AcademyGate Publishing
p-ISSN 2790-0029; e-ISSN 2790-0037

THE INFLUENCE OF TRASS ON THE PROPERTIES OF PORTLAND CEMENT-BASED DRY CONSTRUCTION MIXES

Yasin Khalilov[1]
Jalaladdin Valiyev[2]
Vasif Shahmarov[3]

UDC: 666.942.017:666.952
LBC: 35.45:38.33
HoS: 126
doi: 10.33864/2790-0037.2026.v7.i1.19-28

Keywords:

Trass,
Pozzolan,
Dry construction mix,
Adhesion,
Moisture sorption,
Portland cement

ABSTRACT

This study comprehensively investigates the effect of volcanic trass (tuff) on the fundamental properties of Portland cement–based dry construction mixes. X-ray phase analysis revealed a high content (81%) of the active glassy phase in its composition, confirming its high pozzolanic potential. The research demonstrated that replacing 10–15% of the quartz sand by weight in the mix with finely ground trass significantly improves the technological properties of the material. In particular, the workable life (setting time) of the mortar increased from 8 to 11 hours, and its plasticity was enhanced.

The results of mechanical tests indicate that although the addition of trass leads to a certain reduction in the strength of the hardened mortar at the early stage (7 days), these values are restored after 28 days of curing or even exceeded when an optimal content (15%) is used. This behavior is associated with the gradual development of pozzolanic reactions and the formation of additional calcium silicate hydrate (C–S–H) phases due to the binding of free calcium hydroxide ($Ca(OH)_2$). One of the most significant positive effects of trass is a 22–26% increase in adhesion strength to the surfaces of various construction materials (concrete, ceramics, and natural stone).

In addition, the moisture-regulating capacity of the material increases substantially: at a relative humidity of 90%, the sorption moisture content rises from 1.5% to 3.2% (approximately twofold). This enables the effective use of the developed mortar in high-humidity environments, such as bathrooms and basements.

Consequently, the use of Kemerli trass at a content of 10–15% as a pozzolanic additive replacing quartz sand in dry construction mixes is recommended. This not only provides improved workability and high adhesion properties but also makes the mortar a promising functional material for applications under humid conditions.

[1] Doctor of Philosophy in Technology, Associate Professor,
Department of Design, Faculty of Architecture and Construction, Baku Engineering University; Khirdalan, Azerbaijan
E-mail: yxalilov@beu.edu.az
https://orcid.org/0000-0001-6251-7556
[2] Doctor of Philosophy in Technology,
Faculty of Architecture and Construction, Baku Engineering University; Khirdalan, Azerbaijan
E-mail: cavaliyev@beu.edu.az
https://orcid.org/0009-0003-3982-4154
[3] Department of Materials Science, Azerbaijan University of Architecture and Construction; Baku, Azerbaijan
E-mail: vshahmarov@gmail.com

To cite this article: Khalilov, Y., Valiyev, J., & Shahmarov, V. [2026]. The Influence of Trass on the Properties of Portland Cement-Based Dry Construction Mixes. *History of Science journal*, *7*(1), pp.19-28.
https://doi.org/10.33864/2790-0037.2026.v7.i1.19-28

Article history:
Received: 17.12.2025
Revised: 19.01.2026
Accepted: 01.03.2026
Published: 15.03.2026

TRASIN SEMENT ƏSASLI QURU İNŞAAT QARIŞIQLARININ XASSƏLƏRİNƏ TƏSİRİ

Yasin Xəlilov[1]
Cəlaləddin Vəliyev[2]
Vasif Şahmarov[3]

UOT: 666.942.017:666.952
KBT: 35.45:38.33
HoS: 126
doi: 10.33864/2790-0037.2026.v7.i1.19-28

Açar sözlər:

Tras,
Pozzolan,
Quru qarışıq,
Yapışma,
Nəm sorbsiyası,
Portlandsement

ANNOTASİYA

Bu tədqiqat işində vulkanik tras süxurunun (tras) portlandsement əsaslı quru inşaat qarışıqlarının əsas xassələrinə təsiri hərtərəfli öyrənilmişdir. Rentgen-faza analizi nəticəsində tərkibində yüksək miqdarda (81%) aktiv şüşə fazanın olması aşkar edilmişdir ki, bu da onun yaxşı putsolan potensialını təsdiq edir. Tədqiqat zamanı müəyyən edilmişdir ki, qarışığın tərkibindəki kvars qumunun çəkisinin 10-15%-ni incə üyüdülmüş tras ilə əvəz etmək materialın texnoloji xassələrini əhəmiyyətli dərəcədə yaxşılaşdırır. Xüsusilə, məhlulun işlək vəziyyətdə qalma müddəti (tutma müddəti) 8 saatdan 11 saata qədər uzamış, plastikliyi artmışdır.

