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THE IMPACT OF STEEL, GLASS, AND CRUMB RUBBER ON INTEGRATED GEOPOLYMER CONCRETE: A REVIEW

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ABSTRACT

In an effort to reduce the environmental damage that comes from the open disposal of non-biodegradable waste rubber, the use of scrap tires as building materials has been encouraged. By using tyre grinds instead of natural aggregates, geopolymer concrete (GPC) would have a higher sustainability value. This work was intended to ascertain the amount of potential adverse effects of employing crumb rubber (CR) in GPC, despite the paucity of literature addressing the harm done to GPC properties by rubber aggregates. Furthermore, by adding additives like cement and fibers, this research seeks to alleviate any associated loss in strength and durability. Geopolymer specimens with CR replacement of fine aggregates by volume (0, 5, 10 and 15%) showed a compressive strength reduction of up to 17% when tested according to ASTM standards. Substituting the total binder by weight with Ordinary Portland cement (OPC) (0%, 5%, 10%, 15%, and 20%) improved the microstructural integrity of the rubberised geopolymer mix with the highest percentage of OPC.

Keywords: Geopolymer, OPC, Crumb Rubber, Steel Fibre, Glass Fibre, Sulphuric Acid.

I. INTRODUCTION

Recently, tires that are no longer in use have emerged as a fresh way to pollute the environment. The rate at which trash tires are being dumped has increased in recent years. The vulcanization process used in the production of old automobile and truck tires renders rubber irreversible, making it impossible to recover. Consequently, used tires are either burned in a fire or disposed of in a landfill. Land contamination results from the non-biodegradable nature of tires, which allows poisons to seep into the soil. Burning tires releases heavy metals and hazardous compounds into the atmosphere, which prolongs air pollution. As a result, it is imperative that this hazardous waste material be handled effectively right away. Broken down into smaller pieces, used tires can be effectively used in concrete as a fiber addition or as a substitute for gravel. With a particle size range of around 0.1 mm to 4.76 mm, crumb rubber is a suitable substitute for conventional fine aggregates in concrete. Prior research on rubberized concrete revealed that the mechanical and strength characteristics of the concrete declined with the addition of rubber particles. Furthermore, when the proportion and size of rubber particles grew, the performance decline became more pronounced. Rubber concrete with coarse rubber aggregates performed worse in terms of compressive strength than rubber concrete with fine rubber granules.

The development of geopolymer concrete (GPC) as a dependable and environmentally friendly substitute for conventional OPC-based concrete in the building sector is the focus of current research. There are initiatives underway to improve However, it is important to ensure that the addition of waste materials does not compromise the strength and durability properties of GPC..

II. REVIEW OF LITERATURE

Prabu Baskar et al. (2023)

"A Review on Fresh, Hardened, and Microstructural Properties of Fibre-Reinforced Geopolymer Concrete" Alternative eco-friendly and sustainable construction methods are being developed to address growing infrastructure demands, which is a promising field of study. The development of substitute concrete binders is required to alleviate the environmental consequences of Portland cement. Geopolymers are very promising low-carbon, cement-free composite materials with superior mechanical and serviceability properties, compared to Ordinary Portland Cement (OPC) based construction materials. These quasi-brittle inorganic composites, which employ an "alkali activating solution" as a binder agent and industrial waste with greater alumina and silica content as its base material, can have their ductility enhanced by utilising the proper reinforcing elements, ideally "fibres". By analysing prior investigations, this paper explains and shows that Fibre Reinforced Geopolymer Concrete (FRGPC) possesses excellent thermal stability, low weight, and decreased shrinking properties. Thus, it is strongly predicted that fibre-reinforced geopolymers will innovate quickly. This research also discusses the history of FRGPC and its fresh and hardened properties. Lightweight Geopolymer Concrete (GPC) absorption of moisture content and thermomechanical properties formed from Fly ash (FA), Sodium Hydroxide (NaOH), and Sodium Silicate (Na2SiO3) solutions, as well as fibres, are evaluated experimentally and discussed. Additionally, extending fibre measures become advantageous by enhancing the instance's long-term shrinking performance. Compared to non-fibrous composites, adding more fibre to the composite often strengthens its mechanical properties.

