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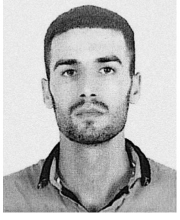
Adding waste to increase the water resistance of concrete in hydraulic structures

This research aimed at improving the durability of the concrete of hydraulic structures by adding waste and curing techniques in order to reduce water permeability. Concrete water permeability was determined using the «wet spot» method in accordance with Russian standard GOST 12730.5 («Concretes. Methods for determining water resistance»). The results showed increased grade of concrete for water resistance with the addition waste (glass, plastic and used engine oil) and curing techniques (polishing concrete surface and concrete vibration during pouring). Using waste in concrete contributes to reducing environmental pollution and solving waste disposal problems.

Keywords: water permeability, concrete, GOST 12730.5, waste, curing techniques.



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Добавление отходов для повышения водонепроницаемости железобетона в гидротехнических сооружениях

Данное исследование было направлено на повышение долговечности бетона гидротехнических сооружений за счет добавления отходов и технологии обработки с целью снижения водопроницаемости. Водопроницаемость бетона определялась методом «мокрого пятна» в соответствии со стандартом ГОСТ 12730.5 «Бетоны. Методы определения водонепроницаемости». Результаты показали повышение водонепроницаемости бетона за счет добавления отходов (стекла, пластика и отработанного моторного масла) и технологии обработки (полировка поверхности бетона и вибрация бетона во время заливки). Использование отходов в бетоне способствует снижению загрязнения окружающей среды и решению проблем утилизации отходов.

Ключевые слова: водонепроницаемость, бетон, ГОСТ 12730.5, отходы, технология обработки.

Introduction

Water resistance is crucial in hydraulic structures, with concrete being essential for their integrity and longevity [11; 26]. Dams, canals and other structures exposed to water pressure face environmental strains that can compromise efficiency, permeability significantly affects durability, controlling the rate of water and chemical infiltration, high permeability can lead to failures from freeze-thaw cycles and corrosion, exacerbated by chloride ions [3; 11]. There is a strong link between concrete permeability and its mechanical properties. High water permeability of concrete weakens structural integrity. Using low-permeability concrete is vital in designing hydraulic structures to resist cracking under loads and environmental impacts, ultimately extending lifespan and reducing maintenance costs [26].

One of the determining factors that establish the operational reliability and durability of hydraulic structures is the concrete water resistant. The ingress of water and aggressive substances is the primary reason for the chemical and physical degradation of concrete infrastructure, leading to a reduction in durability and a shortening of life span. The use of integral waterproofing admixtures has the potential to increase the service life and improve the durability of concrete structures and infrastructure. However, the admixtures may have a negative impact on some concrete properties, such as workability and strength [26]. To enhance water resistance in hydraulic infrastructures, careful material selection and treatment methods are essential. A key strategy involves optimizing the concrete composition, it was found that reducing the size of aggregates leads to a decrease in the coefficient of permeability of concrete [18], the lower water-cement ratio decreases permeability [3; 5; 6; 30]. Proper curing techniques are vital for achieving low permeability, improving the concrete surface by a polished surface increases the density of the concrete surface and reduces pores, which leads to high abrasion resistance [32], maintaining adequate moisture during curing significantly affects pore structure and hydration dynamics, influencing permeability rates [24; 30]. Moreover, the correct placement and consolidation of concrete are equally important. Adequate consolidation minimizes voids and prevents honeycombing, both of which can lead to heightened permeability issues. Strategies to ensure sufficient compaction include utilizing vibrators and closely monitoring compaction parameters [5; 20; 21; 30]. Incorporating chemical admixtures designed to reduce water permeability can further enhance moisture resistance. Crystalline admixtures create a barrier against water movement and provide self-healing properties for cracks [19; 26; 34], which lead to improving durability and extending the lifespan of concrete structures. In study [8], compositions of concrete composites with water tightness W16 and frost-resistance F300 have been developed with the use of expanding agents and complex of chemical additives. Innovative materials like «nano natural pozzolana» can significantly boost water resistance by filling microscopic voids [17; 26]. Adopting these best practices enables the creation of low-permeability concrete for hydraulic structures, enhancing their longevity.

Waste can be added to concrete to improve some of its properties, environmental sustainability and economic benefits. According to previous research studies [3; 5; 7; 9; 10] and also [24–26], it was found that the addition of supplementary cementitious materials like fly ash, silica fume slag to the concrete improved microstructural integrity of concrete and decreased permeability. The research [14] revealed that concrete made with high percentage of crude oil contamination by weight offered more resistance to water absorption and surface resistivity as an electrical indication of its permeability. That is, it resists sulphate and chloride ions penetrations into the concrete. In [13; 16] the porosity decreased and compressive strength of concrete was enhanced at 1% oil contamination due to the sand reaching optimum cohesion as a result of oil binding sand particles. In [31] the water permeability parameters of concrete samples were significantly improved when added black olive oil at percentages of 0.3%, 0.5%, 0.7% and 1% by weight of cement content. The add used engine oil 2% by weight of cement in concrete exhibited a progressive increase in compressive strength over time and demonstrated a decreased susceptibility to chloride penetration and enhanced fire performance [22]. The results in [27] indicate that the addition of cooking oil waste emulsions reduced the total porosity and refined the pore size of concrete and increase in compressive strength. The research [11] has confirmed the assumption that the introduction into the concrete mix of organo-mineral modifier consisting of a polycarboxylate superplasticiser and fine ash of rice husk, up to 90% consisting of amorphous silica, will increase the

