),	Sand (S)	Water (W)
RS: Reference sample	950.000	0.000	0	950.0	427.5
Lg=0.015	949.858	0.143	0	950.0	427.5
Lg=0.020	949.810	0.190	0	950.0	427.5
Lg=0.025	949.763	0.238	0	950.0	427.5
Lg=0.030	949.715	0.285	0	950.0	427.5
Lg=0.035	949.668	0.333	0	950.0	427.5
Sp=0.015	950.000		0.045	950.0	427.5
Sp =0.020	949.810		0.190	950.0	427.5
Sp =0.025	949.763		0.238	950.0	427.5
Sp =0.030	949.715		0.285	950.0	427.5
Sp =0.035	949.668		0.333	950.0	427.5

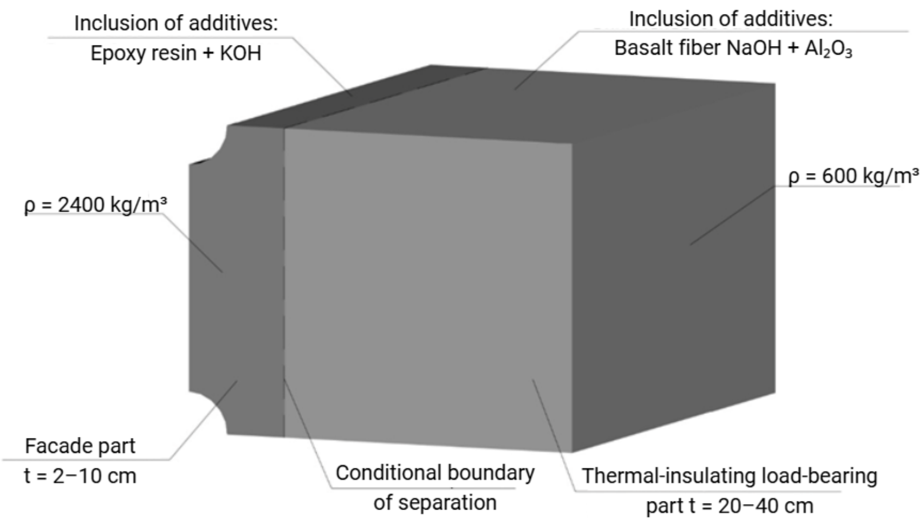


Figure 1 - Structure of the wall block

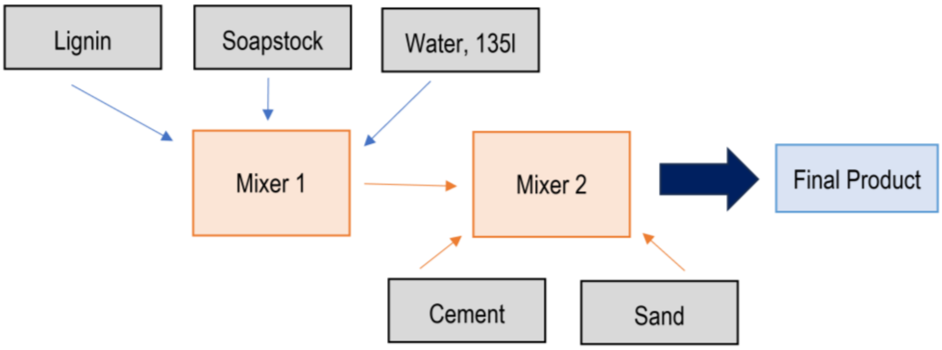


Figure 2 - Production technology of the outdoor part of the unit

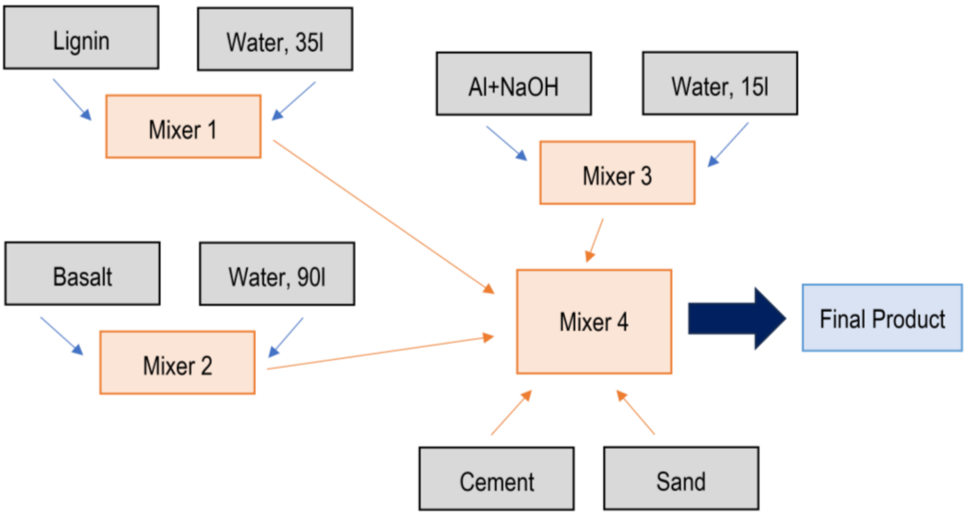


Figure 3 - Production technology of the inner layer

Results and Discussion

1. Workability of Concrete Mix

Figure 4 shows the results of the workability of the concrete mixture with varying composition. Specifically, Figure 1 presents the flow results of the mixture at different lignin (Lg) contents. Figure 5 shows the flow results of the mixture with varying soapstock (Sg) content. Figure 6 presents the flow results of the mixture at the maximum contents of both Lg and Sg.

According to preliminary tests, the water–cement ratio at which a flow spread of 150 cm was achieved is 0.55. Therefore, all workability tests were conducted at this water–cement ratio. The W/C ratio was intentionally kept constant (0.55) to isolate the effect of additives on rheology. Although plasticizers may allow water reduction in conventional concrete technology, varying w/c conditions would introduce additional uncertainty and make it difficult to attribute rheological changes solely to the additives being investigated. Therefore, a fixed w/c ratio was selected to ensure accurate interpretation and comparability of the results. As can be seen from the curve in Figure 4, lignin (Lg) has a pronounced effect on the workability of the mixture: with each increase in Lg concentration, the spread diameter increases. It is also noticeable that the dynamics of the spread change are proportional to the change in concentration.