Manvendra Verma et al. (2022)

"Strength properties of geopolymer concrete using steel fibre" The building industry's rising carbon emissions have made the utilisation of alternate materials called Geopolymer Concrete (GPC) which is absolutely necessary for construction. Concurrently, the vulnerability of concrete as a material to severe climatic conditions has necessitated the development of weather-resistant geopolymer concrete. It has been demonstrated that the addition of steel fibres to traditional fiber-reinforced concrete can improve the material's resistance to cracking, which in turn can favourably working in the construction field. Despite this, there have only been a few research that investigate the addition of steel fibre on the property attributes of geopolymer concrete that has been cured at room temperature and has a low NaOH content of 8 millilitres per litre. Fly ash, ground granulated blast furnace slag (GGBS), sodium hydroxide, sodium silicate, Manufacture sand (M-Sand), Fine aggregate and Coarse aggregate were used in the preparation of an ambiently cured geopolymer concrete for the purpose of this investigation. In addition, steel fibres with an aspect ratio of 60 were added to mixture in doses of 0%, 0.5%, 1%, 1.5%, and 2% based on the volume fraction of the mixture.

Sherin Khadeeja Rahman et al. (2023)

"Structural assessment of Basalt FRP reinforced self-compacting geopolymer concrete using artificial neural network (ANN) modelling" Basalt FRP geopolymer composites are considered a sustainable solution to address the conventional OPC-Steel composite structures' structural and environmental concerns, especially the increased carbon emissions and structural deterioration due to corrosion attacks. Recent research on novel composites reports the superior performance of these FRP-geopolymer concrete structural applications reporting high strength and durability. However, the existing design guidelines do not accurately predict the flexural capacity and strength characteristics, which hinders the broader use of FRP-based geopolymer composites. This study aims to develop a prediction tool to help the researchers model the structural performance of the novel FRP-geopolymer composite based on modern machine learning algorithms. It shall address the lack of data on novel composites' structural and long-term performance in various exposure conditions. This paper thus reports the suitability of Artificial Neural Network (ANN) based models to accurately predict the flexural strength of Basalt FRP reinforced self-compacting geopolymer concrete beams under various exposure conditions. The ANN model is trained and validated against the experimental data from the long-term study conducted on the beam specimens subjected to one-year ambient and marine exposures. The ANN prediction model developed in this study reported close agreement with the experimental data showing better prediction accuracy than the existing empirical and numerical models

Mohamad A Hasan et al. (2023)

"Flexural behaviour of geopolymer concrete T-Beams reinforced with GFRP bars" The flexural performance of geopolymer concrete (GPC) T-beams reinforced longitudinally with GFRP bars under a four-point static bending test was investigated. Six full-scale simply supported T-beams were cast and tested; one control specimen was made with ordinary Portland cement concrete (OPCC), while the other five beams were made of geopolymer concrete. The G-GPC2 was designed to attain the same theoretical moment capacity as the G-OPCC6 control beam. The main parameters investigated were the reinforcement ratio of $\rho f / \rho b$ = 0.75, 1.05, 1.12, 1.34

and 1.34 for G-GPC1, G-GPC2, G-GPC3, G-GPC4, and G-GPC5, respectively, and compressive strength of geopolymer concrete. Based on the results of the experiments, the ultimate strain of GPC did not show the same behaviour as that of OPCC, which affects the mode of failure. The beam capacity and deflection were, respectively, overestimated and underestimated using the ACI 440 2R-17 predictive equations.

