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A Review Paper on Partial Replacements in Concrete: Alccofine, Crumb rubber waste and Chromite Sand

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ABSTRACT

In this study investigates the impact of incorporating Alccofine, a novel supplementary cementitious material, along with partial replacement of fine aggregates with crumb rubber and chromite sand, on the properties of concrete. Alccofine, known for its high reactivity and fine particle size, was used to enhance the performance characteristics of concrete. Fine aggregates in the concrete mix were partially replaced by crumb rubber, derived from recycled tires, and chromite sand, a by-product of chromite ore processing. The experimental program involved a comprehensive analysis of the effects of these materials on fresh and hardened concrete properties, including workability, compressive strength, flexural strength, and durability. Results indicated that the incorporation of Alccofine improved the workability and strength of the concrete, while the use of crumb rubber led to a reduction in density and an increase in impact resistance. Chromite sand contributed to enhanced mechanical properties and durability. This research demonstrates that the combination of Alccofine with crumb rubber and chromite sand can lead to more sustainable and high-performance concrete formulations, potentially offering solutions for both waste management and construction industry challenges.

Keywords: Alccofine 1203, Crumb Rubber Waste, Chromite Sand

INTRODUCTION

Concrete is a vital component in modern construction, valued for its strength, durability, and versatility. As the construction industry seeks more sustainable and resource-efficient solutions, innovative material modifications are being explored to enhance concrete's performance and environmental footprint. This study investigates the properties of concrete incorporating Alccofine, a high-performance mineral admixture, along with partial replacements of traditional fine aggregates with crumb rubber waste (10%) and chromite sand (10%, 20%, 30%, 40%, 50%). By systematically evaluating these components, this research aims to understand their effects on concrete's workability, strength, durability, and sustainability. The findings are expected to contribute to more environmentally friendly and high-performance concrete solutions, paving the way for advancements in construction practices.

Alccofine 1203

Alccofine 1203 is typically used in high-performance concrete applications, such as in structural elements, pavements, and precast concrete products, where enhanced strength and durability are required. Overall, Alccofine 1203 is valued for its ability to enhance concrete properties while potentially reducing the environmental impact associated with traditional cement production. Incorporation of Alccofine 1203 in concrete mixes typically results in higher compressive and flexural strengths compared to conventional concrete. Its fine particles improve the workability and flowability of the concrete, making it easier to handle and place. The use of Alccofine 1203 can enhance the durability of concrete by reducing its permeability and improving resistance to environmental factors like chemical attack and freeze-thaw cycles.

Crumb Rubber

Crumb rubber, derived from recycled tires, has been investigated for its potential to enhance the impact resistance and flexibility of concrete. By replacing a portion of fine aggregates with crumb rubber, concrete density can be reduced, and its impact resistance can be improved. However, the challenge lies in understanding the trade-offs between these benefits and potential impacts on other concrete properties, such as strength and durability.

Chromite Sand

Chromite sand is a high-quality sand-like material derived from chromite ore, which is the primary source of chromium. Chromite sand is known for its unique physical and chemical properties, making it valuable in various industrial applications, particularly in the production of high-performance materials. In some specialized concrete applications, chromite sand is used as a partial replacement for fine aggregates to enhance the concrete's mechanical properties and durability, particularly in high-temperature or corrosive environments. Overall, chromite sand's unique properties make it a valuable material in several industrial and construction applications, offering enhanced performance and durability.

LITERATURE REVIEW

MCK. Jamenraja and K. Ravichandran (2022) In this study have demonstrated the effectiveness of incorporating supplementary cementitious materials to improve the properties of concrete. Specifically, the inclusion of Nano silica and Alccofine in ternary blended concrete has shown promising results. Nano silica, due to its ultra-fine particles and high reactivity, significantly contributes to the hydration process and microstructure of concrete. According to research, adding 1% Nano silica along with 15% Alccofine to ternary blended concrete resulted in a 6.57% increase in compressive strength. This improvement is attributed to the enhanced pozzolanic reactions and the refining of the pore structure, which lead to a denser and more robust cement matrix.

Balamuralikrishnan R and Saravanan J (2019) Portland cement is the most important ingredient of concrete. A large-scale production of cement plant consumes large amount of energy and produce a number of undesirable products ($CO2$) which negatively affect the environmental and depletion of natural resources. This treat to ecology has to lead to researchers to use industrial by-products as supplementary cementitious material in making concrete. In view this silica fume (SF), ground granulated blast furnace slag (GGBS), rice husk ash, fly ash (FL), metakolin, alccofine (AL), micro fine material, etc.; are tried out for replacing cement partially or fully in concrete, without compromising on its strength, also reduce greenhouse gases and sustainable way of management of waste. A new ultra-fine material emerged in market is called alccofine. This is available as a cementious material for replacing cement. Since this a new material, a study is tried out with the combination of Alccofine and GGBS. Ordinary Portland Cement 53 grade was used throughout the study and the grade of concrete is M20.