However, upon the initial introduction of the additive at a concentration of 0.015, a sharp increase in spread is observed (indicating the maximum intensity of the additive's effect), whereas with further increases, the effect decreases, although it remains consistent. Overall, the increment in spread diameter averages 1–2 cm, indicating the stability of Lg's influence on the workability parameter of the concrete mixture.

Analysis of the coefficients of variation further confirms the stability of this positive effect, as the data dispersion for samples with the additive sharply decreased to 1.5–1.9%, whereas for the reference sample this value was 3.2%. It cannot be concluded that the stability of results increases with higher additive content (despite the apparent decreasing trend in the coefficient of variation with increasing additive), since the fluctuations in variation values are minor and fall within the statistical error, which has a minimum threshold of 1.5%.

According to the curve in Figure 5, the positive effect of the Sp component is also clearly observed. However, the dynamics of change are not consistent. The maximum effect occurs upon the initial introduction of the component. With subsequent additions, the rate of increase decreases but remains noticeable relative to further concentration increases. When the maximum concentration is applied, the increase in spread diameter compared to the previous value is only 1 cm, whereas the initial introduction produced an increase of 4 cm. This indicates that the maximum concentration of Sp = 0.035% approaches the peak effect of the component on enhancing workability. Despite the decreased intensity of the increase, the influence of Sp remains stable.

