

REVIEW PAPER ON INVESTIGATING THE INFLUENCE AND PERFORMANCE OF LIGHTWEIGHT COARSE AGGREGATES WITH FLY ASH IN CONCRETE

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ABSTRACT

This study aims to thoroughly examine the interaction and performance effects of using lightweight coarse aggregates (LWCA) and fly ash in concrete mixtures. Lightweight aggregates are highly valued for their low density, which provides benefits such as reduced structural weight and improved thermal insulation. Fly ash, a byproduct of coal combustion, is used as an additional cementitious material that enhances both the mechanical properties and environmental sustainability of concrete.

The research aims to comprehensively assess the impact of LWCA and fly ash mixtures on many aspects of concrete performance, including compressive strength, durability, and other relevant engineering parameters. The study intends to clarify the subtle impacts of different quantities of lightweight coarse aggregates (LWCA) and fly ash on concrete behavior by using a comprehensive strategy that combines concrete mix design, mechanical testing, and thorough microstructural analysis.

This work aims to enhance our comprehension of the feasibility and possible advantages of integrating LWCA, fly ash, and concrete elements in concrete production procedures by unraveling their complex interconnections. Moreover, the results offer vital information for improving concrete compositions in order to not only meet, but beyond performance criteria, while simultaneously promoting sustainability goals in the building sector.

In the conclusion, the results of this research project have the potential to provide information and guidance for improving manufacturing procedures in order to achieve higher levels of performance, durability, and sustainability in infrastructure development.

Key Words: Lytag, Sintered flyash aggregate, lightweight aggregate concrete, sand light weight aggregate concrete, lightweight concrete.

1. INTRODUCTION

Concrete is a fundamental material in contemporary building, found in a wide range of constructions, from towering skyscrapers to simple sidewalks. Nevertheless, the need to construct in an environmentally friendly manner has sparked a reassessment of conventional concrete compositions, leading researchers and professionals to investigate substitute resources and inventive methods. Among these options, combining lightweight coarse aggregates (LWCA) with fly ash has great potential, as it can lead to reduced environmental impact, higher performance, and increased sustainability.

The main objective of this study is to examine the impact and effectiveness of Lightweight Concrete Aggregates (LWCA) combined with fly ash in concrete mixtures. This introduction explains the reasoning behind this research project, emphasizing the importance of investigating the interactions between LWCA, fly ash, and traditional concrete components.

The environmental impact of concrete, mainly due to the energy-intensive manufacturing of cement, highlights the need for the construction industry to prioritize sustainable practices. Researchers have attempted to create concrete mixtures that reduce the amount of cement used, while still maintaining or improving performance. This endeavor has resulted in the adoption of supplemental cementitious materials (SCMs) such as fly ash, which is a residue produced from the burning of coal in thermal power plants. Fly ash demonstrates pozzolanic characteristics by chemically interacting with calcium hydroxide in the presence of water to produce more cementitious compounds. This reduces the need for Portland cement and helps to reduce carbon emissions.

Moreover, the use of Lightweight Concrete Aggregates (LWCA) in concrete offers a chance to tackle another crucial element of sustainability: diminishing the environmental consequences linked to the mining and transportation of aggregates. Lightweight aggregates, which are usually made from natural materials or industrial leftovers, have lower densities than regular aggregates. This leads to less structural dead loads and transportation expenses. Furthermore, LWCA provides thermal insulation characteristics that have the ability to enhance the energy efficiency of buildings and infrastructure.

In this context, the combination of LWCA and fly ash in concrete has great potential to improve the material's performance and contribute to sustainability goals. This study aims to enhance the existing knowledge on sustainable construction materials and practices by examining the combined impacts of LWCA and fly ash on different characteristics of concrete.

The project aims to conduct a comprehensive examination of LWCA-fly ash concrete mixtures, with a specific focus on examining their mechanical properties, durability, workability, and microstructure. The primary objective of the study is to investigate the mechanical properties of LWCA-fly ash concrete by conducting extensive tests, which include evaluating its compressive strength, flexural strength, and modulus of elasticity. Comprehending the interaction of LWCA and fly ash with other components of concrete is essential in evaluating the material's appropriateness for structural purposes.

Furthermore, the inquiry focuses on the durability properties of LWCA-fly ash concrete, specifically analyzing its ability to withstand chloride ion penetration, sulfate assault, alkali-silica reaction, and other harmful processes. Considering the significance of durability in guaranteeing the long-lasting nature of concrete structures, this part of the research focuses on crucial issues pertaining to the performance of materials under extreme environmental circumstances.

