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A Review on Geocement Concrete

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ABSTRACT

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 (CO2) emissions, the environment must be preserved. Geocement was used in this project to completely (100%) replace of cement. Although the Tamil Nadu Public Works Department claims that 5,500 to 6,000 truckloads of 200 cubic feet of sand are mined each day, it is actually thought that 55,000 truckloads of 400 cubic feet of sand are mined each day. 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 concrete (20%, 30%, 40%, and 50%). To determine the mechanical characteristics, durability studies, and microstructural behavior of geocement concrete.

Keywords: Sustainability, Geocement, Foundry Sand (Chromite Sand), Geoconcrete, Strength of Concrete.

INTRODUCTION

Concrete, a widely used building material, raises environmental concerns due to the impact of cement production on CO2 emissions. This study explores the integration of geo-cement, comprising fly ash, bottom ash, and slag, into traditional Portland cement to create a denser structure with reduced porosity. With two tons of raw materials needed to produce one ton of cement and 0.87 tons of CO2 released during the process, cement manufacture is a significant source of carbon dioxide emissions. Geo-cement, derived from industrial waste like fly ash and slag, serves as an eco-friendly alternative. The geopolymer binder, created from waste elements, replaces conventional cement, mitigating carbon emissions and waste in the construction industry. Geo-cement's lower carbon footprint makes it environmentally favorable, addressing sustainability concerns and contributing to a greener approach in concrete production.

Foundry sand, a byproduct of metal casting, consists mainly of high-quality silica sand from sand molds and cores. Primarily composed of silica, it may include materials like clay and additives. With superior quality and grading, it suits diverse construction uses. Research explores foundry sand as a sustainable substitute in concrete production, offering advantages like waste reduction and cost-effectiveness by partially replacing traditional aggregates. Optimal replacement and effects on properties depend on factors such as sand type, treatment, and application requirements. Scientific studies confirm positive impacts on mechanical properties – compressive, split tensile, and flexural strength – aligning with sustainable construction principles. Meticulous assessment of foundry sand properties in each application is crucial for ensuring structural integrity and environmental sustainability.

LITERATURE STUDY

Dr. K. Chandrasekhar Reddy, G. Ashok (2017) The paper provides information about a study on the durability properties of concrete using Geo cement and Vermiculite. The properties of various materials used in the study, such as cement, fine aggregate, coarse aggregate, water, geocement, and vermiculite. It highlights the importance of using quality water in construction works and the potential environmental benefits of geocement. However, it does not provide a specific summary of the review mentioned in the question.

Dr. S. Siddiraju, M. Pavan Kumar (2016) The experimental study concludes that the compressive strength of geocrete is higher than that of normal concrete. Geocrete has a compressive strength of 86 MPa at the age of 28 days, while M25 grade concrete has a compressive strength of 32.26 MPa at the same age. Geocrete is advantageous in terms of simplicity and cost, with a manufacturing cost that is 15-30% lower compared to normal concrete. Geocrete has a quick setting action and can achieve high initial strength gain within 3 hours of casting. Geocrete is an eco-friendly concrete that reduces carbon dioxide emissions by up to 65% compared to normal concrete. Geocement used in geocrete has better acid resistance and is suitable for applications in sewerage pipes, water pipes, and food processing industries. Geocement has low specific gravity and can be used in road construction, allowing for vehicle passage within 3 hours.

P.Dinesh kumar et.al., (2019) The determination is made of the compressive strength of the concrete when the proportions of ordinary Portland cement (OPC) and geo-cement are heterogeneous. The assessment is conducted to determine the optimized quantity of activator to be incorporated into the mixture. Through the experimental examination, it is observed that a combination of 60% OPC and 40% geo-cement, with the addition of 5% activator, yields the highest strength of 40.26MPa. Additionally, it is noted that the percentage of strength increase decreases from 52.24% to 14.77% as the OPC content rises from 20% to 60%.

Kamal Neupane et.al., (2015) The experimental investigation on Portland cement and geocement concretes (Grades 40, 50, 65, and 80) yields several key findings. Geocement demonstrates significantly reduced binder and water requirements at similar consistencies compared to Portland cement. At ambient temperature, geocement sets faster than Portland cement. Up to 28 days, both types exhibit similar compressive strength, but from 28 to 90 days, geocement outperforms with 15–20% strength increases. Heat curing at 70°C for 4 hours achieves 34–45% of the 28-day strength, rising to 63–79% with a 24-hour cure. Changing fly ash and slag proportions minimally impacts strength but suggests adjusting the water-to-binder ratio with varying fly ash content to optimize compressive strength and porosity.