Mexaniki sınaqların nəticələri göstərir ki, tras əlavəsi ilkin mərhələdə (7 gün) bərkimiş məhlulun möhkəmliyində müəyyən azalma səbəb olsa da, 28 günlük bərkimədən sonra bu göstəricilər bərpa olunur və ya optimal (15%) miqdarda əlavə zamanı hətta keçə bilir. Bu, putsolan reaksiyalarının tədricən baş verməsi və sərbəst kalsium hidroksidin ($Ca(OH)_2$) bağlanması nəticəsində əlavə kalsium-silikat-hidrat (CSH) fazalarının əmələ gəlməsi ilə bağlıdır. Trasın ən əhəmiyyətli müsbət təsirlərindən biri müxtəlif tikinti materiallarının (beton, keramika, təbii daş) səthinə yapışma gücünün 22-26% artmasıdır. Bundan əlavə, materialın rütubət-idarəedici funksiyası kəskin yüksəlir: 90% nisbi rütubətli mühitdə sorbsion nəm qabiliyyəti 1.5%-dən 3.2%-ə qədər (təxminən 2 dəfə) artır. Bu, hazırlanmış məhlulun yüksək rütubətli mühitlərdə (vanna otaqları, zirzəmilər) effektiv istifadəsinə imkan verir.

Nəticə etibarilə, Kəmərli trasının 10-15% miqdarında quru inşaat qarışığı tərkibində kvars qumu əvəzinə putsolan əlavə kimi istifadə edilməsi tövsiyə olunur. Bu, məhlula nəinki yaxşı işlənmə və yüksək yapışma xassələri verir, həm də onu nəmli şəraitdə tətbiq üçün perspektivli funksional materiala çevirir.

[1] Texnika üzrə fəlsəfə doktoru, Dosent,
Dizayn kafedrası, Memarlıq və İnşaat fakultəsi, Bakı Mühəndislik Universiteti; Xırdalan, Azerbaycan
E-mail: yxalilov@beu.edu.az
https://orcid.org/0000-0001-6251-7556
[2] Texnika üzrə fəlsəfə doktoru,
Memarlıq və İnşaat fakultəsi, Bakı Mühəndislik Universiteti; Xırdalan, Azərbaycan
E-mail: cavaliyev@beu.edu.az
https://orcid.org/0009-0003-3982-4154
[3] Materialşunaslıq kafedrası, Azərbaycan Memarlıq və İnşaat Universiteti; Bakı, Azerbaycan
E-mail: vshahmarov@gmail.com

Məqaləyə istinad: Xəlilov, Y., Vəliyev, C., & Şahmarov, V. [2026]. Trasın Sement Əsaslı Quru İnşaat Qarışıqlarının Xassələrinə Təsiri. *History of Science jurnalı*, *7*(1), səh.19-28.
https://doi.org/10.33864/2790-0037.2026.v7.i1.19-28

Məqalənin tarixçəsi:
Daxil olub: 17.12.2025
Yenidən baxılıb: 19.01.2026
Təsdiqlənib: 01.03.2026
Dərc olunub: 15.03.2026

ВЛИЯНИЕ ТРАССА НА СВОЙСТВА СУХИХ СТРОИТЕЛЬНЫХ СМЕСЕЙ НА ОСНОВЕ ПОРТЛАНДЦЕМЕНТА

Ясин Халилов[1]
Джаладдин Валиев[2]
Васиф Шахмаров[3]

УДК: 666.942.017:666.952
ББК: 35.45:38.33
HoS: 126
doi: 10.33864/2790-0037.2026.v7.i1.19-28

Ключевые слова:

Трасс,
Пуццолан,
Сухие строительные смеси,
Адгезия,
Сорбция влаги,
Портландцемент

АННОТАЦИЯ

В данной работе всесторонне исследовано влияние вулканического трасса на основные свойства сухих строительных смесей на основе портландцемента. В результате рентгенофазового анализа установлено наличие высокого содержания активной стеклообразной фазы (81%), что подтверждает высокий пуццолановый потенциал данного материала. В ходе исследования выявлено, что замещение 10–15% массы кварцевого песка в составе смеси тонкоизмельчённым трассом приводит к существенному улучшению технологических свойств материала. В частности, время сохранения работоспособного состояния раствора увеличивается с 8 до 11 часов, а также повышается его пластичность.

