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A Review on Geocement Mortar:

Libanesh S [a], A.Vennila [b], Preetha S [c]

PG Student [a,c], Assistant Professor [b]

Department of Civil Engineering, Kumaraguru College of Technology, Coimbatore- 641049, Tamil Nadu, India

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A B S T R A C T

Geocement claims to reduce carbon dioxide emissions, hence reducing global warming. Geo-cement's lower carbon footprint makes it environmentally favorable, addressing sustainability concerns and contributes to a greener approach. Geocement is a type of geopolymer binder derived from industrial by-products and offers sustainable and eco-friendly properties. Geocement is made from Geopowder and Geobinder. Geopowder uses industrial by-products such as fly ash, rice husk ash, slag, activated clay and alumina. Geobinder can be of polymers that acts as a additives. Geocement claims to reduce carbon dioxide emissions, hence halting global warming. Geopowder is a green product that is favorable to the environment. By limiting the uncontrolled dumping of waste byproduct materials and by halting carbon dioxide (CO_2) emissions, the environment must be preserved. Geocement was used in this project to completely (100%) replace of cement. Due to the high demand for sand in the market, foundry sand was utilized in place of river sand and M-sand to solve this issue. Foundry sand was used in place of the sand in mortar (20%, 30%, 40%, and 50%). To determine the mechanical characteristics, durability studies, and microstructural behavior of geocement mortar.

Keywords: Geocement ,Waste Foundry Sand, Microstructural behavior ,Geocement Mortar.

INTRODUCTION

In recent years, the construction industry has increasingly focused on developing sustainable materials to address environmental challenges. Two significant innovations in this effort are Geocement mortar and the use of waste foundry sand. Geocement mortar offers a promising alternative to conventional cement-based products. This geopolymer binder is made from industrial by-products such as fly ash, slag, and rice husk ash, combined with a polymer additive known as Geobinder. By utilizing these waste materials, Geocement mortar not only reduces carbon dioxide emissions compared to traditional cement but also boasts eco-friendly properties, a lower carbon footprint, and enhanced mechanical performance and durability. These attributes make it a compelling choice for modern construction needs and support its role in advancing green building practices.

At the same time, waste foundry sand—an industrial by-product from metal casting—presents another opportunity for sustainable development. This material, primarily composed of silica sand and various additives, is typically discarded after use due to contamination and changes in properties. With the growing volume of waste foundry sand, finding sustainable management solutions is crucial. Repurposing this by-product in construction applications, such as in concrete and road construction, helps reduce dependence on natural sand resources and addresses waste disposal challenges. Using waste foundry sand not only conserves natural resources but also supports waste minimization and environmental protection. Research into its mechanical properties, durability, and performance indicates its viability as an alternative to traditional sand, reinforcing its potential for sustainable construction practices. Together, Geocement mortar and waste foundry sand signify important strides towards eco-friendly construction solutions, enhancing both environmental sustainability and resource efficiency..

LITERATURE STUDY

Vishnu Prasad. S, Vennila. A, Aakash. V (2024) This paper examines the effects of incorporating geocement into concrete, highlighting significant improvements in its fresh, hardened, and durable properties. Each batch of specimens achieved the target slump value, which enhanced the workability of the concrete. The use of geocement, especially when activated by specialized chemicals in the GGBS, produced stronger concrete compared to traditional mixes. The GC2 mix, consisting of 75% geocement and 25% Ordinary Portland Cement (OPC), demonstrated superior compressive, split tensile, and flexural strengths compared to standard concrete. Under a 4-ton load, the geocement-reinforced beam exhibited deflections of 1.25 mm at L/3 and 1.51 mm at L/2, with minor cracking indicating flexural failure. When subjected to a 4.5-ton load, the beam deflected 2.57 mm at L/2 and 2.15 mm at L/3, with ongoing signs of flexural failure. Experimental results showed that conventional reinforced concrete beams had a maximum deflection of 9.1 mm, whereas ANSYS simulations predicted a lower deflection of 6.75 mm. For the geocement-reinforced beam, ANSYS estimated a deflection of 7.36 mm, slightly higher than the experimental maximum of 8.5 mm.