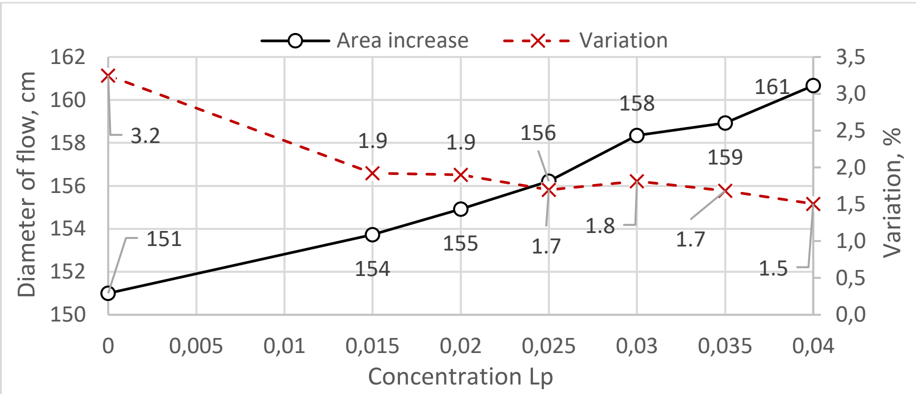


Figure 4 - Change in mix workability with Lg

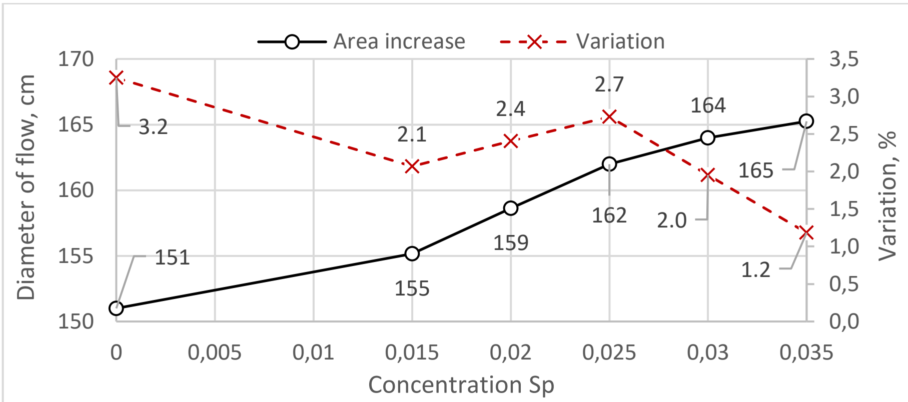


Figure 5 - Change in mix workability with Sp

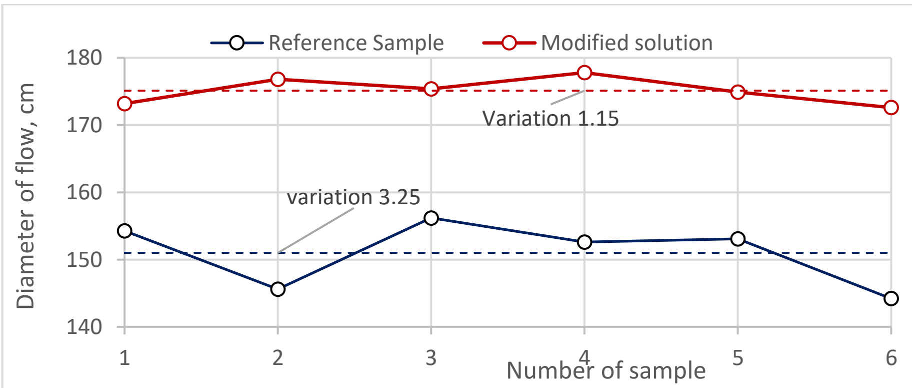


Figure 6 - Workability at maximum Lg and Sp

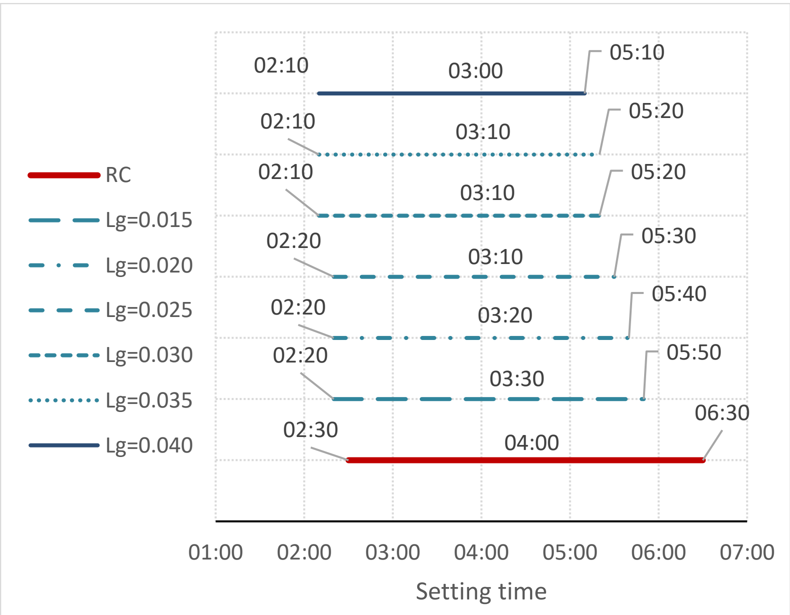
Moreover, although the intensity of workability improvement decreases with higher concentrations, the stability of the data points increases, as indicated by the coefficients of variation. The dynamics of the coefficients' changes are evident: they decrease proportionally to the increase in concentration, and minor fluctuations (observed in the range of 0.015–0.030%) fall within the statistical error.