Результаты механических испытаний показывают, что, несмотря на некоторое снижение прочности затвердевшего раствора на ранней стадии (7 суток) при введении трасса, после 28 суток твердения данные показатели восстанавливаются либо даже превышают исходные значения при оптимальном содержании добавки (15%). Это обусловлено постепенным протеканием пуццолановых реакций и образованием дополнительных фаз гидросиликатов кальция (C–S–H) в результате связывания свободного гидроксида кальция ($Ca(OH)_2$). Одним из наиболее значимых положительных эффектов применения трасса является увеличение прочности сцепления с поверхностями различных строительных материалов (бетон, керамика, природный камень) на 22–26%.

Кроме того, существенно возрастает влагорегулирующая способность материала: при относительной влажности воздуха 90% сорбционная влажность увеличивается с 1,5% до 3,2% (примерно в 2 раза). Это обеспечивает возможность эффективного применения разработанного раствора в условиях повышенной влажности (ванные комнаты, подвальные помещения).

В результате рекомендуется использовать трасс месторождения Кемерли в количестве 10–15% в составе сухих строительных смесей в качестве пуццолановой добавки взамен кварцевого песка. Это не только обеспечивает улучшенную удобоукладываемость и высокие адгезионные свойства раствора, но и делает его перспективным функциональным материалом для применения в условиях повышенной влажности.

[1] Доктор философии по техническим наукам, Доцент,
Кафедра дизайна архитектурно-строительного факультета Бакинского инженерного университета; Хырдалан, Азербайджан
E-mail: yxalilov@beu.edu.az
https://orcid.org/0000-0001-6251-7556
[2] Доктор философии по техническим наукам,
Факультет архитектуры и строительства, Бакинский инженерный университет; Хырдалан, Азербайджан
E-mail: cavaliyev@beu.edu.az
https://orcid.org/0009-0003-3982-4154
[3] Кафедра материаловедения, Азербайджанский университет архитектуры и строительства; Баку, Азербайджан
E-mail: vshahmarov@gmail.com
Цитировать статью: Халилов, Я., Валиев, Дж., & Шахмаров, В. [2026]. Влияние трасса на свойства сухих строительных смесей на основе портландцемента. *Журнал History of Science, 7*(1), с.19-28.
https://doi.org/10.33864/2790-0037.2026.v7.i1.19-28

История статьи:
Поступила: 17.12.2025
Переработана: 19.01.2026
Принята: 01.03.2026
Опубликована: 15.03.2026

1.Introduction

The use of ready-mixed dry construction mixes in modern construction practice is steadily increasing [Játiva et al., 2022]. Their main advantage lies in ensuring a stable composition and consistent quality under precise control during the production process. Such mortars typically consist of a binder (e.g., Portland cement), a filler (quartz sand), and special modifiers that regulate workability properties [Bajenov, 2011].

With increasing market demands, the development of new types of dry mixes suitable for application in areas with high humidity and strict sanitary requirements (bathrooms, basements, kitchens) has become particularly relevant. Such materials should possess not only sufficient mechanical strength but also additional functionalities, such as antifungal activity and moisture regulation. For this purpose, the use of pozzolanic active additives, which enter into secondary reactions with cement hydration products and thereby increase the density and durability of the material, is considered effective [Meçay et al., 2012]. In this study, the effectiveness of trass from the Kemerli deposit in Azerbaijan as such a pozzolanic additive is investigated.