Krivenko Pavel Vasiljevich, Guziy Sergey Grigorjevich, Kyrychok Vladimir Ivanovich (2014) This study explores geocement-based coatings designed for the repair and protection of concrete structures, including those used in biogas production, water supply, and sewage disposal pipelines. The coatings have been developed and practically tested. The study assessed their resistance to a 5% ammonium sulfate solution and investigated the fundamental physico-chemical processes occurring during the interaction of ammonium salts with geocements. The findings demonstrate that these geocement-based coatings ($Na2O·Al2O3·6SiO2·30H2O$) exhibit strong corrosion resistance in the ammonium sulfate environment. This effectiveness is due to the presence of synthesized zeolites—such as faujasite, chabazite, and mordenite—and ammonium-containing zeolites like ammonium analcime, (NH4, Na)-zeolite-E, zeolite α, zeolite ZK-21, and NH4-zeolite-Ω, all known for their high corrosion resistance. The coated concrete surfaces achieved a resistance coefficient (Kr) of 1.01 at 30 days, which is 1.2 times higher than that of uncoated concrete of the same age.

Grigorii Vozniuk, Elena Kavalerova, Pavel Krivenko, Oleg Petropavlovskii(2013) This paper reports on a study examining the physico-chemical and mechanical properties of geocement-based adhesives, which demonstrate notable advantages including high compressive and bond strength under diverse long-term conditions and exceptional durability. Developed and tested for bonding materials such as granite, marble, ceramic tiles, glass panels, concrete, and ceramics, these geocement-based adhesives were assessed for durability factors like frost and weather resistance, in line with Ukrainian standards. The test results show that the adhesives either meet or surpass the required performance criteria, and long-term observations affirm their superior durability.

Lampros N. Koutas , Christos G. Papakonstantinou(2021) This paper details an experimental study on enhancing the flexural strength of reinforced concrete (RC) beams using externally bonded layers of textile-reinforced mortar (TRM). The study aimed to evaluate how different types of mortar, textiles, and the number of textile layers affect the performance of the TRM strengthening system. Nine medium-scale RC beams were constructed and tested under 4-point bending with simple supports. One beam served as a control specimen, tested without any strengthening. The remaining beams were reinforced with various configurations and then subjected to monotonic bending tests. The study investigated several parameters: a) the type of mortar (with two variations, M1 and M2), b) the number of strengthening layers (three versus six), and c) the type of textile (basalt-fiber with small mesh versus glass-fiber with large mesh). The primary distinction between mortars M1 and M2 was the inclusion of synthetic polymers in mortar M1. The findings indicate that the type of mortar significantly impacts the increase in flexural capacity, the flexural stiffness response after yielding, and the failure modes. The study also uncovered combined effects between different mortar types and the other parameters investigated.

Abdullah Al-Saidy,Sherif El-Gamal, Kazi Abu Sohail(2023) This study evaluates the effectiveness of strengthening fifteen reinforced concrete beams (150 x 100 x 2700 mm) using textile-reinforced mortars (TRMs). One beam served as a control, while others were strengthened with one, two, or three layers of textile bonded with either commercially available or lab-prepared mortars. Some beams also incorporated U-shaped strips for improved bond anchorage. Results showed that epoxy-bonded textiles increased ultimate load by 33% compared to the control, while mortar-bonded textiles improved load by 15-27%. Mortar-bonded textiles also enhanced ductility by about 25%. Increasing the number of textile layers did not significantly boost strength due to bond failures, but using U-shaped strips effectively improved both strength and ductility, especially when distributed along the beam. The findings suggest that TRMs can be a viable solution for upgrading concrete structures, provided strong bond maintenance.

Saman Babaeidarabad, Ph.D, Giovanni Loreto, Ph.D, and Antonio Nanni, Ph.D,P.E., F.ASCE(2014) Concrete structures often face deterioration for various reasons, necessitating upgrades to maintain their safety and performance. Traditional retrofitting methods for reinforced concrete (RC) beams include the use of steel plates, external post-tensioning, and both externally bonded and near-surface-mounted fiber-reinforced polymer (FRP) systems to enhance flexural and shear capacities. This study aims to assess the viability of fabric-reinforced cementitious-matrix (FRCM) materials as an alternative strengthening technique. FRCM is a composite comprising a cement-based matrix reinforced with dry-fiber fabric layers. The experimental program involved testing 18 RC beams reinforced in flexure using two FRCM configurations—one with a single layer and one with four layers of fabric. The study includes an analysis and design based on established methods to calculate the beams' flexural capacity and compare the results with experimental data.