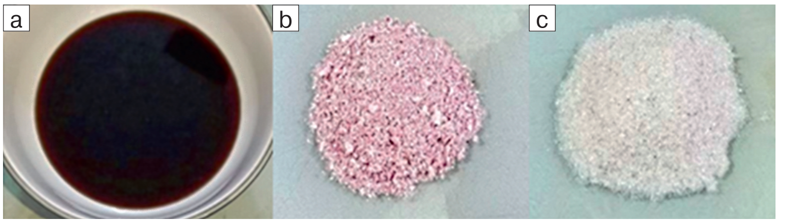

Illustration 1. Waste used in the concrete mixtures (*a*) used engine oil UEO, (*b*) PVC plastic waste, (c) glass waste. Author A. W. R. Razzaq

density of hydraulic concrete structure, which will increase their strength, water resistance and reduce permeability for chloride ions. In [2] the use of textile concrete products, including concrete sheets led to development of a composite binder containing components that reduce negative pressure in hardening concrete, and consequently shrinkage and cracking, has made it possible to obtain products with the following water resistance indicators: 1.2 MPa, determined by the «wet spot» method; W12 grade of concrete for water resistance. In [1] the use of additives to seal the capillary-porous structure of concrete makes it possible to increase the physico-mechanical characteristics of the composite, thereby increasing its resistance to moisture penetration. The simultaneous use of a penetrating additive and 3% fibers makes it possible to increase the strength and water resistance of concrete, thereby increasing its density and resistance to moisture penetration. The study [4] shows that adding used clay of oil production to concrete increases their waterproofing qualities and reduces water absorption. The use of glass waste in concrete increases workability due to its smooth surface. The hydrophobic nature of waste glass leads to a significant decrease in the permeability of waste glass used concrete. An increase in the waste glass content causes a decline in the compressive strength of concrete [15; 23; 30]. The study [33] showed that used oils can be used as release for steel molds used in the production of concrete elements. In [20], concrete samples with solvent-based mold oil resisted water absorption. In the study [12], a low-viscosity lubricant based on domestic solvents and oils is used to lubricate the mold and reduce of concrete surface porosity. In [28] up to 30% of normal fine aggregate of concrete can be replaced with plastic waste PVC without scarifying the strength, density and water absorption of concrete.

Hence the importance of this research in investigating the impact of adding waste to improve the water resistance of concrete, including used engine oil, waste glass, plastic waste as well as applying some concrete curing techniques, as they contribute to reducing environmental pollution in line with sustainable development goals. In the experimental test to determine the water resistance of concrete, the «wet spot» method is used in accordance with Russian standard GOST 12730.5 «Concretes. Methods for determining water resistance» [2; 3; 11].

Materials and methods

Concrete mixture is designed to for concrete B30 (also known as M400) production, it is one of the most popular classes of concrete used in hydraulic structures with compressive strength of 30MPa (at 28 days). Portland cement was used as the main binder. Gravel of 5–10 mm was used as a coarse aggregate, and sand was used as a fine aggregate. Ordinary water was used in the preparation of mixtures in this research, as well as it was used in the curing of concrete samples. The used engine oil UEO was used as an additive to the concrete mix, where it was collected from local mechanical car service station. PVC aggregate used in this study was prepared from PVC plastic waste. After crushing by using a small electrical crusher, the maximum size of PVC was 1 mm. Glass aggregate used in this study was prepared from glass waste. After crushing by using a small electrical crusher, the maximum size of glass was 1 mm (Illustration 1).

Both the fine and coarse aggregates were spread out on neat concrete floor to dry out, so as not to influence the concrete strength and water resistance testing which depend on concrete components as a result of increase in water-cement ratio of the concrete. Concrete mixtures were prepared according to Table 1, concrete Mix 1 was without any additives and it represents the ordinary concrete. In concrete Mix 2 and Mix 3 crushed glass waste and crushed PVC plastic waste were used respectively as a 30% substitute for fine aggregate, because this has little effect on the compressive strength [15; 23; 28; 30]. In concrete Mix 4 was used the used engine oil UEO contaminated sands, the sand was weighed and oil corresponding to 1% of the weight of this portion was

Table 1. Proportions of the components of the concrete mixtures per 1 m^3. Author A. W. R. Razzaq

label	Water (kg/m³)	Cement (kg/m³)	Fine aggregate (kg/m³)	Coarse aggregate (kg/m³)	Additives		Curing
					Type	Percentage %	
Mix 1					—	—	—
Mix 2					Glass waste	Replacing 30% of fine aggregate	—
Mix 3					PVC plastic waste	Replacing 30% of fine aggregate	—
Mix 4	190	420	625	1085	Used engine oil UEO	1% by weight of sand	—
Mix 5					UEO -Water emulsion	3% by weight of binder mass fractions (cement + water)	—
Mix 6					—	—	Polishing concrete surface
Mix 7					—	—	Concrete vibration during pouring
Mix 8					—	—	low viscosity UEO was used as a mould release agent
Mix 9					—	—	Spraying with UEO immediately after pouring