Furthermore, the research aims to analyze and describe the physical and mechanical features of lightweight coarse aggregate (LWCA)-fly ash concrete. This includes evaluating its ability to be worked with, its density, porosity, and tendency to shrink. These features have a significant impact on both the construction procedures and the quality of the finished product. Additionally, they offer valuable information about how the material behaves over time.

Finally, a thorough examination of the microstructure using sophisticated methods like scanning electron microscopy (SEM) and X-ray diffraction (XRD) will provide important information about the hydration products and the morphology of the interfacial transition zone (ITZ) in lightweight aggregate (LWCA)-fly ash concrete. Gaining insight into the microstructural changes of the material enhances our comprehension of its performance traits and guides us towards prospective avenues for improvement.

This study aims to enhance our comprehension of sustainable concrete technology by examining the impact and effectiveness of Lightweight Concrete Aggregates (LWCA) combined with fly ash. The research seeks to enhance the understanding of how these materials work together with traditional concrete components. Its goal is to design concrete mixtures that are optimized to meet performance standards and promote sustainability. The findings have significant implications for several stakeholders in the building sector, including researchers, engineers, policymakers, and environmental advocates, who are all working towards creating a more sustainable future.

2. LITERATURE REVIEW

Lucyna Domagala (2020) conducted an experiment to test the strength and longevity of lightweight concrete that included sintered flyash aggregates. A total of twelve distinct concrete mixtures were created, each varying in terms of water cement ratio (either 0.55 or 0.37), coarse aggregate gradation (either 4/8 mm or 6/12 mm), and initial moisture state of coarse aggregates (either oven dried, wet, or water saturated). The density of all the concrete mixes ranged from 1470 kg/m³ to 1920 kg/m³. Utilizing a 4/8 mm aggregate fraction resulted in the concrete attaining more strength compared to concrete containing a 6/12 mm aggregate fraction. This was attributed to the increased crushing resistance of the 4/8 mm aggregate. The water absorption of the concrete was determined by its densities, which reflect the porosity of the aggregate and cement matrix. The higher the density of concrete, the lower its water absorption. The durability of the concrete made with pre-saturated aggregates was lower compared to the concrete made with dried or moistened particles. The water absorption of this type of pre-saturated aggregate concrete was exceptionally high. Pre-saturated aggregate concrete exhibited reduced resistance to freezing and thawing as a result of these factors.

A. Arokiaprakash and V. Thenarasan (2018) conducted an experiment to investigate the strength qualities of concrete when a portion of the coarse aggregates were substituted with sintagg aggregates. The mix design for concrete with a grade of M25 was conducted according to the specifications stated in IS 10262:2009. The test specimens were created by substituting 10%, 20%, 30%, 40%, and 50% of the coarse aggregates with sintagg aggregates. The specimens underwent testing to determine their compression, tension, and flexural strengths on the 3rd, 7th, 14th, and 28th days of the curing process. The materials utilized included OPC 53 cement, which adhered to the specifications outlined in IS 8112:1989, river sand that met the requirements of zone III in IS 383:1970, coarse aggregates with a maximum size of 12mm that complied with IS 2386:1993, and Sintagg flyash aggregates. The characteristics of the sintagg flyash aggregates utilized are presented in table 1. The mix ratio achieved for M25 grade

concrete, as per the specifications of IS 10262:2009, was 1 part cement, 2.6 parts fine aggregate, and 2.5 parts coarse aggregate. As the ratio of sintagg grows, the density of concrete falls. The specific gravity of all the synthetic aggregate concrete was lower than that of conventional concrete. The concrete using 50% sintagg as a replacement had the lowest unit weight compared to other concrete mixtures. A cube compressive strength test was conducted on a cube of 100 x 100 x 100 mm. Increasing the proportion of substitution of sintagg aggregates from 10% to 30% results in a decrease in the compressive strength of concrete. The compressive strength of concrete with 40% replacement was superior to the other concrete proportions. Comparable fluctuations were noted throughout the 3, 14, and 28-day curing periods. Specimens with a cylindrical shape, measuring 100 mm in diameter and 200 mm in length, underwent testing for durations of 7, 14, and 28 days. Concrete cylinders made with conventional concrete and concrete with 40% sintagg replacing the coarse aggregate were tested for split tensile strength. There was a slight drop in the strength of the sintagg replacement concrete, with the reduction in strength being less than 1%. Prism specimens of 100 x 100 x 500 mm were subjected to flexural strength testing after 7, 14, and 28 days of curing. Four point load tests were conducted. A comparison was made between conventional concrete and concrete with 40% of its content replaced with sintagg. An analysis revealed a decrease in the flexural strength of concrete using sintagg as a replacement, in comparison to traditional concrete. The highest compressive strength of lightweight concrete is attained by replacing 40% of the sintagg aggregate, resulting in a 1.39% increase in compressive strength. The split tensile and flexural test results indicate a marginal decline in the strength characteristics, which warrants further investigation through the incorporation of fibers in the concrete.