Dr. K. Chandrasekhar Reddy, G. Ashok(2017) This study explores using Geo Cement as a complete substitute for conventional cement in new concrete and evaluates its water absorption after 28 days. It also tests the effect of partially replacing sand with 10%, 15%, and 20% vermiculite by weight. Concrete with 10% vermiculite shows higher water absorption compared to other mixes, with a 3.46% gain in weight for M30 grade and a 3.98% gain for M35 grade concrete. Overall, concrete containing vermiculite has lower water absorption and porosity than the control mix, with the minimum water absorption recorded as 3.87% for M30 and 4.26% for M35 grades.

Sinem Çevik1 & Tugba Mutuk & Başak Mesci Oktay & Arife Kübra Demirbaş(2017) This study explores the use of waste foundry sand (WFS) as a partial substitute for natural sand in cement mortar. The experimental results showed a decrease in mechanical strength with increasing WFS replacement, although compressive strength improved with 15% and 30% WFS, reaching 22.51 MPa and 22.28 MPa respectively, compared to 19.83 MPa for the control mortar at 3 days. All strength results met TS EN standards. SEM/EDS analyses revealed the expected microstructure, and the morphological information from fractured surfaces correlated with the tensile and compression test results. Waste foundry sand, typically underused in the cement-concrete industry, especially in Turkey, offers an environmentally friendly solution and adds value to industrial by-products. This study provides a foundation for WFS recycling in the cement-concrete sector, with future research planned to further investigate its applications.

Arife Kübra Demirbaş, Sinem Çevik, Tuğba Mutuk,Suna Avcioğlu This study examined cement mortars made by replacing 15%, 30%, 45%, and 60% of the aggregate with waste foundry sand from steel foundries. After curing for 7 and 28 days, the density of the samples was measured using Archimedes' principle. The impact of waste foundry sand on mortar density and porosity was analyzed, with additional investigation into the effects of grain size based on sieve analysis of both waste foundry sand and regular sand. The results indicate that waste foundry sand can be effectively used in cement mortars, with the 15% WFS addition yielding density and porosity values closest to those of the reference specimens. Thus, a 15% WFS replacement is optimal for achieving suitable density and water absorption in cement mortars.

Chandrasen F. Rajemahadik, S. S. Mane, Priyanka Shinde, Sayali Koynde, Kshitija Gaikwade, Shital Desai.(2014) This paper addresses the issue of foundry sand disposal, a byproduct from ferrous and non-ferrous metal casting. Approximately 100 million tons of foundry sand are produced annually, with 6-10 million tons discarded globally. The study investigates the impact of waste foundry sand on the compressive strength of cement blocks, sized 7.07 x 7.07 x 7.07 cm^3, when mixed with mortar at a 1:3 ratio. Natural sand was used as the fine aggregate in the mix. Waste foundry sand replaced natural sand in proportions of 0%, 10%, 20%, 30%, 40%, 50%, and 60% to assess its effect on the compressive strength of mortar blocks at ages 3, 7, and 28 days. The tests revealed that as the percentage of foundry sand replacement increased, the weight of the blocks decreased. Compressive strength dropped from 19.18 N/mm^2 to 11.71 N/mm^2 at 3 days, and from 39.02 N/mm^2 to 16.97 N/mm^2 at 28 days with increasing replacement.

Pendhari Ankush R, Demse Dhananjay G, Nikam Madhuri E, Karpe Balraj E, Khairnar Pramod R, Suryawanshi Priyanka R.(2017) This paper reviews the current use of fine sand in the construction industry and highlights the volume of waste foundry sand produced. It evaluates the potential for utilizing waste foundry sand as a cementitious material, focusing on the optimal percentage of foundry sand that maximizes strength. The paper provides significant findings on the compressive and flexural strength of concrete incorporating waste foundry sand.Overall, the paper demonstrates the promising potential of waste foundry sand for environmentally friendly and stronger cementitious concrete, reflecting positive advancements in its use in construction.