Kavishan Sathsara Ranatunga et.al., (2023) This research aimed to optimize concrete mixtures with Coconut Shell Ash (CSA) to reduce environmental impact while maintaining a target compressive strength of 25 MPa, a common requirement in Sri Lankan structural designs. Five mixes (CSA 0, CSA 15, CSA 20, CSA 25, CSA 30) were examined, and properties were assessed through SEM, EDS, XRF, and DIA analyses. CSA showed improved surface roughness, more carbon particles, and better gradation compared to cement. Workability reduced with increasing CSA content, with CSA 15 and CSA 20 maintaining sufficient workability. Compressive strength peaked at CSA 15 and declined with higher CSA content after 28 and 56 days. GWP, a critical environmental impact category, decreased with increasing CSA content, with CSA 20 identified as the optimal mix, reducing GWP by over 15%. Limitations include the study's constrained timeline, the use of only five concrete mixes, and restricted chemical analysis methods due to resource limitations. Despite these constraints, the study provides valuable insights into optimizing concrete for both structural performance and environmental impact.

Swaptik Chowdhury et.al., (2014) Wood ash characteristics vary with factors like combustion temperature and wood species, necessitating proper analysis before concrete application. Chemical composition differs with wood species but mainly contains lime and silica. Wood ash particles, coarser and more porous than cement, have higher specific surface. Wood ash as cement replacement reduces concrete slump. Water absorption increases with higher wood ash percentages. Marginal initial strength decrease, but age-related pozzolanic reactions enhance strength. Bulk density decreases with rising wood ash content. Up to 10% wood ash replacement in the binder weight is viable for structural-grade concrete. Wood ash replacement doesn't negatively impact chloride permeability. Wood ash incorporation doesn't affect freeze-thaw resistance. Drying shrinkage significantly decreases with wood ash. Water absorption rises with increased wood ash content.

Roz-Ud-Din Nassar et.al., (2021) The field and laboratory investigations of wood-gypsum (WG) concrete, with 20 wt% cement replacement by powder WG, revealed enhanced strength and durability after three years of exposure to harsh weathering and service loads. In field conditions, the WG concrete exhibited up to a 57% increase in compressive strength, a 61% reduction in abrasion weight loss, and a 57% decrease in moisture sorption compared to normal concrete at 300 days. In laboratory tests, WG concrete showed a 43% gain in compressive strength and a 28% gain in flexural strength compared to normal concrete at 90 days. After three years, physical examinations showed no signs of deterioration, affirming WG concrete's constructability akin to normal concrete. Adopting powder WG in concrete practices offers substantial energy, environmental, cost, and performance benefits, potentially reducing the construction industry's carbon footprint.

Tao Luo et.al., (2022) In this study, a carbon footprint-reducing concrete was developed by replacing 0-10% of cement paste with two types of solid waste silica fume (SF and HSF). The fresh concrete's workability decreased with increasing replacements, showing a 27.0-33.6% slump reduction and a 13.7-25.5% decrease in air content. The mechanical properties significantly improved, with cubic compressive strength and splitting-tensile strength increasing by 26.7-57.4%. Total porosity decreased by 41.4-57.3%, correlated with improved strength. Despite the enhancement, the cost per cubic meter increased modestly by 1.9-5.3%, while maintaining economic efficiency compared to silica fume-free concrete. The study suggests that incorporating SF and HSF as cement paste replacements not only improves mechanical properties but also demonstrates economic viability, contributing to both environmental and cost efficiency.

Amrutha K et.al., (2017) In this research, F3 mix demonstrated superior mechanical properties with maximum compressive, flexural, and split tensile strengths attributed to its high density. F3 exhibited a notable 46.63% and 19.28% increase in compressive strength at 7 and 28 days, respectively, compared to conventional concrete. Tensile strength also saw improvements by 38.04% and 12.36% at 7 and 28 days. Although flexural strength showed a slight increase of 0.68% and 0.955% at 7 and 28 days, F3 outperformed in acid attack resistance due to its higher siliceous content. Additionally, a cost reduction of 2.56% was achieved at a 30% replacement level, establishing the economic viability of F3 mix over conventional concrete.

Tarranum Khan et.al., (2018) The compressive strength of concrete exhibits an ascending trend as the proportion of discarded foundry sand increases, up to a certain level of substitution. Specifically, at 30% replacement, the compressive strength of the concrete increased by a significant 23.79% compared to the ordinary mix which did not involve any replacement of foundry sand, after a curing period of 28 days. Furthermore, the workability of the concrete experienced a slight enhancement across different levels of substitution. Consequently, waste foundry sand can be effectively utilized in concrete mixtures, thereby mitigating the challenges associated with its disposal.