Peng Zhang. (2021)

"Mechanical and fracture properties of steel Fiber reinforced geopolymer concrete" In this study, the effects of steel fibers on the mechanical properties of the geopolymer concrete – compressive, splitting tensile, and flexural strength; compressive elastic modulus; and fracture properties – were evaluated. Milling steel fibers were incorporated into the geopolymer concrete, and the volume fraction of the steel fibers was varied from 0 to 2.5%. Fly ash and metakaolin were chosen as the geopolymer precursors. Fracture parameters – critical effective crack length, initial fracture toughness, and unstable fracture toughness – were measured by a three-point bending test. The results indicated that all the mechanical properties of the geopolymer concrete are remarkably improved by the steel fibers with the optimum dosage. When the steel fiber content was under 2%, the cubic and axial compressive strength and the compressive elastic modulus increased. The inclusion of 2% steel fibers enhanced the cubic and axial compressive strength and the compressive elastic modulus by 27.6, 23.7, and 47.7%, respectively. When the steel fiber content exceeded 2%, the cubic and axial compressive strength and the compressive elastic modulus decreased, having values still higher than those of the geopolymer concrete without steel fibers. The splitting tensile strength and flexural strength of the concrete were enhanced with increasing steel fiber content. When the steel fiber content was 2.5%, the increment of the splitting tensile strength was 39.8%, whereas that of the flexural strength was 134.6%. The addition of steel

Chithambar Ganesh A et al (2020)

"Investigation on the effect of steel fibers in geopolymer concrete" This research work throws lime light in mitigating the brittleness of GGBS based geopolymer concrete through the addition of high modulus fibers. This work invests the effects of incorporation of steel fibers in geopolymer concrete over workability, compressive, split tensile, flexural, ductility factor and energy absorption capacity. The steel fibers were added in proportions such as 0.25, 0.5, 0.75, 1 and 1.25 percent of the volume of concrete. The results report that addition of steel fibers have positive impacts over mechanical properties, ductility and energy absorption capacity. This paves way for extending the scope of geopolymer concrete in various facets to replace the cement concrete effectively.

Megha rima Datta et al (2018)

"Comparative study of geopolymer concrete with steel fibers in beam column joint" An equivalent test examination was done on the quality and strength of conventional concrete and geo polymer concrete with and without steel fibers in beam column joints and the outcomes were analyzed. Geo polymer concrete are selected building materials which can be utilized as a part in place of Ordinary Portland cement (OPC) and can undoubtedly change the improvement of development industry without causing damage to the nature. In geo polymer concrete we will utilize fly slag, GGBS, Alkaline activated solution as an arrangement. The use of cement emits carbon dioxide which causes pollution. This work has been done to research the Geo polymer concrete (GPCs) with the utilization of steel fiber and compare it with conventional concrete with steel fibers. By making Four GPC blends 1) fly ash remains 60% and 40% GGBS, 2) fly slag 50% and GGBS 50%, 3) 40% fly ash and 60% GGBS, 4) 30% fly ash and 70% GGBS alongside control GPC blend which is then included with snared steel fibers. In conventional concrete we will assess utilizing with and without steel.

III. OBJECTIVES OF VIEWS

- Steel Fiber, Glass Fiber, and Crumb Rubber are used in geopolymers concrete are innovative materials that offer unique properties and advantages compared to traditional construction materials. The objectives of using these materials in construction projects include:
- Objectives of Steel Fiber in Geopolymer Concrete: The objective of steel fibers in geopolymer concrete is to enhance performance by improving toughness, impact resistance, and abrasion resistance. Steel fibers also reduce sorptivity, enhance durability, and improve interfacial bond strength and mechanical behavior in polymer composites.

- Different trial mix of Steel Fiber used as a partially replacement of Coarse aggregates by percentages of 0%,10%,20%,30% and 40%.
- Different trial mix of Crumb Rubber used as a partially replacement of Fine aggregates by percentages of 0%,10%,20%,30% and 40%.
- Glass fibres also affect workability and density negatively but significantly improve impact strength. Glass fibres used in Geopolymer Concrete with 1.5% used.
- Additionally, glass fibres are aimed to reduce concrete matrix porosity so they can be of structural use for long time under harsh acidic environments.