According to the curve in Figure 6, which shows the change in spread at the maximum concentrations of Lg and Sp, a presumptive synergistic effect of the components is observed. If the average spread diameter of the reference sample is 151 cm, it reaches 161 cm at the maximum concentration of Lg = 0.04 and 165 cm at the maximum concentration of Sp = 0.035. Under the combined action of Lg and Sp, the increase reaches 175 cm.

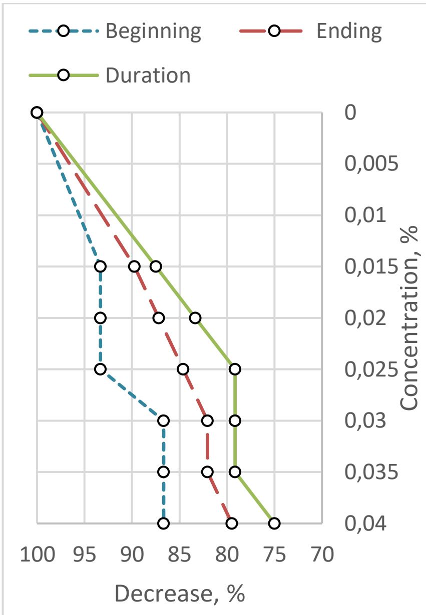
In percentage terms, the increase in workability is 15.9% when evaluated based on the increase in diameter as a linear dimension $\left(15.9\% = 100 \times \frac{(175-151)}{151}\right)$, while considering the radial proportional increase in spread area, the gain reaches 34.5% $\left(34.5\% = 100 \times \frac{3.14\times\left({}^{175}/_{2}\right)^{2}-3.14\times\left({}^{151}/_{2}\right)^{2}}{3.14\times\left({}^{151}/_{2}\right)^{2}}\right)$. The coefficients of variation also indicate a synergistic effect of the combined influence of the components.

2. Setting Time of Concrete Mix

Figures 7 and 8 show the results of cement setting time tests. In Figure 7A, the initial setting time, setting duration, and final setting time are presented, while Figure 7B illustrates the dynamics of their changes depending on the Lg concentration. Figures 8A and 8B show the same results for varying concentrations of Sp.



A



B

Figure 7 - Setting times at varying Lg content

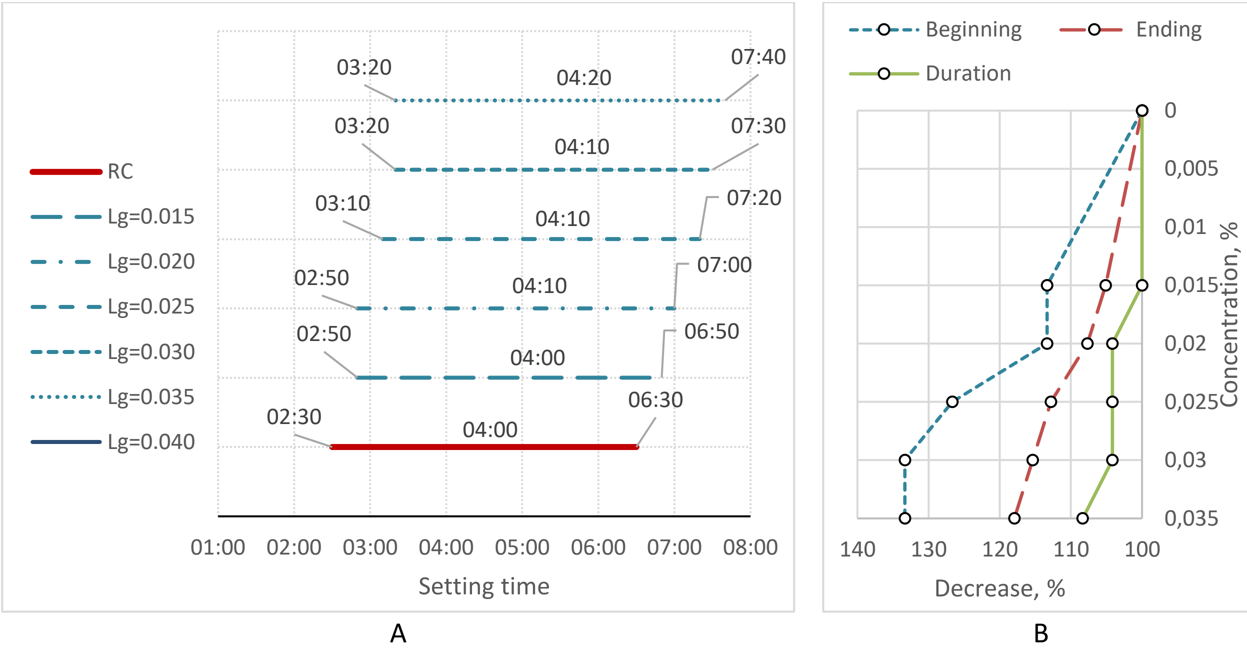


Figure 8 - Setting times at varying Sp content

According to the tests, for samples without admixtures (RS – reference samples), the setting of the paste began 150 minutes after mixing, while full hardening occurred after 420 minutes, with a duration of 240 minutes.