Jagadeesan R and Gokul S (2023) Alccofine, a rice husk-based cementitious material, was tested for its effects on concrete strength and durability. Six concrete mixes with varying Alccofine and cement ratios were evaluated. Results showed that a 15% Alccofine replacement significantly boosted strength and reduced porosity, improving resistance to water and chloride penetration. The best performance was observed with 100 kg/m³ of Alccofine. While Alccofine enhanced concrete properties, crumb tyre rubber reduced compressive strength due to bonding issues. Further research is needed to optimize Alccofine dosage and explore its long-term effects.

Bode Venkata Kavyateja, J. Guru Jawahar and C. Sashidhar (2020) Cement is essential in concrete but its production is energy-intensive and environmentally damaging. To address this, researchers are exploring industrial by-products like quartz powder, metakaolin, slag, silica fume, and fly ash as sustainable alternatives. This study examines the effects of Alccofine as a partial cement replacement (at 0%, 5%, 10%, and 15%) with a constant 25% fly ash on concrete properties. Analytical methods such as TGA, XRD, FTIR, and SEM showed that Alccofine and fly ash significantly enhance concrete performance. TGA revealed reduced mass loss and increased hydrate decomposition, SEM showed improved microstructure, XRD confirmed better CSH and CASH formation, and FTIR indicated improved mineral composition.

K. Jagannadha Rao and Mohammed Abdul Mujeeb (2013) Cement concrete's high demand strains natural resources like sand and stone and raises environmental concerns due to excess solid waste, including fly ash and silica fume. This study examines the effect of crumb rubber on Ordinary Portland Cement (OPC) and Ternary Blended Concrete (TBC) of M40 grade, which includes fly ash and silica fume. Adding crumb rubber slightly reduced workability and unit weight, with reductions of 2.16% for 5% crumb rubber, 5.15% for 10%, and 7.43% for 15%. While compressive strength decreased with more than 5% crumb rubber, leading to unsuitability for structural use, impact energy increased significantly. Concrete with 5% crumb rubber showed a 100% boost in impact strength and narrower cracks compared to non-rubber concrete. In India, scrap tyres could be useful in concrete for vibration damping in applications such as foundation pads and airport runways.

Rudrapratap Singh Kaurav, Sandeep Gupta and Shailendra Prasad Tiwari (2021) This paper investigates the use of waste tyre crumb rubber as a partial replacement for fine aggregates in concrete, with silica fume added to improve bonding properties. The study tested M30 grade concrete with crumb rubber at 5%, 10%, and 15% replacement levels. Results indicated that while increasing crumb rubber decreased compressive, flexural, and split tensile strength, silica fume enhanced the bonding properties. The concrete's workability improved with higher rubber content, leading to better compaction and fewer voids. The optimal performance was found with 5% crumb rubber, balancing improved workability with acceptable strength.

Shashwati Soumya Pradhan, Umesh Mishra, Sushant K. Biswal and (2022) This study explores using alternative binders and crumb rubber (CR) to create lightweight alkali-activated concrete (AAC). Four binders fly ash, rice husk ash (RHA), metakaolin, and bottom ash were tested with CR substitutions of 0%, 10%, 20%, and 30%. AAC mixes, prepared with a 12M sodium hydroxide (NaOH) solution and a sodium silicate to NaOH ratio of 2.5, were cured at ambient temperature. Results indicated that while strength decreased with higher CR content especially at 30% it remained acceptable. AAC showed consistent performance in compressive, flexural, and split tensile strengths, though the highest water absorption was observed with bottom ash binder and 30% CR. Fly ash and metakaolin binders outperformed others in acid resistance. Overall, AAC with 20% CR proved to be a sustainable and durable option.

Mr. Jaydeo Phadtare, Dr. N. K. Patil and Dr. A.D. Katdare (2022) The purpose of this paper is to evaluate the impact of partially replacing coarse aggregate with untreated waste tyre rubber on concrete properties. This study employs tests such as compressive strength, split tensile strength, flexural strength, and slump cone tests. With the rising number of vehicles in India, the generation of waste tyres is also increasing, making their recycling challenging. Our goal is to incorporate waste tyre rubber into concrete without adversely affecting its properties. The study analyzes concrete with partial replacement of coarse aggregate by waste tyre rubber chips (10-15mm x 10mm) and assesses the effects on compressive, flexural, and split tensile strengths after 7 and 28 days of curing.