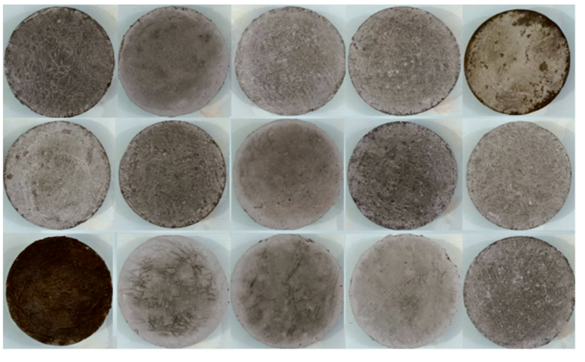

Illustration 2. Concrete samples with different mixtures. Author A. W. R. Razzaq

added as contamination to the fine aggregate. The mixture was thoroughly stirred to ensure uniformity of the mix and the resulting was air-dried to allow proper reaction of the mixture, this has little effect on compressive strength [13; 14; 16]. For concrete Mix 5, to enhance the dispersion of the UEO, the superplasticizer, the UEO, and an amount of water roughly equivalent to the UEO weight were mixed for half an hour at a speed of 900 rpm using a magnetic stirrer, forming a homogeneous mixture. The emulsion is left in a container for 24 hours to make sure that the used engine oil UEO is not separated from the water. Emulsion of used engine oil UEO and water was added with binder mass fractions 3%. For concrete Mix 6 Portland cement was used in polishing the concrete surface, which works to harden the concrete surface and reduce pores during the polishing process. As soon as the concrete starts to solidify, i. e. after the initial setting time of the concrete (1–4 hours), the surface is leveled and polished to make it smooth and perfectly flat by a rotating blade used to smooth and level the concrete with the addition of cement powder, which acts as a hardener, is sprayed on the concrete surface during the polishing process. These rotary blades have been passed several times over the surface, starting at a low speed and then gradually increasing the speed to ensure a perfectly polished surface with a smooth degree and high flatness, free of pores and cracks. For concrete Mix 7 the fresh concrete mix was cast into standard metal moulds and vibrated for 3 minutes using an electrically operated vibrating table. For concrete Mix 8 low viscosity UEO was used as a mould release agent to produced concrete with high-quality surface. For concrete Mix 9 the concrete surface was sprayed with low viscosity UEO immediately after pouring. Details and proportions of the components of concrete mixtures are given in Table 1.

The water resistance of concrete is assessed by the volume of water absorbed by the samples under pressure and the waterproofness of the materials using the «wet spot» method in accordance with Russian standard GOST 12730.5 «Concretes. Methods for determining water resistance»[1]. Six cylindrical concrete samples were formed from each concrete mix with a diameter 150 mm and height of 50 mm (Illustration 2), the concrete samples were carefully removed from the moulds after 24 hours, cleaned, and placed inside water for curing at normal room temperature. The samples underwent a full maturation procedure (28 days) under normal hardening conditions (temperature of 20+/−2°C and relative humidity of at least 95%).

Before testing, the side faces of the samples were treated with silicone sealant to prevent water from seeping through them. To conduct the experiment using the «wet spot» method, pressurized water was supplied to the lower ends of the cylinder samples. The water pressure was increased in steps of 0.2 MPa for 5 minutes and maintained at each step for 6 hours. The test was carried out until signs of water filtration in the form of droplets or a wet spot appeared on the upper end surface of the sample. Water resistance was assessed by the maximum value of the water pressure, at which it has not yet been observed to seep through the sample.

Results and discussion

The effect of a waste additives and curing techniques on permeability properties of concrete grade B30 was experimentally examined. The water resistance of six samples for each mixture was assessed by the maximum water pressure at which no water filtration has been observed on at least four of the six samples. The grade of concrete for water resistance is taken according with Russian standard GOST 12730.5[2] as shown in Table 2.

1 ГОСТ 12730.5–2018. Бетоны. Методы определения водонепроницаемости. Concretes. Methods for determination of water tightness. 01.09.2019. 25 с.: [сайт] — URL: https://protect.gost.ru/document.aspx?control=7&id=242805 (дата обращения: 19.01.2026).

2 Там же.

The test results of concrete Mix 1 showed that the grade of concrete for water resistance (W8), while (W10) for the concrete Mix 2. It can be noticed that the glass content in the concrete resulted in a barrier effect for water penetration. The water-repellent and smooth surface properties of the glass waste are responsible for its impermeable nature towards water. The permeability of concrete depends on the smoothness and fineness of the glass waste used. During the study of samples of concrete Mix 3, it was found that the introduction of PVC plastic waste additive reduces the porosity of the concrete matrix, thereby increasing the water resistance. The use of PVC plastic waste increases the grade of concrete in terms of water resistance (W10) compared with the ordinary concrete (W8). The test results of concrete Mix 4 showed that the grade of concrete for water resistance (W12), UEO concrete increased hydrophobicity compared to ordinary concrete, the addition of UEO refines the pore structure of concrete, reducing surface roughness and pore connectivity. The presence of contaminants sands with oil seems to delay or prevent the full hydration of the cement particles, by interfering with the water cement binding reactions. This contaminant being oily in nature formed an oil film around the fine aggregate and this possibly explains why water was expelled.

It is shown that the waste additives in concrete mixtures create the dense structure, reduce the permeability including diffusion, which prevents the corrosion of concrete and steel reinforcement. Based on the results obtained, graphs of the dependence of grade of concrete for water resistance by the samples on the applied pressure were constructed (Illustration 3).