The mechanism of pozzolanic activity primarily involves the binding of free calcium hydroxide ($Ca(OH)_2$), released during the hardening of the binder, with silicon and aluminum oxides, resulting in the formation of additional strong and durable hydration products [Nikolayenko, 2014]. As a result of this process, the pore structure of the material becomes more refined, its resistance to chemical effects is enhanced, and strength development continues over time [Hossain, 2005]. In addition, finely dispersed pozzolanic particles, due to their moisture absorption capacity, are capable of temporarily regulating the moisture balance of the surrounding environment [Berry & Malhotra, 1980].

In cement systems containing pozzolanic additives, the initial hardening process begins as a result of the interaction between the main cement phases and water. This interaction leads to the formation of calcium hydroxide ($Ca(OH)_2$), high-basic calcium silicates, as well as calcium aluminate and ferrite hydrates [Taylor, 1997]. The reactive amorphous silicon and aluminum oxides (SiO_2 and Al_2O_3) present in the mineral pozzolanic additive subsequently enter into secondary reactions with these initial hydration products, particularly with free calcium hydroxide (lime) [Massazza, 1998]. This process reduces the concentration of calcium ions in the liquid phase of the system, resulting in the formation of more stable and less basic calcium silicate hydrate (C–S–H) phases, such as tobermorite-like compounds [Lothenbach et al., 2011].

At the same time, high-basic calcium aluminate hydrates react with active SiO_2 to form calcium aluminosilicate hydrates (for example, stratlingite or hydrogarnet-type compounds). These compounds, especially in the presence of sulfate ions, enhance the resistance of cement systems to sulfate attack [Shi & Day, 2001]. The binding of calcium hydroxide by pozzolanic particles significantly reduces the amount of free lime present in the mortar. This, in turn, leads to increased durability of mortars or concretes produced using pozzolan-modified cements when exposed to the destructive effects of fresh and mineral waters [Mehta & Monteiro, 2014].

Highly dispersed pozzolanic particles possess a large number of active surface sites. This not only increases their chemical reactivity but also enables them to exhibit high sorption (e.g., hygroscopic) capacity [Snellings et al., 2012]. Thus, pozzolans play an important role not only in the chemical reactions that modify the composition of the binder matrix but also in regulating moisture within the system. They can absorb additional moisture, facilitating the continuation of hydration processes, or temporarily retain excess moisture, thereby regulating ambient relative humidity. Moreover, the participation of water surrounding pozzolanic particles in chemical reactions causes a slight increase in their volume (swelling), which contributes to greater density and compaction of the hardened matrix. The resulting denser structure hinders the penetration of aggressive media (salts, acids) into the material and thus ensures long-term durability [Neville, 2011].

2.Experimental Methodology

Since the activity of the additive determines its dosage, the activity of Kemerli trass was first determined using the lime absorption method from a standard lime solution [ASTM C618, 2022; European Committee for Standardization, 2012]. The activity of the trass was found to be 82 mg CaO/g. The chemical composition of the trass was analyzed using an S8 TIGER spectrometer (Bruker, Germany) [Table 1], while its mineralogical composition was examined using a Miniflex 600 X-ray diffractometer (Rigaku, Japan) with a copper anode [Figure 1; Table 2]. According to the results of X-ray phase analysis, the mineral composition of the Kemerli trass used in the study is mainly represented by an active glassy phase (81%), feldspar (8%), and quartz (8%). The high content of the glassy phase further confirms the high activity of the trass.

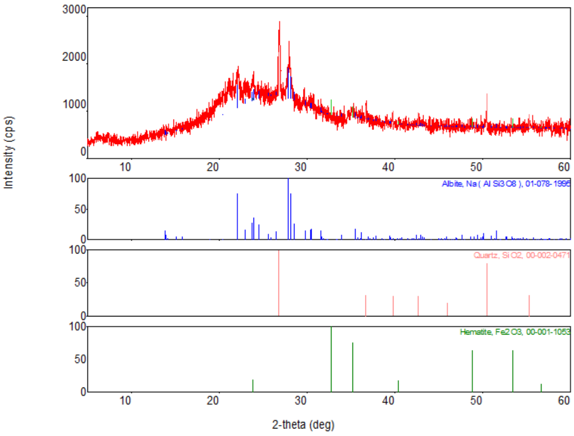

Figure 1. *Diffractogram of the trass.*

Kemerli Trass	*Kemerli Trass Mineralogical Composition of Kemerli Trass, mass %*				
	Quartz	Feldspar	Hematite	Volcanic glass	Total
	8	8	3	81	100