With the addition of Lg, a trend toward a reduction in all setting times is observed, and the higher the admixture concentration, the greater the reduction: at the initial dosage, the initial setting time decreases by 7%, the duration by 10%, and the final setting time by 12%; at the maximum concentration, the same parameters decrease (relative to RS) by 13%, 21%, and 25%, respectively. This trend is of minor significance for the outer layer, as it only requires adjustments in the production process. However, for the inner layer made of lightweight concrete, this trend is more advantageous, as the reduction in setting times contributes to the formation of a more stable pore structure. Therefore, a higher concentration of Lg for the inner layer can be considered justified in terms of reducing setting times, due to the higher alkalinity of the mix compared to the outer layer. Lignosulfonate-based lignin acts primarily as a plasticizing agent, improving cement grain dispersion and reducing the effective w/c ratio. Therefore, lignin leads to a moderate reduction in both initial and final setting times (18–34%), which is consistent with hydration acceleration.

In contrast, the addition of Sp exhibits the opposite pattern. This behavior is expected because soapstock contains vegetable fats with water-repellent properties, which slow the hardening process: at the initial dosage, the initial setting time increases by 13%, the duration by 5%, and the final setting time remains unchanged; at the maximum concentration, the same parameters increase (relative to RS) by 33%, 18%, and 8%, respectively.

Soapstock contains fatty acids, glycerides, and small amounts of alkaline residues. These amphiphilic molecules adsorb onto cement grain surfaces and form thin hydrophobic films which reduce water penetration and slow ionic transport to clinker phases, thereby delaying the dissolution of alite and the nucleation and growth of early C–S–H. The hydrophobic films and altered air-entrainment behavior also change pore-formation and capillary connectivity, which jointly modify hydration kinetics and early age microstructure [[22], [26], [27], [28]].

The coefficients of variation in all tests (six samples per series) did not exceed 5.0%; thus, the observed trends in setting times can be considered significant, as the percentage changes exceed the statistical measurement error. Since the effects of these components partially offset each other, and the setting time primarily influences adjustments in the production process rather than operational performance, the resulting indicators for selecting the optimal concentration should be the concrete's compressive strength (which is expected to increase due to plasticizing and water-reducing effects) and water absorption (which is expected to decrease due to hydrophobization).

Conclusions

1. A comprehensive set of laboratory tests was conducted to evaluate the workability of concrete, including workability and setting time tests. The studies were carried out to facilitate the subsequent adjustment of the technological process for manufacturing the wall block, which is composed of a two-component concrete mix. Tests were performed on samples with varying contents of lignin (Lg) and soapstock (Sp).

2. Workability tests confirmed the influence of Lg and Sp on the workability of the concrete mixture. Each component significantly affects the dynamics of the spread diameter. The higher the concentration of each component, the more pronounced the change in workability. The maximum increase in spread diameter with the addition of Lg, relative to the reference sample, was 6.4%. For Sp, this increase was 9.5%. When both components were added to the concrete mixture, a synergistic effect was observed, with workability increasing by 16% relative to the linear diameter, and by 35% in terms of the radial area. The increase in workability due to Lg is primarily attributed to its plasticizing effect, whereas the increase observed with Sp is due to the presence of vegetable fats in its composition. It should also be noted that the inclusion of these components stabilizes the results, reducing deviations in individual measurements, which positively affects the material quality.

3. Setting time tests produced contrasting results. The addition of Lg to the mixture resulted in a relatively linear decrease in all setting times, whereas the addition of Sp caused an increase in all setting times. The increase in setting times with Sp is explained by the water-repellent effect of the vegetable fats in its composition, while the reduction in setting times with Lg is associated with a decreased w/c ratio due to its plasticizing effect. The trend of increased setting times has little significance for the external part, as it only requires adjustments in the production process. However, for the internal part made of lightweight concrete, the trend is more beneficial, as the reduction in setting time contributes to the formation of a more stable pore structure. In any case, the final adjustment of setting times will be carried out after a control assessment of the basic operational parameters of the wall block (such as strength, frost resistance, water absorption, etc.).