Ranjitha B Tangadagi, P. T. Ravichandran(2024) This study compares the performance of cement mortar using waste foundry sand (WFS), water-treated foundry sand (WTFS), and chemically treated foundry sand (CTFS). It aims to determine the optimal proportions of these sands by assessing their impact on the mortar's strength, durability, and microstructural properties, according to Indian standards.Proportions tested included 0%, 10%, 20%, 30%, 40%, and 50% by weight of fine aggregate. The results indicated that mortar with 30% CTFS and WTFS performed best. The optimal range for WTFS and CTFS was identified as 30–40%. Incorporating WFS into cement mortar helps address disposal issues in the metal and foundry industries and supports the creation of environmentally friendly construction materials

Abhishek Srivastava,S.K.Singh(2020) Rapid urbanization and industrialization have depleted construction materials like sand and increased industrial waste. Excessive sand dredging and lack of disposal sites for waste have driven the search for alternatives. Recycling industrial waste into construction materials offers a sustainable solution, reducing sand demand and providing eco-friendly waste disposal methods. This paper reviews the use of industrial wastes as alternatives to natural sand in mortar, examining their physical, chemical, and structural properties. It covers various materials, including coal bottom ash, crushed rock sand, copper slag, foundry sand, and recycled fine aggregate. The paper also discusses challenges and future research directions, aiming to build a knowledge base for the development of standards and applications for alternative sand mortars.

M. Selvakumar, S. Geetha, B. V. Agaliya, S. Shine, R. U. Rupasudharshnee, and M. Sakthivel(2021) Conventional cement mortar has been widely used for repairs but has limitations. To address these, polymers have been added as additives, offering an effective and cost-efficient solution. Polymers, made from various monomers, come in forms like latexes, emulsions, powders, and resins.In this study, foundry sand, which is finer and bulkier than M-sand with a specific gravity of 2.1, was tested as a partial replacement for M-sand. Replacing up to 20% of the sand with foundry sand improved strength, but further increases reduced strength. Additionally, adding 0.05% SBR latex by weight of cement significantly enhanced strength compared to ordinary mortar. The best results were achieved with a 20% foundry sand replacement combined with 0.05% SBR latex.

Maria Mavroulidou ,David Lawrence (2019) Foundry sand (FS) waste, a global solid waste issue, can potentially be used in concrete as an alternative to landfilling. While current knowledge limits FS use to minor sand replacements, this study investigates chemically bound FS (with polymeric resins). Results show that this type of FS can fully replace regular sand in concrete, achieving comparable or superior mechanical properties and durability. This offers both economic and environmental benefits. Unlike greensand, chemically bound FS needs further research and long-term durability studies to validate its broader application and market readiness.

Saveria Monosi, Daniela Sani and Francesca Tittarelli (2010) This paper explores the use of used foundry sand (UFS) as a partial replacement for natural sand in mortars and concretes. Classified as non-hazardous, UFS shows potential for recycling in construction. The study finds that a 10% UFS addition does not impact mortar performance, but higher amounts reduce workability and require more superplasticizer. Mechanical properties drop by 20-30%, with greater reductions in higher-quality mixes. UFS mixtures have low slump due to fine binders but maintain a stable modulus of elasticity. Increased drying shrinkage is noted with reduced mechanical performance. Further research is needed on UFS's effects on cement hydration and cleaning processes.

Deepasree Srinivasan,Hariharan Arumugam,Kavikumaran Kannadasan,Muthukaruppan Alagar,Abdul Aleem Mohamed Ismail(2023) This study explores using spent foundry sand as a filler in masonry products to tackle environmental issues from foundry waste. Green foundry sand faces problems like high shrinkage and inconsistent water absorption. To address these, the study uses melamine-formaldehyde resin and functional additives (stearic acid, calcium stearate, cardanol). Results show that a 15% polymer binder mix achieves 13.8 MPa strength and 7.3% water absorption. Adding functional additives reduces water absorption by up to 83% and boosts strength by 42%. The optimal mix of 15% binder and 10% additives improves durability and performance, making waste foundry sand a viable, eco-friendly construction material.