For the concrete Mix 5, the grade of concrete for water resistance was (W10), caused by the effect of the UEO-Water emulsion additive on the concrete water resistance. During the preparation of the concrete mixture, the integrity of the hydrophobic films located on the surface of the cement particles is disrupted, and after mixing, the mixture sets and hardens normally. The additive is distributed throughout the entire volume of the concrete mix, clogging the pores and capillaries, giving their surface hydrophobic properties, creating a barrier to the penetration of aggressive media. The introduction of an UEO-Water emulsion additive significantly reduces the total and capillary porosity and, as a result, has a positive effect on water resistance of concrete. This is due to the fact that the UEO-Water emulsion additive covers the cross-section of pores and capillaries, and giving them water-repellent properties. The grade of concrete Mix 6 for water resistance was (W10). The reason is that when the concrete surface was polished and cement powder was added as a hardener, this process leveled the surface, reduced pores and permeability, and made the surface have a smooth and even texture as shown in Illustration 4c. The test results of concrete Mix 7 showed that the grade of concrete for water resistance (W10), as the compaction of concrete during pouring significantly affects the permeability of concrete, microcapillaries filled with water create the so-called effect of colmatation of pores and capillaries, which reduces the permeability of concrete. With increasing age of concrete, the degree of cement hydration increases and, as a result, the volume of micropores decreases, as a result of which the permeability of concrete decreases. The permeability of concrete is also affected by the aggregate, the greater its porosity, the less waterproof concrete will have.

Table 2. The grade of concrete for water resistance according to GOST 12730.5

Water resistance of a series of samples, MPa	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2
Grade of concrete for water resistance	W2	W4	W6	W8	W10	W12	W14	W16	W18	W20

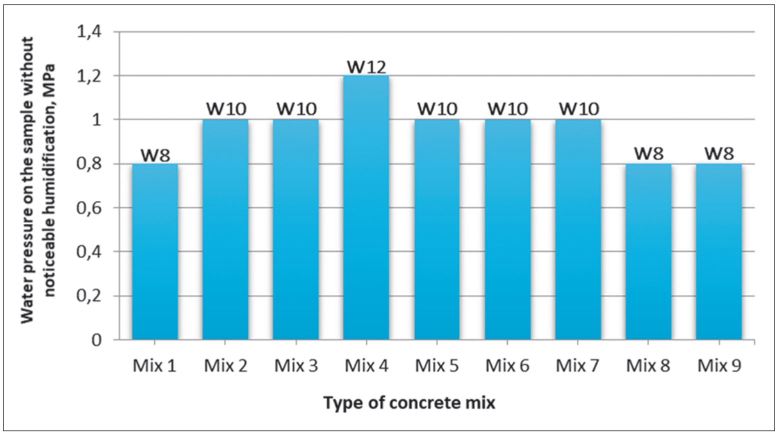

Illustration 3. Water resistance of the concrete mixtures at the age of 28 days. Author A. W. R. Razzaq

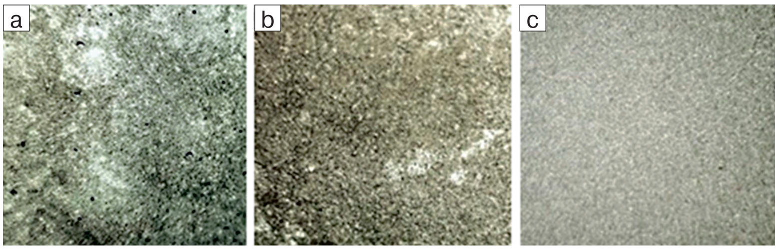

Illustration 4. Concrete surface texture for (*a*) ordinary concrete sample (Mix 1), (*b*) sample which used low viscosity UEO as a mould release agent (Mix 8) and (*c*) polished sample (Mix 6). Author A. W. R. Razzaq

The grade of concrete Mix 8 for water resistance was (W8), the ordinary concrete samples cast molded with the low viscosity UEO-based release agent had fewer surface voids compared to control samples concrete Mix 1, Illustration 4a shows the surface condition of the concrete after unmolding the samples of concrete Mix 1 and Illustration 4b for concrete Mix 8. The consideration of interaction between air bubbles, lubricant and liquid phase of concrete is of great importance. The low viscosity of UEO was allowed air to migrate to a certain extent and leave concrete interface. In addition, the UEO was given maximum hydrophobization to a mould and have minimal adhesion in respect of the concrete mix. In the concrete Mix 9, the grade of concrete for water resistance was (W8), as spraying the concrete with UEO after pouring did not reduce the permeability.

Conclusion

Ensuring high water resistance and low permeability is essential for safety and economic viability in hydraulic structure applications, necessitating attention throughout design and execution. High permeability of concrete over time causes surface degradation, cracks, chloride profiles and corrosion of embedded reinforcements. Use of waste is solution that not only diminishes environmental impacts but also bolsters concrete water resistance. The addition of glass waste, PVC plastic waste and used engine oil UEO decreased the amount of pores easily accessible by water, this is proven by the by increased the grade of concrete for water resistance of concrete mixes samples with these additives compared to the ordinary mixes. The permeability of concrete has also been reduced by using processing techniques such as concrete surface polishing and concrete vibration during casting. The addition waste can improve the water resistance of concrete, provided that the concrete strength is not significantly reduced. The disposal of waste for improving concrete properties is rational and will have great technical and economic efficiency, since the use of these wastes will not only reduce environmental pollution, but also reduce the costs. Furthermore, maintaining effective construction practices is essential. Upholding stringent quality control during construction phases is necessary to ensure compliance with best practices that reduce voids and improve hydration by emphasizing appropriate curing techniques.