Vinit Kumar, Munesh Kumar, Nakul Gupta, Akula Prakash, Hemanth Raju, Amandeep Nagpal, Pradeep Kumar Chandra, Q.Mohammad (2024) The use of recycled rubber in construction is gaining significance due to its benefits in conserving landfill space and reducing reliance on natural resources. Incorporating rubber scraps as fine or coarse aggregates in Portland cement can enhance the strength and durability of concrete. This paper reviews studies on replacing conventional fine aggregates with waste rubber ash in cement-based mortar and concrete. Findings indicate that up to 10% substitution of natural sand with waste rubber ash improves compressive strength by 14.93% and increases water absorption capacity. However, strength decreases if the substitution level exceeds 10%.

Bhanavath Sagar and M V N Sivakumar (2021) In these Review a Supplementary cementitious materials (SCMs) have transformed concrete production by enhancing traditional binders. This paper reviews the mechanical and durability properties of concrete using alccofine-1203 as an SCM. Its ultra-fine particles and unique chemical composition improve hydration, workability, and early strength while reducing segregation, heat of hydration, and permeability. Alccofine-1203, with its calcium and silica content, outperforms other SCMs. The optimal dosage is between 8% and 12%, where the benefits are most pronounced. This study summarizes alccofine-1203's effectiveness in various concrete types and its impact on concrete properties.

S. Kavitha and T. Felix Kala (2016) The study examines how combining alccofine and GGBS enhances the strength of Self-Consolidating Concrete (SCC). Using the Nan-Su method for mix design, varying alccofine dosages (5%, 10%, 15%, and 20% by volume) with a constant 30% GGBS improved SCC's workability and strength. Key findings include increases in compressive strength from 36.6 to 42.9 N/mm^2, splitting tensile strength from 3.8 to 7.9 N/mm^2, and flexural strength from 4.9 to 8.3 N/mm^2 at 28 days. The combination of alccofine and GGBS effectively enhances SCC's mechanical and rheological properties, achieving high performance and strength.

Abhijitsinh Parmar and Dhaval M Patel (2013) India, a developing country, is increasingly constructing skyscrapers and other heavy structures, which require high-performance concrete. For decades, researchers have explored alternative binders and cement replacement materials, including fly ash, volcanic ash, volcanic pumice, pulverized-fuel ash, blast furnace slag, and silica fume. These materials are pozzolanic, reacting with lime released during cement hydration. This study aims to develop economical and eco-friendly High Strength Concrete (HSC). Fresh concrete tests were conducted to assess the properties of the concrete at the hardened stage.

Samar Raffoula, Reyes Garciaa, Kypros Pilakoutasa, Maurizio Guadagninia, Nelson Flores Medina (2016) This article examines rubberized concrete (RuC) with high rubber content to optimize its mechanical properties. It tested 40 RuC mixes, varying rubber volume, aggregate type, water content, binder type, and rubber treatments. Scanning Electron Microscope (SEM) analysis explored the rubber-concrete bond at the Interface Transition Zone (ITZ). The study identified an “optimum” RuC mix that improved workability and strength, showing up to a 160% increase in compressive strength compared to non-optimized concrete with 100% fine aggregate replacement. This optimized mix, with a better binder and moderate water/binder ratio, is suitable for sustainable, high-value applications. Higher rubber contents generally reduce workability, density, and strength, but combining fine and coarse aggregates helps maintain strength and workability.

Ajith Thomas and Reni Kuruvilla (2023) Disposing of waste tires is a major environmental issue due to their non-biodegradable nature. One effective solution is using tire rubber as a substitute for fine aggregate in concrete. This study tested various concrete mixes with 20%, 25%, and 30% tire rubber replacing sand and found that 20% rubber provided the best strength characteristics, nearly matching conventional concrete in compressive and flexural strength but lacking in split tensile strength. Incorporating 25% fly ash into the mix improved strength and stability, with the 20% rubber and 25% fly ash mix performing better than ordinary concrete. Thus, 20% rubber is optimal for fine aggregate replacement, and adding 25% fly ash enhances the mix while aiding in the disposal of tire rubber and fly ash.

Parmender Gill and Parveen (2022) This experimental study presents a systematic mix-design procedure for developing rubberized geopolymer concrete (RGPC). The method aims to determine the optimal mix ratios for high-strength, low-calcium fly ash-based geopolymer concrete, using Ordinary Portland Cement (OPC) as a supplementary binder and crumb rubber as a partial replacement for fine aggregates. Key variables include binder content (80% fly ash and 20% OPC) at 350, 375, and 400 kg/m^3, crumb rubber percentages (0%, 5%, 10%, and 15%), and NaOH molarity (8, 10, and 12 M). The focus is on achieving the desired compressive strength and workability under heat curing (60°C). Thirty-six mix designs were tested for compressive strength at 7 and 28 days, with results illustrated in CR-GPC graphs. A trial experiment confirmed the effectiveness of the proposed mix-design procedure. The methodology is unique due to the extensive range of variables and mix designs tested. The proposed mix design reliably achieves the target strength, with an OPC-supplemented GPC incorporating 15% crumb rubber achieving a compressive strength of 43.26 MPa at 7 days under heat curing.