Table 1. *Mineralogical Composition of the trass*

Kemerli Trass	*Chemical Composition of Kemerli Trass, mass %*							
	Na_2O	MgO	Al_2O_3	SiO_2	K_2O	CaO	FeO	Total
	3,72	1,15	14,65	70,68	3,95	2,60	3,25	100

Table 2. *Chemical Composition of the trass*

The base dry mix formulation (40% Portland cement, 59% quartz sand, and 1% polymer modifiers) was modified by adding finely ground trass in amounts of 5%, 10%, 15%, and 20% by weight relative to the quartz sand. The workability properties of the obtained mixes (normal consistency, setting time, and density), adhesion strength to various surfaces (concrete, ceramic, and stone), and moisture sorption capacity after hardening were determined using standard methods.

3.Discussion of Research Results

To determine the optimal amount of trass in dry mixes, finely dispersed trass (in our experiments, the residue on the 0.8 mm sieve did not exceed 15%) was introduced into the adopted Portland cement–based dry mix composition (Portland cement 42.5 MPa (Garadag Holcim cement plant) – 40%, quartz sand – 59%, polymer additive – 0.8%, cellulose additive – 0.2%) in amounts of 5%, 10%, 15%, and 20% as a replacement for quartz sand. Subsequently, X-ray phase analysis of the hydration products was carried out, and the content of free CaO was determined.

The results of the analyses showed that replacing quartz sand with trass beyond the 10–15% range is not expedient. Above this interval, no further reduction in the content of free CaO is observed. At the same time, the granulometric composition of the system is disturbed, which negatively affects the mechanical properties of the hardened coating [Table 3; Table 4].

Port-land cement, %	**Quartz sand, %**	**Trass, %**	**Normal consistency, %**	**Open time**		**Plasticity, cm**	**Mortar density, kg/m³**
				Initial, min	**Final, hour**		
40	59	-	27	48	8	8	1790
40	54	5	28	53	9	8	1787
40	49	10	30	60	10	9	1780
40	44	15	31	68	11	9	1776
40	39	20	34	73	13	9	1770

Table 3. *Technological Properties of Dry Mixes with Trass Additive* [ASTM C230/C230M, 2021]

Portland cement, %	**Quartz sand, %**	**Trass, %**	**% CaO content in 7-day hydration product**	**Flexural strength limit, MPa**			**Compressive strength limit, MPa**		
				7-day	**14-day**	**28-day**	**7-day**	**14-day**	**28-day**
40	59	-	5,4	0,85	1,70	2,50	10,2	12,6	16,5
40	54	5	3,8	0,78	1,68	2,50	10,0	12,2	16,4
40	49	10	2,0	0,76	1,65	2,44	9,8	12,5	16,4
40	44	15	0,7	0,75	1,64	2,53	9,5	12,2	16,4
40	39	20	0,7	0,75	1,60	2,52	8,4	12,2	15,6

Table 4. *Strength of Construction Mortars Based on Dry Construction Mixes Containing Volcanic Ash (on a Dense-Structured Substrate)*

Based on Table 3, as the trass content increased, the normal consistency of the mortar gradually rose from 27% to 34%. This increase can be attributed to the finer, dispersed trass particles having a larger specific surface area than quartz sand, which leads to higher water demand. An extension in the workable life (setting time) of the mortar was also observed: the initial setting time increased from 40 to 65 minutes, and the final setting time extended from 8 to 13 hours. This is particularly beneficial for large-area applications, as it facilitates easier handling of the mortar. A slight increase in the plasticity index (from 8 cm to 9 cm) was also recorded. However, due to the high water demand of trass and the increase in its fine fraction, a minor decrease in the density of the fresh mortar (from approximately 1800 kg/m³ to 1775 kg/m³) was observed.

The strength results presented in Table 4 reflect the characteristic behavior of pozzolanic additives. After seven days of curing, an increase in trass content led to a decrease in both flexural strength (from 0.85 MPa to 0.75 MPa) and compressive strength (from 10.2 MPa to 8.4 MPa). This is because, in the early stages, cement hydration plays the primary role in strength development, while pozzolanic reactions of trass have not yet fully progressed. This assumption is confirmed by the sharp reduction in free CaO content in the 7-day hydration product (from 5.4% to 0.7%), indicating that trass had already begun actively binding free calcium hydroxide.