References

[1] Abzalilova A.V., Strokova V.V. Ispol'zovanie penetriruyushchej dobavki dlya povysheniya vodonepronicaemosti betona // Vestn. Belgorod. gos. tekhnol. un-ta im. V.G. Shuhova. — 2020. — № 5. — C. 18–24. — DOI: 10.34031/2071-7318-2020-5-5-18-24

[2] Agafonova N.Z., Tajchinov D.R., Podoprigorov P.A. Vodonepronicaemost' betonnogo polotna // Inzhenernyj vestnik Dona. — 2024. — T. 111. — № 3. — S. 328–334. — EDN: ACYHLI

[3] Butakova M.D., Mihajlov A.V., Saribekyan S.S. Vliyanie kremnij soderzhashchih dobavok na svojstvo vodonepronicaemosti betonnyh obrazcov // Vestn. Yuzhno-Ural'skogo gos. un-ta. Ser. Stroitel'stvo i arhitektura. — 2017. — T. 17. — № 2. — C. 34–41. — DOI: 10.14529/build170205

[4] Grechuhin V.A. Uluchshenie svojstv betona na osnove primeneniya novoj dobavki // Nauka i tekhnika. — 2012. — № 5. — C. 47–51. — EDN: TMNGXV

[5] Zholdasov A.T. Vodopronicaemost' i vodopogloshchenie betona // Vestnik nauki. — 2024. — T. 1. — № 12 (81). — C. 1384–1389. — EDN: FCGFNI

[6] Kazanskaya L.F., Majer V.A., Sibgatullin E.S. Vzaimosvyaz' faktorov, opredelyayushchih dolgovechnost' betonov // Izv. Peterburg. un-ta putej soobshcheniya. — 2024. — T. 21. — № 4. — C. 931–943). — DOI: 10.20295/1815-588X-2024-04-931-943

[7] Kairov T.A., Lukpanov R.E. Vliyanie mikrokremnezema i plastifikatorov na fiziko-mekhanicheskie i teplo-izolyacionnye svojstva neavtoklavnogo penobetona // Mezhdunarodnyj nauchnyj zhurnal «In the world of science and education». — 2025. — C. 17–24. — DOI: 10.24412/3007-8946-2025-15-17-24

[8] Lesovik V.S., Gridchina A.A. Monolitnye betony na osnove rasshiryayushchih dobavok i himicheskih modifikatorov // Stroitel'nye materialy. — 2015. — № 8. — C. 81–83. — EDN: UHHPHX

[9] Rumyanceva V.E., Krasil'nikov I.V., Krasil'nikova I.A. Ocenka effektivnosti nekotoryh sostavov betonnyh smesej, primenyaemyh pri torkretirovanii, po kriteriyam dolgovechnosti // Sovremennye problemy grazhdanskoj zashchity. — 2024. — № 4 (53). — C. 97–108. — EDN: CGJWBL

[10] Tulegenov D.Zh. Vliyanie shlaka i dobavok na svojstva portlandcementov // Mezhdunarodnyj nauchnyj zhurnal «In the world of science and education». — 2025. — C. 3–11. — DOI: 10.24412/3007-8946-2025-15-3-7

[11] Hung N.S., Lam T.V., Bulgakov B.I. i dr. Vliyanie zoly risovoj sheluhi na svojstva gidrotekhnicheskih betonov // Vestn. MGSU. — 2018. — T. 13. — № 6 (117). — C. 768–777. — DOI: 10.22227/1997–0935.2018.6.768–777

[12] Yuhnevskij P.I., Dimitriadi N.P. O sinergeticheskom vliyanii smazki i himicheskih dobavok na poluchenie kachestvennoj poverhnosti betonnyh izdelij // Nauka i tekhnika. — 2019. — № 4. — C. 303–310. — DOI: 10.21122/2227-1031-2019-18-4-303-310

[13] Abousnina R., Manalo A., Lokuge W., Al-Jabri K.S. Properties and structural behavior of concrete containing fine sand contaminated with light crude oil // Construction and Building Materials. — 2018. — November. — Vol. 189. — P. 1214–1231: [sajt] — URL: https://doi.org/10.1016/j.conbuildmat.2018.09.089 (data obrashcheniya: 19.01.2026).

[14] Ajagbe W.O., Rabiu W.A. Effects of crude oil imparted sand on the durability of concrete // J. of Civil Engineering and Architecture. — Vol. 6. — Iss. 4. — P. 205–211. — DOI: 10.13189/cea.2018.060403

[15] Ali S., Scott A., Mackechine J. Effects of waste glass on strength and durability characteristics of self compacting concrete // Proceedings of the NZ Concrete Industry Conference. — 2015. — URL: https://concretenz.org.nz/page/Conference_2015

[16] Aljuaydi F., Abousnina R., Alajarmeh O., Alajmi A. The influence of fibres on the properties and sustainability of oil-impacted concrete // Sustainability. — 2024. — Vol. 16. — Iss. 17:7344: [sajt] — URL: https://doi.org/10.3390/su16177344 (data obrashcheniya: 19.01.2026).

[17] Alsubai S., Alqahtani A., Hashim Muhodir S. et al. The remarkable potential of machine learning algorithms in estimating water permeability of concrete incorporating nano natural pozzolana // Scientific Reports. — 2024. — 14:12532: [sajt] — URL: https://doi.org/10.1038/s41598-024-62020-3 (data obrashcheniya: 19.01.2026).