Paulo Paiva Oliveira Leite Dyer, Luis Miguel Gutierrez Klinsky, Silvelene Alessandra Silva, Rodrigo Alves e Silva & Maryangela Geimba de Lima(2019) This study assessed waste foundry sand (WFS) from landfills and steel industries for use in asphalt paving. Analysis showed WFS has similar physical and petro graphic properties to conventional sand and poses minimal alkali-reactivity risk. Its composition mainly silica, ferrous oxides, and carbonaceous materials does not adversely affect asphalt. Benefits of using WFS include cost savings, reduced resource use, lower waste, extended landfill life, and decreased environmental impact. Key findings include**,**WFS is comparable to fine aggregate, Higher carbon content does not affect asphalt performance,WFS's petro graphic classification matches manufactured sand, No significant harmful elements in WFS.

WR. L Da Silva E. Tochetto B L. R. Prudêncio JR. C A. L. Oliveira D (2011) This study evaluated the impact of foundry sand waste (FSW) on concrete. Mixtures with CPV-ARI-RS cement, water-reducing admixtures, and FSW showed increased air content, cracking, and reduced compressive strength due to expansive reactions. Follow-up tests with different FSW compositions confirmed similar issues. Key findings include,FSW adversely affects both fresh and hardened concrete properties, Coal powder in FSW caused more severe reactions and strength loss than NaSiO2 or CO2,Metal traces in FSW worsened these effects, The new binder Foumann reduced expansive reactions but still led to significant strength loss.FSW's expansive reactions cause cracking and reduced strength, making it risky for structural use. Preliminary testing is crucial due to varying FSW compositions.

B.A. Feijoo, J.I. Tobón, O.J. Restrepo-Baena(2021) The study assessed the impact of replacing normalized aggregate with residual foundry sand (WFS) in mortars, testing natural (WFS), washed (WFSW), and heat-treated (WFST) forms. WFS and WFSW, up to 20% replacement, enhanced mortar density and strength by reducing porosity. In contrast, WFST caused significant strength loss due to increased porosity and water demand from thermally activated clays. Although the Frattini test initially indicated pozzolanic activity in raw clay, this was not confirmed by lime fixation tests. Thermally treated clays showed real pozzolanic activity but also increased water demand and porosity, negatively affecting mortar str

CONCLUSION

This study highlights the benefits of incorporating 1623geocement into concrete, demonstrating improvements in workability, strength, and durability. Geocement-based mixes, particularly GC2, exhibit superior mechanical properties and lower deflection under load compared to traditional concrete. Additionally, Geocement-based coatings and adhesives offer excellent corrosion resistance and bonding strength, respectively. The research also shows that textile-reinforced mortar (TRM) and fabric-reinforced cementitious-matrix (FRCM) systems enhance the flexural strength of concrete beams effectively. Further, the study explores the use of waste foundry sand (WFS) and other industrial by-products as sustainable alternatives to natural sand, presenting promising results for improved density, strength, and environmental benefits. Overall, these innovations support enhanced performance and sustainability in concrete and construction material.

References

[1]. Vishnu Prasad. S, Vennila. A, Aakash. V (2024) "Experimental Study on Flexural behaviour of Geocement Concrete Beam" https://doi.org/10.55248/gengpi.5.0524.1291

[2]. Krivenko Pavel Vasiljevich, Guziy Sergey Grigorjevich, Kyrychok Vladimir Ivanovich (2014) "Geocement-based Coatings for Repair and Protection of Concrete Subjected to Exposure to Ammonium Sulfate" http://dx.doi.org/10.4028/www.scientific.net/AMR.923.121

[3]. Grigorii Vozniuk, Elena Kavalerova, Pavel Krivenko, Oleg Petropavlovskii(2013) "Physical and Chemical Properties of Adhesives Based on Geocement for Restoration and Rehabilitation of Building Materials" http://dx.doi.org/10.4028/www.scientific.net/AMR.688.123

[4]. Lampros N. Koutas , Christos G. Papakonstantinou(2021) **"**Flexural strengthening of RC beams with textile-reinforced mortar composites focusing on the influence of the mortar type" https://doi.org/10.1016/j.engstruct.2021.113060

[5]. Abdullah Al-Saidy,Sherif El-Gamal, Kazi Abu Sohail(2023) "Strengthening of Reinforced Concrete (RC) Beams using Textile Reinforced Mortars (TRMs)" https://doi.org/10.1007/s40999-023-00867-9