IV. RAW MATERIALS

Raw materials

1. OPC-43 grade cement

Ordinary Portland Cement 43, or OPC-43 grade cement, is a type of cement that is included in the Ordinary Portland Cement category. Because of its intermediate strength, OPC-43 grade cement is appropriate for a variety of construction projects that call for a compromise between resilience and cost-effectiveness. This kind of cement is a popular option for residential construction projects in India since it provides fair strength, constant performance, decent workability, and affordability.

Figure 1: Ordinary Portland Cement 43 grade

2. Glass fiber

Glass fiber used in fiberglass production comes in various types, each with specific properties and applications. The main types of glass used in fiberglass production include:

S-Glass: S-Glass is an alumina silicate glass without calcium oxide but with high magnesium oxide content, offering exceptional tensile strength.

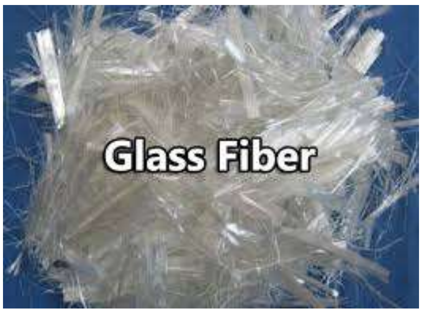

Figure 2: Glass fiber

3. Steel Fiber

Short steel fibers are added to concrete to improve its toughness and ductility, which raises the material's tensile and bending strengths. This process is known as steel fiber reinforced concrete. These steel fibers are available in a range of diameters, from longer microfibers that increase ductility and strength to smaller microfibers that lessen cracking. The best usage of the material for various applications, whether in commercial or residential construction projects, depends on the type of steel fibers used and how much of them are added to the concrete mix.

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Figure 3: Steel fibers

4. Fine Aggregate (Sand)

Any natural sand particles that are extracted from the ground during the mining process are considered fine aggregates. They are made up of ¼" or smaller natural sand or crushed stone particles. The size or grading of these aggregates frequently lead to them being referred to as 1/4" minus. There are several ways to obtain fine aggregates, including "Quarry Fines," C33, Mark West Quarry Clay, and ¼" minus.

Figure 4: Fine Aggregate (Sand)

5. Crumb Rubber (Fine Aggregate)

Made from discarded tires that have been cleaned, ground into tiny bits, and screened to obtain consistent sizes, crumb rubber is a multipurpose material. These particles range in size from dust-like particles to minuscule particles that are slightly smaller than a coin, measuring about half an inch. Steel and tire cord are removed to produce crumb rubber, which is granular rubber with a variety of uses.

Figure 5: Crumb Rubber (Fine Aggregate)

6. Coarse Aggregate

When Coarse Aggregate are sieved based on size, the larger particles that are kept on a sieve are referred to as coarse aggregate. Because they make up the majority of the mix volume, coarse aggregates are a necessary ingredient in the manufacturing of concrete. Usually, resources like crushed stone, gravel, or recycled concrete are used to make these aggregates. By preventing compressive loads, coarse particles give concrete strength. By offering protection against weathering and other external variables, they also add to the concrete's longevity. Using too much coarse aggregate can make the concrete less workable, but using the proper amount can make the concrete more workable by giving the mix a skeleton.

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Figure 6: Coarse Aggregate

V. CONCLUSION

1. The work's main goal is to effectively replace the coarse aggregate in M30 grade concrete with steel Fiber and the fine aggregate with crumb rubber were evaluated in comparison to traditional concrete between Glass Fiber concrete.
2. Steel Fiber aggregate was used to substitute natural coarse aggregate to varying degrees (10%, 20%, 30%, and 40%), in order to determine the obtained optimal value of steel slag utilized Glass Fiber concrete.
3. To effectively replace fine aggregate (Sand) with crumb rubber is evaluated in comparison to traditional concrete. Replace a portion of the natural fine aggregate and the fine aggregate at varied ratios of (10%, 20%, 30%, and 40%), with crumb rubber utilized Glass Fiber concrete.
4. The workability of concrete for different percentage replacement of the coarse aggregate in M30 grade concrete with steel Fiber and the fine aggregate with crumb rubber were evaluated in comparison to traditional concrete between Glass Fiber concrete.

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