[18] Altwair N.M., Al-Kilani A.M., Sryh L.S., Sreh M.M. Evaluating the effect of local aggregate type and size on the water permeability of plain concrete // Sebha university conference proceedings. 2024: Proceedings of the 7th International conference on science and technology. — 2024. — Vol. 3. — Iss. 2. — P. 140–146: [sajt] — URL: https://doi.org/10.51984/sucp.v3i2.3304 (data obrashcheniya: 19.01.2026) [na arab. yaz.].

[19] Ammar M.A., Chegenizadeh A., Budihardjo M.A., Nikraz H. The effects of crystalline admixtures on concrete permeability and compressive strength: A review // Buildings. — 2024. — Vol. 14. — Iss. 9:3000: [sajt] — URL:

https://doi.org/10.3390/buildings14093000 (data obrashcheniya: 19.01.2026).
[20] Azizi N., Sharifi M., Shokrzadeh M. R. Experimental investigation of the effect of mold type and mold oil on the physical characteristics of self-compacting concrete // Civil infrastructure researches. — 2024. — Vol. 10. — Iss. 2. — P. 81–98. — DOI: 10.22091/cer.2024.10881.1559
[21] Banevičienė V., Malaiškienė J., Boris R., Zach J. The effect of active additives and coarse aggregate granulometric composition on the properties and durability of pervious concrete // Materials. — 2022. — Vol. 15. — Iss. 3:1035: [sajt] — URL: https://doi.org/10.3390/ma15031035 (data obrashcheniya: 19.01.2026).
[22] Chen H., Zhao X., Astudillo J. C. et al. Upcycling used engine oil into concrete: Ecological and mechanical performances in coastal applications // Construction and building materials. — 2025. — Vol. 483:141605: [sajt] — URL: https://doi.org/10.1016/j.conbuildmat.2025.141605 (data obrashcheniya: 19.01.2026).
[23] De Moura J. M. B. M., Pinheiro I. G., Aguado A., Rohden A. B. Sustainable pervious concrete containing glass powder waste: Performance and modeling // J. of cleaner production. — 2021. — Vol. 316:128213. — DOI: 10.1016/j.jclepro.2021.128213
[24] García Calvo J. L., Sánchez Moreno M., Carballosa P. et al. Improvement of the concrete permeability by using hydrophilic blended additive // Materials. — 2019. — Vol. 12. — Iss. 15:2384: [sajt] — URL: https://doi.org/10.3390/ma12152384 (data obrashcheniya: 19.01.2026).
[25] Gojević A., Ducman V., Netinger Grubeša I. et al. The effect of crystalline waterproofing admixtures on the self-healing and permeability of concrete // Materials. — 2021. — Vol. 14. — Iss. 8:1860: [sajt] — URL: https://doi.org/10.3390/ma14081860 (data obrashcheniya: 19.01.2026).
[26] Jahandari S., Tao Z., Alim M. A., Li W. Integral waterproof concrete: A comprehensive review // J. of building engineering. — 2023. — Vol. 78:107718: [sajt] — URL: https://doi.org/10.1016/j.jobe.2023.107718 (data obrashcheniya: 19.01.2026).
[27] Liu Y., Yu Z., Lv C. et al. Preparation of waste cooking oil emulsion as shrinkage reducing admixture and its potential use in high performance concrete: Effect on shrinkage and mechanical properties // J. of building engineering. — 2020. — Vol. 32:101488. — DOI: 10.1016/ j.jobe.2020.101488
[28] Mohammed A. A., Mohammed I. I., Mohammed S. A. Some properties of concrete with plastic aggregate derived from shredded PVC sheets // Construction and building materials. — 2020. — Vol. 13: e00467: [sajt] — URL: https://doi.org/10.1016/j.cscm.2020.e00467 (data obrashcheniya: 19.01.2026).
[29] Naik N. M., Kulkarni G. S., Prakash K. B. Effect of solid wastes on the characteristics behaviour of petroleum products soaked concrete: A review // International journal of current engineering and technology. — 2013. — September. — P. 32–36: [sajt] — URL: https://inpressco.com/wp-content/uploads/2013/09/Paper832–36.pdf (data obrashcheniya: 19.01.2026).
[30] Navaneetha E., Rao P. N., Bahurudeen A. Compatibility of waste glass with other by-products for the production of sustainable concrete // J. of building engineering. — 2023. — Vol. 80:107922: [sajt] — URL: https://doi.org/10.1016/j.jobe.2023.107922 (data obrashcheniya: 19.01.2026).
[31] Ogbo H. E., Ugwu O. O. Performance of black olive oil as permeability reducing admixture in concrete // Nigerian Journal of Technology. — 2023. — Vol. 42. — Iss. 1. — P. 46–54. — DOI: 10.4314/njt.v42i1.6
[32] Razzaq A. W. R., Alekhin V. N. Experimental study on abrasion resistance of polished concrete in the water environment // Akademicheskij vestnik UralNIIproekt RAASN. — 2025. — № 2 (65). — S. 87–94. — DOI: 10.25628/UNIIP.2025.65.2.013
[33] Szafraniec M., Barnat-Hunek D. Effect of natural release oils on concrete wettability // AIP conference proceedings. Central european symposium on thermophysics. 2021 (CEST 2021). — Vol. 2429. — Iss. 1:020037. — DOI: 10.1063/5.0069709
[34] Zhang Y., Wu S., Ma X. et al. Effects of additives on water permeability and chloride diffusivity of concrete under marine tidal environment // Construction and building materials. — 2022. — Vol. 320. — Iss. 2:126217. — DOI: 10.1016/ j.conbuildmat.2021.126217