1. Vehicle types were divided into five categories: A1 – bicycles; A2 – motorcycles (mopeds); A3 – passenger cars; A4 – light trucks and buses with very low capacity; A5 – trucks and buses. For each category, voltage ranges were calculated depending on the type of vehicle, the standard load capacity, and tire pressure.

2. For each category of motor vehicles, calculations of normal stresses on the road surface have been performed: for category A1, the stress range is from 48.7 kN/m^2 (0.50 kg/cm^2) to 229.8 kN/m^2 (2.34 kg/cm^2); for A2, from 111.4 kN/m^2 (1.13 kg/cm^2) to 346.2 kN/m^2 (3.53 kg/cm^2); for A3, from 168.8 kN/m^2 (1.72 kg/cm^2) to 316.2 kN/m^2 (3.22 kg/cm^2); for A4 from 259.0 kN/m^2 (2.62 kg/cm^2) to 546.6 kN/m^2 (5.57 kg/cm^2); for A5 from 349.4 kN/m^2 (3.56 kg/cm^2) to 1216.7 kN/m^2 (12.41 kg/cm^2).

Conflicts of interest. The corresponding author declares that there is no conflict of interest.

CRediT author statement: **R. Lukpanov:** concept, methodology; **D. Duyssembinov**: analysis, modeling; **A. Altynbekova**: data collection, editing; **G. Kaklauskas**: editing; **A. Zhumagulova**: analysis, interpretation, visualization.

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Модификацияланған қабырға блогын зерттеу аясында бетон қоспасының қозғалғыштығына қоспалардың әсерін бағалау

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ТҮЙІНДЕМЕ
Мақалада екі компонентті қабырға блокттарын өндіруде қолданылатын бетон қоспасының қозғалғыштығы мен қату уақытына модификациялық қоспалардың әсерін эксперименттік зерттеу нәтижелері ұсынылған. Блок құрылымы сыртқы қасбет қабатын және құрылымдық және жылу оқшаулағыш қабатын қамтиды, бұл бетон қоспасының реологиялық және технологиялық параметрлерін тізбекті қалыптау кезінде дәл реттеуді талап етеді. Модификациялық компоненттер ретінде ағаш және май өңдеу өнеркәсібінің қосалқы өнімдері болып табылатын лигнин және соапсток пайдаланылды. Тәжірибелік бағдарлама бетон қоспасының ағындылығын және қоспалардың әртүрлі концентрацияларында цемент қамырының қату уақытын анықтауды қамтыды. Лигнин мен сабын қоспасын енгізу бақылау құрамымен салыстырғанда бетон қоспасының қозғалғыштығына оң әсер ететіні анықталды: ағып кетудің максималды өсуі лигнин енгізілгенде 6,4%-ға дейін, ал сабын қоспасын енгізген кезде 9,5%-ға дейін жетті. Қоспаларды бірге қолдану айқын синергетикалық әсер берді, бұл қозғалғыштықтың сызықтық тұрғыдан 16%-ға дейін және таралу аймағында 35%-ға дейін артуымен сондай-ақ эксперименттік деректердің шашырауын азайтуды қамтамасыз етті. Қату уақытын зерттеу компоненттердің көп бағытты әсерін көрсетті: лигнин бастапқы және соңғы қату уақытын азайтуға көмектеседі, ал соапсток гидрофобты қасиеттерге ие болғандықтан, олардың артуына әкеледі. Алынған нәтижелер қоспалардың оңтайлы мөлшерін негіздеуге және оларды қасиеттерінің тұрақтылығы мен дайын өнім сапасын арттыратын екі компонентті қабырға блоктарын өндірудің технологиялық регламенттерін түзету үшін пайдалануға мүмкіндік береді.

Түйін сөздер: қабырға блогы, қоспа, қозғалғыштық,, қатаю уақыты, лигнин, соапсток.