Boobala Krishnan K V et.al., (2021) Waste foundry sand, with 30%, 40%, and 50% replacement in concrete, exhibits higher compressive strength, split tensile strength, and flexural strength than standard concrete. Notably, 30% replacement yields the highest values in all three properties. Treated used foundry sand (TUFS) with 5% soluble glass treatment, containing about 80% silica, enhances concrete's mechanical properties with increasing TUFS content. Across replacement levels, TUFS concrete shows improved compressive strength (4-11%), split tensile strength (4-11%), and flexural strength (5-13%) at 28 days. These findings suggest that TUFS can efficiently contribute to high-quality concrete production, offering a sustainable solution that reduces environmental pollution and conserves natural sand resources.

Sunit Kumar et.al., (2023) The utilization of Waste Foundry Sand (WFS) in concrete aligns with the growing emphasis on sustainable construction materials. WFS, a byproduct from non-ferrous and ferrous metal industries, offers a mass-produced waste solution, contributing to the zero-waste goal. Literature indicates that optimal partial replacement levels, typically in the range of 20–30%, enhance concrete properties effectively. However, a comparison between partial and full WFS replacement reveals challenges in full substitution, leading to reduced workability and compressive resistance due to increased water demand. Therefore, while partial replacement showcases technological, economic, and environmental advantages, full replacement might not be suitable for structural concrete, emphasizing the importance of balanced approaches for sustainable construction practices.

N.T. Sithole et.al., (2022) This study proposes a circular economy approach for metal casting industries, repurposing waste foundry sand (WFS), crushed stones, and alkali-activated GGBFS in concrete production. Concrete specimens with 40% GGBFS, 30% WFS, and 30% crushed stones, cured for 90 days, achieved the highest UCS of 12.69 MPa. Microstructural analysis revealed CSH hydration products contributing significantly to strength development. Synthesized specimens met ASTM standards for various construction applications, showing low water absorption. Long-term curing effectively immobilized metals, with leachates below EPA limits, ensuring environmental safety. Alkali-activated GGBFS proved effective as a binder, and WFS demonstrated its potential to replace natural sand in sustainable concrete production. The results suggest a circular economy for concrete, transforming GGBFS into a low-CO2 binder and utilizing WFS for eco-friendly concrete applications. Future research could explore efflorescence formation and excess Na concentration for a comprehensive understanding.

Yogesh Aggarwal et.al., (2014) The study affirms the viability of using waste foundry sand and bottom ash as recycled fine aggregates for structural concrete. Water content increases consistently up to 30% replacement and doubles thereafter, highlighting the potential to vary water content for replacements up to 30%. Concrete with waste foundry sand and bottom ash exhibits mechanical behavior comparable to conventional concrete, with the greatest strength increase observed at 30% replacement. FB30 mix surpasses the control mix in splitting tensile strength at all ages. Strength improvement from 28 to 90 days ranges from 14.52% to 23.89% for FB mixes. Overall, incorporating waste foundry sand and bottom ash positively impacts concrete, offering technical, economic, and environmental benefits, aligning with sustainability goals in construction.

Natt Makul (2019) The study on using Foundry Dust Waste (FDW) as a fine aggregate replacement in Self-Compacting Concrete (SCC) and Rice Husk Ash (RHA) as a partial replacement for Ordinary Portland Cement (OPC) reveals several conclusions of FDW in SCC up to 50 wt% increases superplasticizer requirements, impacting flow slump and decreasing density in the fresh state. FDW usage prolongs V-funnel flow time and setting times due to the inert SiO2 in FDW.SCC with 10% RHA and 30 wt% FDW achieves the highest compressive strength, splitting tensile strength, and static modulus of elasticity. Water and chloride permeability decrease with FDW replacement, and drying shrinkage is influenced by RHA and FDW content. Environmental benefits include reducing landfill leachate, potentially containing hazardous trace concentrations, from RHA and FDW in SCC production.

CONCLUSIONS

The studies delve into sustainable innovations in concrete. The first highlights Geo cement and Vermiculite's success in Geocrete, boasting 86 MPa strength at 28 days and a 65% reduction in CO2 emissions. Coconut Shell Ash and wood ash prove effective replacements, while geocement outperforms Portland cement. The second highlights introduce F3 mix, excelling in mechanical properties and showcasing acid resistance. Waste foundry sand (WFS) enhances concrete, and treated used foundry sand (TUFS) with soluble glass treatment improves mechanical properties. A circular economy approach utilizes WFS, crushed stones, and alkali-activated GGBFS, achieving high strength and meeting environmental standards. Integrating waste foundry sand and bottom ash offers triple benefits, while foundry dust waste (FDW) in self-compacting concrete presents advantages such as reduced landfill leachate.

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