[6]. Saman Babaeidarabad, Ph.D, Giovanni Loreto, Ph.D, and Antonio Nanni, Ph.D,P.E., F.ASCE(2014) " Flexural Strengthening of RC Beams with an Externally Bonded Fabric-Reinforced Cementitious Matrix" http://dx.doi.org/10.1061/(ASCE)CC.1943-5614.0000473

[7]. Dr. K. Chandrasekhar Reddy, G. Ashok(2017) "A study of durability properties of concrete using Geo cement and Vermiculite" ISSN 2319 – 4847

[8]. Sinem Çevik1 & Tugba Mutuk & Başak Mesci Oktay & Arife Kübra Demirbaş(2017) "Mechanical and microstructural characterization of cement mortars prepared by waste foundry sand (WFS)" DOI 10.1007/s41779-017-0096-9

[9]. Arife Kübra Demirbaş, Sinem Çevik, Tuğba Mutuk,Suna Avcioğlu **"**The effect of waste foundry sand on the densification of cement mortars"

[10]. Chandrasen F. Rajemahadik, S. S. Mane, Priyanka Shinde, Sayali Koynde, Kshitija Gaikwade, Shital Desai.(2014) "Replacing waste foundry sand with natural sand in mortar mix 1:3, to investigate compressive strength: A Waste management and environmental approach." http://www.masterbuilder.co.in/data/edata/ASCE/ICSCI-2014.pdf

[11]. Pendhari Ankush R, Demse Dhananjay G, Nikam Madhuri E, Karpe Balraj E, Khairnar Pramod R, Suryawanshi Priyanka R.(2017) "Partial Replacement Of Sand By Waste Foundry Sand" e-ISSN: 2395 -0056 Volume: 04 Issue: 05 | May -2017 www.irjet.net p-ISSN: 2395-0072

[12]. Ranjitha B Tangadagi, P. T. Ravichandran(2024) "Performance Evaluation of Cement Mortar Prepared with Waste Foundry Sand as an Alternative for Fine Aggregate: A Sustainable Approach" https://doi.org/10.1007/s40996-024-01505-7

[13]. Abhishek Srivastava,S.K.Singh(2020) “Utilization of alternative sand for preparation of sustainable mortar:A review”

https://doi.org/10.1016/j.jclepro.2019.119706

[14]. M. Selvakumar, S. Geetha, B. V. Agaliya, S. Shine, R. U. Rupasudharshnee, and M. Sakthivel(2021) “Study on Properties of Polymer Mortar with Foundry Sand” https://doi.org/10.1007/978-981-16-5041-3_16

[15]. Maria Mavroulidou ,David Lawrence (2019) “Can waste foundry sand fully replace structural concrete sand?” https://doi.org/10.1007/s10163-018-00821-1

[16]. Saveria Monosi, Daniela Sani and Francesca Tittarelli (2010) “Used Foundry Sand in Cement Mortars and Concrete Production” 1876-4002/10

[17]. Deepasree Srinivasan,Hariharan Arumugam,Kavikumaran Kannadasan,Muthukaruppan Alagar,

Abdul Aleem Mohamed Ismail(2023) “Utilization of spent foundry sand for the production of masonry products” https://doi.org/10.1007/s10163-023-01767-9

[18]. Paulo Paiva Oliveira Leite Dyer, Luis Miguel Gutierrez Klinsky, Silvelene Alessandra Silva, Rodrigo Alves e Silva & Maryangela Geimba de Lima(2019) “Macro and microstructural characterisation of waste foundry sand reused as aggregate” https://doi.org/10.1080/14680629.2019.1625807

[19]. WR. L Da Silva E. Tochetto B L. R. Prudêncio JR. C A. L. Oliveira D (2011) “Influence of foundry sand residues on the fresh and hardened properties of mortars produced with portland cement” Volume 4, Number 4 (October, 2011) p. 642-662 • ISSN 1983-4195

[20]. B.A. Feijoo, J.I. Tobón, O.J. Restrepo-Baena(2021) “Substitution of aggregates by waste foundry sand: effects on physical properties of mortars” https://doi.org/10.3989/mc.2021.10320