Salonia, Parveen, Thong M. Pham (2021) This study investigated how various pre-treatment methods for crumb rubber (CR) affect the strength, permeability, and acid resistance of geopolymer concrete (GPC) where pretreated CR replaces fine aggregates. The results led to identifying the most effective pre-treatment method based on specific parameters such as strength or acid resistance. The study concluded that GPC with ultra-fine slag (UFS) treated CR achieved better strength, while GPC with NaOH treated CR demonstrated enhanced acid resistance. Thus, using waste CR in GPC offers a sustainable construction material and promotes cleaner production practices**.**

N.A.G.K. Manikanta Kopuri, and Dr. K. Ramesh (2019) Concrete, composed of fine and coarse aggregates, cement, and water, is crucial in construction. This study explores Ferro chrome slag, a waste from stainless steel production, as an alternative to natural aggregates due to their rapid depletion in India. M30 grade concrete was tested with slag replacing sand at 0%, 10%, 20%, 30%, and 40%. Strength tests (compressive, tensile, and flexural), workability (slump and compaction factor), and durability (acid and alkaline resistance) were conducted. Results show that Ferro chrome slag is effective up to 40% replacement, offering good resistance to aggressive conditions and making it suitable for both PCC and RCC applications.

Serhat and Mehmet (2018) Chrome ore tailings, often discarded during mining, pose land and environmental issues. In Turkey, where the annual ready-mixed concrete consumption is about 1.5 m^3 per person, using these tailings in concrete could address disposal and sand shortages. This study tested replacing fine aggregate with chrome ore tailings at 0%, 10%, 20%, and 30% by weight in ready-mixed concrete. Evaluations of unit weight, compressive strength, and ultrasonic pulse velocity showed that 30% tailings replacement offers both ecological and economic benefits. However, lower proportions may negatively affect concrete properties, suggesting further research on durability is needed.

Manoj Kumar Dash and Sanjaya Kumar Patro (2018) This study evaluates the use of water-cooled ferrochrome slag, a byproduct of the ferrochrome industry, as a partial sand replacement in concrete. Substituting sand with ferrochrome slag at 0%, 10%, 20%, 30%, 40%, and 50% by weight was tested. While some reduction in strength and increase in water absorption were observed, a 30% replacement showed nearly the same performance as the reference mix. Leachability tests and SEM analysis confirmed acceptable pH levels and no adverse micro-structural effects. The study finds that up to 30% ferrochrome slag is a viable sand substitute in concrete, with minimal environmental or performance issues, but suggests further research to confirm its overall suitability.

N manigandan and V Ponmalar (2020) This review evaluates river sand substitutes, specifically Manufactured Sand (Msand) and Ferrochrome Slag (FeCr slag), for use in concrete and mortar. While research on FeCr slag is limited, this study aggregates existing data to assess its effectiveness. Msand, with similar shape, texture, and properties to river sand, proves to be a good replacement. In contrast, FeCr slag, although comparable in shape, is porous and contains MgO and Cr_2O_3, which can impact concrete properties. The study finds that Msand is a strong fine aggregate alternative, and FeCr slag performs well up to a 40%-50% replacement level, improving over time. Detailed strength analyses show that FeCr slag is most effective at 40%-50% replacement, and Msand at 50% offers superior flexural strength compared to other options.

CONCLUSION

In conclusion, the study highlights that incorporating 10% alccofine into concrete can significantly enhance its compressive and tensile strength due to its fine particle size and high reactivity. Alccofine also improves resistance to chemical attacks, reduces permeability, and boosts overall durability. Its impact on workability varies based on the replacement level and binder type used. Meanwhile, crumb rubber waste from recycled tires is being explored as a sustainable alternative for replacing up to 10% of fine aggregates in concrete. Tests on rubber of sizes ranging from 0.01mm to 2.5mm revealed a 14.93% improvement in compressive strength with 10% rubber substitution compared to standard concrete. This use of crumb rubber aids in waste management and aligns with eco-friendly construction practices. Additionally, replacing sand with chromite sand (10% to 60%) results in lower initial strength due to MgO content, but it performs better than ordinary sand over time. Both alccofine and chromite sand offer ecological and economic advantages while maintaining or enhancing concrete durability and strength.

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