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Оценка влияния добавок на подвижность бетонной смеси в рамках исследования модифицированного стенового блока

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АННОТАЦИЯ

В статье представлены результаты экспериментального исследования влияния модифицирующих добавок на подвижность и сроки схватывания бетонной смеси, применяемой при производстве двухкомпонентного стенового блока. Конструкция блока включает наружный фасадный слой и внутренний конструкционно-теплоизоляционный слой, что требует точного регулирования реологических и технологических параметров бетонной смеси при последовательном формовании. В качестве модифицирующих компонентов использованы лигнин и соапсток — побочные продукты деревообрабатывающей и жировой промышленности. Экспериментальная программа включала определение показателей растекаемости бетонной смеси и сроков схватывания цементного теста при различных концентрациях добавок. Установлено, что введение лигнина и соапстока оказывает положительное влияние на подвижность бетонной смеси по сравнению с контрольным составом: максимальный прирост растекаемости составил до 6,4% при введении лигнина и до 9,5% при введении соапстока. Совместное применение добавок обеспечило выраженный синергетический эффект, сопровождающийся увеличением подвижности до 16% по линейному показателю и до 35% по площади растекания, а также снижением разброса экспериментальных данных. Исследование сроков схватывания показало разнонаправленное влияние компонентов: лигнин способствует сокращению начальных и конечных сроков схватывания, тогда как соапсток, обладая гидрофобными свойствами, приводит к их увеличению. Полученные результаты позволяют обосновать оптимальные дозировки добавок и использовать их для корректировки технологического регламента производства двухкомпонентных стеновых блоков с повышенной стабильностью свойств и качеством готовой продукции.

Ключевые слова: стеновой блок, добавка, подвижность, сроки схватывания, лигнин, соапсток.

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References

[1] Peceño B, Alonso-Fariñas B, Vega G, Carrizo D, Leiva C. Sustainable Fire-Resistant Materials: Thermal, Physical, Mechanical, and Environmental Behavior of Walls with Waste from the Aquaculture Industry. Materials. 2024; 18(22):5086. https://doi.org/10.3390/ma18225086

[2] Tamošaitienė J, Parham S, Sarvari H, Chan D W, Edwards D J. A review of the application of synthetic and natural polymers as construction and building materials for achieving sustainable construction. Buildings. 2024; 14(8):2569. https://doi.org/10.3390/buildings14082569

[3] Roy A, Shaik S. Investigation of the potential of repurposing waste disposals into concretes: mechanical properties, reduction in cooling/heating energy costs, and carbon exudation mitigation prospective. Environ Sci Pollut Res. 2025; 32: 21495–21521. https://doi.org/10.1007/s11356-025-36897-0

[4] Sau-Soto N, Lucero-Álvarez J, Borbón-Almada AC, Nájera-Trejo M, Rodríguez-Muñoz NA. Structural analysis for a slab-on-grade cellular concrete foundation to reduce heat losses in temperate climate residential buildings. Journal of Building Engineering. 2024; 91:109740. https://doi.org/10.1016/j.jobe.2024.109740

[5] AlSuwaidi N, Alfalasi S, Al Tayyari R, Al Buraimi K, AlQassimi M, Aidan A, Al-Asheh S. Silica Enrichment and Aerated Light Concrete for Sustainable Construction from Multiple Geographic Locations Within the UAE and UK. Buildings. 2025; 15(21):3869. https://doi.org/10.3390/buildings15213869

[6] Zhang J, Guo X, Tang X. Experimental and numerical simulation of seismic behavior of reinforced concrete frames infilled with refractory straw blocks. In Structures. 2024; 69:107475. https://doi.org/10.1016/j.istruc.2024.107475

[7] Celik A, Mercimek Ö, Akkaya ST, Bıçakçıoğlu K, Anıl Ö. A novel bond-slip model between TRM strips and different types of masonry walls: Experimental approach. Construction and Building Materials. 2025; 458:139595. https://doi.org/10.1016/j.conbuildmat.2024.139595

[8] Lisowski P, Glinicki MA. Promising biomass waste–derived insulation materials for application in construction and buildings. Biomass Conv. Bioref. 2025; 15:57–74. https://doi.org/10.1007/s13399-023-05192-8

[9] Hassan A, Alomayri T, Noaman MF. 3D Printed Concrete for Sustainable Construction: A Review of Mechanical Properties and Environmental Impact. Arch Computat Methods Eng. 2025; 32:2713–2743. https://doi.org/10.1007/s11831-024-10220-5

[10] Thienel K-C, Haller T, Beuntner N. Lightweight Concrete—From Basics to Innovations. Materials. 2020; 13(5):1120. https://doi.org/10.3390/ma13051120

[11] Bertino G, Kisser J, Zeilinger J, Langergraber G, Fischer T, Österreicher D. Fundamentals of Building Deconstruction as a Circular Economy Strategy for the Reuse of Construction Materials. Applied Sciences. 2021; 11(3):939. https://doi.org/10.3390/app11030939