However, after 28 days of curing, the situation changes. Flexural and compressive strength values converge for all compositions and, in the sample with 15% trass addition, can even slightly exceed the initial composition values (flexural strength: 2.50 MPa vs. 2.53 MPa; compressive strength: 16.5 MPa vs. 16.4 MPa). This trend is associated with the contribution of pozzolanic reactions over time: the binding of CaO results in the formation of additional calcium-silicate-hydrate (CSH) phases and increased matrix density, enhancing long-term strength.

Consequently, considering the deterioration of granulometric composition (reduction of the coarse filler fraction) and the excessive drop in early-age strength for trass additions above 15%, it can be concluded that the optimal replacement range is 10–15%. Within this range, the mortar retains favorable workability while long-term mechanical properties improve.

One of the most significant positive effects of trass is the increase in adhesion strength to the surfaces of various construction materials. In particular, the formulation containing 15% trass demonstrated significantly higher adhesion on ceramic and natural stone substrates [Table 5]. This can be attributed to the better penetration of finely dispersed trass particles into minor surface irregularities, resulting in a denser physico-chemical bond.

Portland cement, %	**Quartz sand, %**	**Trass, %**	**Adhesion, MPa**								
			Concrete substrate			**Ceramic brick substrate**			**Sawn stone substrate**		
			7-day	**14-day**	**28-day**	**7-day**	**14-day**	**28-day**	**7-day**	**14-day**	**28-day**
40	59	-	1,8	1,9	2,7	2,1	2,6	3,3	1,9	1,9	3,1
40	54	5	1,9	2,0	2,9	2, 1	2,7	3,7	15,8	2,0	3,5
40	49	10	2,1	2,3	3,2	2,3	3,2	3,9	15,7	2,5	3,7
40	44	15	2,2	2,7	3,3	2,6	3,4	4,1	15,6	2,8	3,9
40	39	20	2,1	2,7	3,2	2,6	3,3	3,8	15,2	2,8	3,6

Table 5. *Adhesion of Trass-Modified Construction Mortars to Substrates of Various Natures after 28 Days of Curing in Dry Air Conditions, MPa* [European Committee for Standardization, 1999].

4.Comparison of Results Across Different Substrate Materials

An increase in adhesion strength was observed for all three substrates (concrete, ceramic brick, and sawn stone), although the degree of increase varies depending on the substrate [Silva et al., 2020]. The highest absolute increase and most effective results were obtained on the *ceramic brick* substrate. After 28 days of curing, the formulation with 15% trass addition exhibited an adhesion strength of 4.1 MPa, approximately 24% higher than that of the additive-free composition (3.3 MPa). This difference can be explained by the relatively porous and hydrophilic surface of ceramic, which allows better wetting by the finely dispersed trass particles and enhances physico-chemical interactions.

Adhesion strength also increased significantly on the *sawn stone* substrate (from 3.1 MPa to 3.9 MPa, approximately 26%), likely due to good mechanical interlocking of trass particles with the natural rough surface of the stone.

Although the increase on the *concrete* substrate was comparatively smaller (from 2.7 MPa to 3.3 MPa, approximately 22%), it remains notable. Better adhesion is expected with ceramic and sawn stone than with dense, smooth-surfaced concrete.

5.Mechanism explanation

The observed increase in adhesion strength can be attributed to several factors:

1. Compared to coarse quartz sand fractions, finely dispersed trass particles penetrate deeper into microscopic imperfections and pores of the substrate surface, creating a “keying” effect and strengthening the mechanical bond.
2. The pozzolanic activity of trass occurs not only in the bulk but also at the substrate-mortar interface. Free $Ca(OH)_2$ released during cement hydration can react with both the silicon/aluminum oxides in trass and surface atoms of some substrates, contributing to stronger chemical bonds at the interface.
3. Trass addition helps the mortar achieve a lighter and more homogeneous structure, reducing voids at the contact area and increasing the contact surface with the substrate.

The table data indicate that adhesion strength reaches its maximum with 15% trass addition. A slight decrease is observed with 20% addition, likely due to excessive particle density and further deterioration of the granulometric composition. Consequently, for applications requiring high adhesion (e.g., tile adhesives, repair mortars), a 10–15% trass replacement is considered optimal.