Список использованной литературы

[1] Абзалилова А. В., Строкова В. В. Использование пенетрирующей добавки для повышения водонепроницаемости бетона // Вестн. Белгород. гос. технол. ун-та им. В. Г. Шухова. — 2020. — № 5. — С. 18–24. — DOI: 10.34031/2071-7318-2020-5-5-18-24
[2] Агафонова Н. З., Тайчинов Д. Р., Подопригоров П. А. Водонепроницаемость бетонного полотна // Инженерный вестник Дона. — 2024. — Т. 111. — № 3. — С. 328–334. — EDN: ACYHLI
[3] Бутакова М. Д., Михайлов А. В., Сарибекян С. С. Влияние кремний содержащих добавок на свойство водонепроницаемости бетонных образцов // Вестн. Южно-Уральского гос. ун-та. Сер. Строительство и архитектура. — 2017. — Т. 17. — № 2. — С. 34–41. — DOI: 10.14529/build170205
[4] Гречухин В. А. Улучшение свойств бетона на основе применения новой добавки // Наука и техника. — 2012. — № 5. — С. 47–51. — EDN: TMNGXV
[5] Жолдасов А. Т. Водопроницаемость и водопоглощение бетона // Вестник науки. — 2024. — Т. 1. — № 12 (81). — С. 1384–1389. — EDN: FCGFNI
[6] Казанская Л. Ф., Майер В. А., Сибгатуллин Э. С. Взаимосвязь факторов, определяющих долговечность бетонов // Изв. Петербург. ун-та путей сообщения. — 2024. — Т. 21. — № 4. — С. 931–943). — DOI: 10.20295/1815-588X-2024-04-931-943
[7] Каиров Т. А., Лукпанов Р. Е. Влияние микрокремнезема и пластификаторов на физико-механические и теплоизоляционные свойства неавтоклавного пенобетона // Международный научный журнал «In the world of science and education». — 2025. — С. 17–24. — DOI: 10.24412/3007-8946-2025-15-17-24
[8] Лесовик В. С., Гридчина А. А. Монолитные бетоны на основе расширяющих добавок и химических модификаторов // Строительные материалы. — 2015. — № 8. — С. 81–83. — EDN: UHHPHX
[9] Румянцева В. Е., Красильников И. В., Красильникова И. А. Оценка эффективности некоторых составов бетонных смесей, применяемых при торкретировании, по критериям долговечности // Современные проблемы гражданской защиты. — 2024. — № 4 (53). — С. 97–108. — EDN: CGJWBL
[10] Тулегенов Д. Ж. Влияние шлака и добавок на свойства портландцементов // Международный научный жур-

нал «In the world of science and education». — 2025. — С. 3–11. — DOI: 10.24412/3007-8946-2025-15-3-7

[11] Хунг Н.С., Лам Т.В., Булгаков Б.И. и др. Влияние золы рисовой шелухи на свойства гидротехнических бетонов // Вестн. МГСУ. — 2018. — Т. 13. — № 6 (117). — С. 768–777. — DOI: 10.22227/1997–0935.2018.6.768–777

[12] Юхневский П.И., Димитриади Н.П. О синергетическом влиянии смазки и химических добавок на получение качественной поверхности бетонных изделий // Наука и техника. — 2019. — № 4. — С. 303–310. — DOI: 10.21122/2227-1031-2019-18-4-303-310

[13] Abousnina R., Manalo A., Lokuge W., Al-Jabri K.S. Properties and structural behavior of concrete containing fine sand contaminated with light crude oil // Construction and Building Materials. — 2018. — November. — Vol. 189. — P. 1214–1231: [сайт] — URL: https://doi.org/10.1016/j.conbuildmat.2018.09.089 (дата обращения: 19.01.2026).

[14] Ajagbe W.O., Rabiu W.A. Effects of crude oil imparted sand on the durability of concrete // J. of Civil Engineering and Architecture. — Vol. 6. — Iss. 4. — P. 205–211. — DOI: 10.13189/cea.2018.060403

[15] Ali S., Scott A., Mackechine J. Effects of waste glass on strength and durability characteristics of self compacting concrete // Proceedings of the NZ Concrete Industry Conference. — 2015. — URL: https://concretenz.org.nz/page/Conference_2015

[16] Aljuaydi F., Abousnina R., Alajarmeh O., Alajmi A. The influence of fibres on the properties and sustainability of oil-impacted concrete // Sustainability. — 2024. — Vol. 16. — Iss. 17:7344: [сайт] — URL: https://doi.org/10.3390/su16177344 (дата обращения: 19.01.2026).

[17] Alsubai S., Alqahtani A., Hashim Muhodir S. et al. The remarkable potential of machine learning algorithms in estimating water permeability of concrete incorporating nano natural pozzolana // Scientific Reports. — 2024. — 14:12532: [сайт] — URL: https://doi.org/10.1038/s41598-024-62020-3 (дата обращения: 19.01.2026).