[12] Qadir G, Rashid Y, Hassan A, Vall E, Saleh S, Salim K. Development and Mechanical Testing of Porous-Lightweight Geopolymer Mortar. Buildings. 2021; 11(1):1. https://doi.org/10.3390/buildings11010001

[13] Zajac M, Kuzniar K, Tatara T. Effect of Load-Bearing Wall Material on Building Dynamic Properties. Materials. 2024; 17(24): 6101. https://doi.org/10.3390/ma17246101

[14] Hassan HZ, Saeed NM. Advancements and applications of lightweight structures: a comprehensive review. Discov Civ Eng. 2024; 1:47. https://doi.org/10.1007/s44290-024-00049-z

[15] Yeo S J, Oh M J, Yoo P J. Structurally controlled cellular architectures for high-performance ultra-lightweight materials. Advanced Materials. 2019; 31(34):1803670. https://doi.org/10.1002/adma.201803670

[16] Tao L, Shi C, Ding P. A study on bearing characteristic and failure mechanism of thin-walled structure of a prefabricated subway station. Front. Struct. Civ. Eng. 2022; 16:359-377. https://doi.org/10.1007/s11709-022-0816-2

[17] Costantino C, Bigiotti S, Marucci A, Gulli R. Long-Term Comparative Life Cycle Assessment, Cost, and Comfort Analysis of Heavyweight vs. Lightweight Construction Systems in a Mediterranean Climate. Sustainability. 2024; 16(20):8959. https://doi.org/10.3390/su16208959

[18] Jelčić Rukavina M, Skejić D, Kralj A, Ščapec T, Milovanović B. Development of Lightweight Steel Framed Construction Systems for Nearly-Zero Energy Buildings. Buildings. 2022; 12(7):929. https://doi.org/10.3390/buildings12070929

[19] Santos P, Lopes P, Abrantes D. Thermal Performance of Load-Bearing, Lightweight, Steel-Framed Partition Walls Using Thermal Break Strips: A Parametric Study. Energies. 2022; 15(24):9271. https://doi.org/10.3390/en15249271

[20] Wei R, Sakai Y. Improving the properties of botanical concrete based on waste concrete, wood, and kraft lignin powder. Powder Technology. 2022; 397:117024. https://doi.org/10.1016/j.powtec.2021.11.068

[21] Wang L, Wang Y, Zhang J, Wang F, Liu Z, Jiang J. Investigation on self-healing polyurethane coating doped with lignin composites for protecting cementitious materials. Construction and Building Materials. 2024; 411:134368. https://doi.org/10.1016/j.conbuildmat.2023.134368

[22] Dyussembinov D, Lukpanov R, Altynbekova A, Zhantlesova Z, Awwad T. Effect of soapstock in the composition of modified additive for improving strength characteristics of concrete structures. Kompleksnoe Ispolzovanie Mineralnogo Syra= Complex use of mineral resources. 2025; 334(3):37-50. https://doi.org/10.31643/2025/6445.26

[23] Kozhas A, Kozhasov S. Fine-grained concrete for repair and restoration based on complex modifiers. Technobius. 2023; 3(2):0038. https://doi.org/10.54355/tbus/3.2.2023.0038

[24] GOST 310.4–2012 Cements. Methods for determining consistency, setting time and soundness. Moscow: Standartinform. 2013.

[25] GOST 56587–2015 Concrete mixtures. Methods for determining workability. Moscow: Standartinform. 2016.

[26] Lukpanov R, Dyussembinov D, Altynbekova A, Yenkebayev S, Zhumagulova A. Investigation of Effect of proposed two-stage foam injection method and modified additive on workability of Foam concrete. Materials. 2024; 17(9):024. https://doi.org/10.3390/ma17092024

[27] Sartaev DT, Orynbekov YS, Baisarieva AM, Uxikbayeva DA. Influence of additives and temperature regime on the setting kinetics and strength of foamed concrete. Kompleksnoe Ispolzovanie Mineralnogo Syra= Complex use of mineral resources. 2027; 340(1):5-16. https://doi.org/10.31643/2027/6445.01

[28] Abdyrov A, Niyazbekova P, Serekbayev H, Ibrayeva Ж, Shansharova Л, Ospanova H, Aldabergenova C. The effect of ash and slag waste on the setting time of cement dough and paste. Bulletin of L.N. Gumilyov Eurasian National University Technical Science and Technology Series. 2023; 145(4):98–110. https://doi.org/10.32523/2616-7263-2023-145-4-98-110