These results confirm that trass positively affects not only strength but also functional qualities that ensure reliable bonding of mortar with structural elements.

Finally, based on the pozzolanic nature and high dispersity of trass, its moisture absorption capacity was evaluated. Experiments showed that trass addition increases the moisture retention of hardened mortar in a high relative humidity environment (90%) by 2–3 times. This indicates that the mix could help regulate ambient moisture fluctuations when used as a wall coating in humid rooms. The performance of the studied construction mortars under humid conditions was evaluated according to their sorption moisture capacity in accordance with GOST 24816-81.

Portland cement, %	**Quartz sand, %**	**Trass, %**	**Sorption moisture at 90% relative air humidity, %**
40	59	-	1,5
40	54	5	2,5
40	49	10	2,8
40	44	15	3,2
40	39	20	3,4

Table 6. *Sorption Moisture of Hardened Construction Mortars*

Results [Table 6] show that replacing the quartz sand in the composition with trass leads to a sharp increase in the amount of moisture the material can sorb in a 90% relative humidity environment. The sorption moisture of the initial, trass-free formulation is 1.5%. With a 5% trass addition, this indicator rises to 2.5%, and with 15% trass, it reaches 3.2%. A maximum sorption moisture of 3.4% was recorded with a 20% addition. This represents an approximate 2.3-fold increase.

This significant rise in sorption capacity is directly related to the physico-chemical nature of trass [Woloszyn & Rode, 2008]:

1. Finely dispersed and amorphous-structured trass particles possess a much larger internal and external surface area compared to quartz sand. This provides them with more active centers for absorbing and retaining atmospheric moisture.
2. The additional hydration products (CSH phases) formed as a result of pozzolanic reactions lead to the creation of finer and more numerous capillary pores within the cement

matrix. These micropores create ideal conditions for moisture sorption through capillary condensation.

3. The hydrophilic properties of the amorphous silicon and aluminum oxides in the trass composition further enhance its ability to attract water molecules.

The substantial increase in sorption moisture indicates that coatings produced from trass-modified dry mixes can act as a kind of natural "moisture regulator." This creates a number of practical advantages:

– In high-humidity environments (bathrooms, basements, kitchens), the wall coating can absorb excess moisture, preventing an excessive rise in ambient relative humidity. When humidity decreases, it gradually releases the sorbed moisture, protecting the environment from drying out.

– Reducing surface moisture condensation lowers the risk of moisture freezing and spalling within the wall and creates unfavorable conditions for the development of mold spores.

– Active moisture management improves the overall hygienic condition of the room and enhances living comfort.

Table 6 shows that the increase in sorption moisture is nearly linear with the increase in trass content. However, as discussed in previous sections, replacement above 15% requires certain compromises in other technological and mechanical properties. Therefore, for applications requiring high moisture regulation, a 10-15% trass replacement also provides an optimal balance.

6.Conclusion

Thus, Kemerli trass not only improves mechanical strength and adhesion but also comprehensively enhances the performance qualities of the material by imparting an active moisture-regulating function. This transforms it into a valuable local raw material resource for developing a new generation of environmentally friendly and functional dry construction mixes intended for humid environments.

The research results demonstrate that Kemerli trass can be used as an effective and prospective pozzolanic additive in Portland cement-based dry construction mixes. Specifically, trass replacing 10-15% of quartz sand improves the workability quality and adhesion strength of the mortar, while also increasing the moisture sorption capacity of the hardened product. This provides a basis for recommending it as a constituent component of a new generation of functional dry mixes designed for use under conditions of high humidity.

7.REFERENCES

1. ASTM International. (2022). *ASTM C618-22: Standard specification for coal fly ash and raw or calcined natural pozzolan for use in concrete*. ASTM International. (in English)
2. ASTM International. (2021). *ASTM C230/C230M-21: Standard specification for flow table for use in tests of hydraulic cement*. ASTM International. (in English)
3. Bajenov, Y. M. (2011). *Technology of dry building mixtures*. Assotsiatsii stroitelnikh vuzov. (in Russian)
4. Berry, E. E., & Malhotra, V. M. (1980). Fly ash for use in concrete—A critical review. *Journal of the American Concrete Institute, 77*(8), 59–73. (in English)
5. European Committee for Standardization. (1999). *EN 1542:1999. Products and systems for the protection and repair of concrete structures—Test methods—Measurement of bond strength by pull-off*. European Committee for Standardization. (in English)