[18] Altwair N.M., Al-Kilani A.M., Sryh L.S., Sreh M.M. Evaluating the effect of local aggregate type and size on the water permeability of plain concrete // Sebha university conference proceedings. 2024: Proceedings of the 7th International conference on science and technology. — 2024. — Vol. 3. — Iss. 2. — P. 140–146: [сайт] — URL: https://doi.org/10.51984/sucp.v3i2.3304 (дата обращения: 19.01.2026) [на араб. яз.].

[19] Ammar M.A., Chegenizadeh A., Budihardjo M.A., Nikraz H. The effects of crystalline admixtures on concrete permeability and compressive strength: A review // Buildings. — 2024. — Vol. 14. — Iss. 9:3000: [сайт] — URL: https://doi.org/10.3390/buildings14093000 (дата обращения: 19.01.2026).

[20] Azizi N., Sharifi M., Shokrzadeh M.R. Experimental investigation of the effect of mold type and mold oil on the physical characteristics of self-compacting concrete // Civil infrastructure researches. — 2024. — Vol. 10. — Iss. 2. — P. 81–98. — DOI: 10.22091/cer.2024.10881.1559

[21] Banevičienė V., Malaiškienė J., Boris R., Zach J. The effect of active additives and coarse aggregate granulometric composition on the properties and durability of pervious concrete // Materials. — 2022. — Vol. 15. — Iss. 3:1035: [сайт] — URL: https://doi.org/10.3390/ma15031035 (дата обращения: 19.01.2026).

[22] Chen H., Zhao X., Astudillo J.C. et al. Upcycling used engine oil into concrete: Ecological and mechanical performances in coastal applications // Construction and building materials. — 2025. — Vol. 483:141605: [сайт] — URL: https://doi.org/10.1016/j.conbuildmat.2025.141605 (дата обращения: 19.01.2026).

[23] De Moura J. M. B. M., Pinheiro I.G., Aguado A., Rohden A.B. Sustainable pervious concrete containing glass powder waste: Performance and modeling // J. of cleaner production. — 2021. — Vol. 316:128213. — DOI: 10.1016/j.jclepro.2021.128213

[24] García Calvo J.L., Sánchez Moreno M., Carballosa P. et al. Improvement of the concrete permeability by using hydrophilic blended additive // Materials. — 2019. — Vol. 12. — Iss. 15:2384: [сайт] — URL: https://doi.org/10.3390/ma12152384 (дата обращения: 19.01.2026).

[25] Gojević A., Ducman V., Netinger Grubeša I. et al. The effect of crystalline waterproofing admixtures on the self-healing and permeability of concrete // Materials. — 2021. — Vol. 14. — Iss. 8:1860: [сайт] — URL: https://doi.org/10.3390/ma14081860 (дата обращения: 19.01.2026).

[26] Jahandari S., Tao Z., Alim M.A., Li W. Integral waterproof concrete: A comprehensive review // J. of building engineering. — 2023. — Vol. 78:107718: [сайт] — URL: https://doi.org/10.1016/j.jobe.2023.107718 (дата обращения: 19.01.2026).

[27] Liu Y., Yu Z., Lv C. et al. Preparation of waste cooking oil emulsion as shrinkage reducing admixture and its potential use in high performance concrete: Effect on shrinkage and mechanical properties // J. of building engineering. — 2020. — Vol. 32:101488. — DOI: 10.1016/ j.jobe.2020.101488

[28] Mohammed A.A., Mohammed I.I., Mohammed S.A. Some properties of concrete with plastic aggregate derived from shredded PVC sheets // Construction and building materials. — 2020. — Vol. 13: e00467: [сайт] — URL: https://doi.org/10.1016/j.cscm.2020.e00467 (дата обращения: 19.01.2026).

[29] Naik N.M., Kulkarni G.S., Prakash K.B. Effect of solid wastes on the characteristics behaviour of petroleum products soaked concrete: A review // International journal of current engineering and technology. — 2013. — September. — P. 32–36: [сайт] — URL: https://inpressco.com/wp-content/uploads/2013/09/Paper832–36.pdf (дата обращения: 19.01.2026).

[30] Navaneetha E., Rao P.N., Bahurudeen A. Compatibility of waste glass with other by-products for the production of sustainable concrete // J. of building engineering. — 2023. — Vol. 80:107922: [сайт] — URL: https://doi.org/10.1016/j.jobe.2023.107922 (дата обращения: 19.01.2026).

[31] Ogbo H.E., Ugwu O.O. Performance of black olive oil as permeability reducing admixture in concrete // Nigerian Journal of Technology. — 2023. — Vol. 42. — Iss. 1. — P. 46–54. — DOI: 10.4314/njt.v42i1.6

[32] Razzaq A.W.R., Alekhin V.N. Experimental study on abrasion resistance of polished concrete in the water environment // Академический вестник УралНИИпроект РААСН. — 2025. — № 2 (65). — С. 87–94. — DOI: 10.25628/UNIIP.2025.65.2.013

[33] Szafraniec M., Barnat-Hunek D. Effect of natural release oils on concrete wettability // AIP conference proceedings. Central european symposium on thermophysics. 2021 (CEST 2021). — Vol. 2429. — Iss. 1:020037. — DOI: 10.1063/5.0069709

[34] Zhang Y., Wu S., Ma X. et al. Effects of additives on water permeability and chloride diffusivity of concrete under marine tidal environment // Construction and building materials. — 2022. — Vol. 320. — Iss. 2:126217. — DOI: 10.1016/ j.conbuildmat.2021.126217

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