6. European Committee for Standardization. (2012). *EN 450-1:2012. Fly ash for concrete—Part 1: Definition, specifications and conformity criteria*. European Committee for Standardization. (in English)

7. Gosstandart SSSR. (1981). *GOST 24816-81. Building materials. Method for determining sorption moisture*. Izd-vo standartov. (in Russian)

8. Hossain, K. M. A. (2003). Blended cement using volcanic ash and pumice. *Cement and Concrete Research*, *33*(10), 1601–1605. https://doi.org/10.1016/S0008-8846(03)00127-3 (in English)

9. Hossain, K. M. A. (2005). Volcanic ash and pumice as cement additives: Pozzolanic, alkali-silica reaction and autoclave expansion characteristics. *Cement and Concrete Research*, *35*(6), 1141–1144. (in English)

10. Játiva, A., Ruales, E., & Etxeberria, M. (2022). Volcanic ash as a sustainable binder material: An extensive review. *Materials*, *15*(7), Article 2492. https://doi.org/10.3390/ma15072492 (in English)

11. Korneev, V. I., Zozulya, P. V., Medvedeva, I. N., Bogoyavlenskaya, G. A., Nujdina, N. I., & Brykov, A. S. (2022). *Dry construction mix technology*. E-LanBook. (in Russian)

12. Lothenbach, B., Scrivener, K., & Hooton, R. D. (2011). Supplementary cementitious materials. *Cement and Concrete Research*, *41*(12), 1244–1256. (in English)

13. Massazza, F. (1998). Pozzolan and pozzolanic cements. In P. C. Hewlett (Ed.), *Lea's chemistry of cement and concrete* (4th ed., pp. 471–635). Butterworth-Heinemann. (in English)

14. Mechay, A. A. A., Xotyanovich, O. E., & Sakovich, A. A. (2012). *Hydrolysis and solid minerals of binding substances.* BGTU. (in Russian)

15. Mehta, P. K., & Monteiro, P. J. M. (2014). *Concrete: Microstructure, properties, and materials* (4th ed.). McGraw-Hill Education. (in English)

16. Neville, A. M. (2011). *Properties of concrete* (5th ed.). Pearson Education Limited. (in English)

17. Nikolayenko, E. A. (2014). Investigation of pozzolanic Portland cements based on effusive rocks. *Izvestiya vuzov. Stroitel'stvo*, *1*(6), 45–52. (in Russian)

18. Rosales, J., Rosales, M., Díaz-López, J. L., Agrela, F., & Cabrera, M. (2022). Effect of processed volcanic ash as active mineral addition for cement manufacture. *Materials*, *15*(18), Article 6305. https://doi.org/10.3390/ma15186305 (in English)

19. Sanjuan, M. Á., Frías, M., Monasterio, M., García-Giménez, R., Vigil de la Villa, R., & Álamo, M. (2023). Volcanic ash from La Palma (Canary Islands, Spain) as Portland cement constituent. *Journal of Building Engineering*, 78, 107641. https://doi.org/10.1016/j.jobe.2023.107641 (in English)

20. Shi, C., & Day, R. L. (2001). Acceleration of strength gain of lime-pozzolan cements by thermal activation. *Cement and Concrete Research*, *31*(6), 861–870. (in English)

21. Silva, L. H. P., Tamashiro, J. R., & Kinoshita, A. (2020). On the bonding properties of pozzolanic Portland cement mortars: Experimental and numerical analysis. *Construction and Building Materials*, 262, 120776. https://doi.org/10.1016/j.conbuildmat.2020.120776 (in English)

22. Snellings, R., Mertens, G., & Elsen, J. (2012). Supplementary cementitious materials. *Reviews in Mineralogy and Geochemistry*, *74*(1), 211–278. (in English)

23. Taylor, H. F. W. (1997). *Cement chemistry* (2nd ed.). Thomas Telford Publishing. (in English)

24. Woloszyn, M., & Rode, C. (2008). Tools for performance simulation of heat, air and moisture conditions of whole buildings. *Building Simulation*, *1*(1), 5–24. https://doi.org/10.1007/s12273-008-8116-x (in English)