J.Bright Brabin Winsley and M.Muthukannan (2018) conducted an experiment on two distinct concrete mixes. One mix used conventional coarse aggregate while the other mix used expanded flyash clay aggregate. An reported decrease of 14% in the compressive strength of flyash clay aggregate was noted. The tensile strength of the concrete using flyash clay aggregate was lower. Utilizing flyash clay aggregate in concrete resulted in a decrease in chloride penetration, hence enhancing the safeguarding of the reinforcements in the concrete.

Nallaiahgari Sivanagi Reddy and CH.Vema Reddy (2017) examined how the mechanical characteristics of concrete are affected by the use of fly ash aggregates as coarse aggregates. The mix design for M40 concrete was acquired utilizing the IS 10262:2009 standard. A comparison was made between the characteristics of ordinary concrete and flyash aggregate concrete. Flyash aggregate concrete exhibited superior workability compared to ordinary concrete. The enhanced workability was attributed to the spherical morphology of fly ash aggregates. Therefore, the amount of superplasticizer can be decreased in the case of fly ash aggregate concrete. Utilizing flyash as coarse particles led to a 15% decrease in the density of concrete compared to traditional concrete. The decrease in density was a result of the low mass of flyash aggregates. After 1 day of curing, the compressive strength of conventional concrete exceeded that of flyash concrete by 68%. However, after a curing period of 28 days, the compressive strength of conventional concrete was 48% higher than that of the fly ash concrete. These findings indicate that the initial strength development of fly ash concrete was lower, but the strength of fly ash concrete increases with the progress of curing.

M.S. Nadesan and P. Dinakar examined the characteristics of fly ash aggregates that are appropriate for usage as coarse aggregates. The following conclusions were drawn based on their review. The physical characteristics of fly ash aggregates are mostly determined by the fineness of the fly ash. The flyash aggregates exhibited a spherical morphology and had a specific gravity ranging from 1.33 to 2.35. Fly ash aggregates exhibited lower permeability and chloride penetration compared to traditional aggregates. Fly ash aggregate concrete exhibited superior corrosion resistance compared to standard concrete.

S. Viveka and R. Renuka (2016) conducted an experiment on concrete, where they replaced the coarse and fine aggregates with flyash aggregates. The study utilized OPC 53 grade cement, Flyash, river sand, flyash fine aggregate, hard shattered granite stone, and flyash coarse aggregates as components. The trials were conducted on concrete samples that consisted of 100% fly ash as the fine aggregate. The percentage of coarse aggregate replaced by fly ash was changed from 0% to 100%, with a 10% increment in each succeeding trial. The flyash aggregates were created by combining cement and flyash in a 25:75 ratio, using a water-cement ratio of 0.3. The components were combined in a concrete drum mixer until pellets were created, and then the pellets were dried for a period of 7 days. The desiccated pellets were immersed in water for a duration of 7 days. The mix design for M25 concrete was achieved with a proportion of 1 part cement, 1.36 parts fine aggregate, and 2.41 parts coarse aggregate, with a water-cement ratio of 0.45. The experiment showed that substituting 30% of the coarse aggregates with flyash aggregates led to a higher compressive strength compared to the other mixtures. Furthermore, once the concrete was replaced by 60%, it exhibited a minimum target strength of 25 MPa. However, above this replacement level, the concrete's strength fell

below the target strength. The split tensile strength of the concrete with 30% replacement of coarse particles by flyash aggregates was almost the same as the split tensile strength of conventional concrete. The split tensile strength of concrete decreased when alternative replacement proportions were used.

Priyadharshini.P, Mohan Ganesh.G, and Santhi.A.S (2011) employed OPC 53 cement, 12.5 mm crushed coarse gravel as coarse aggregates, and river sand as fine aggregates. Flyash aggregates were produced by combining flyash and cement in a pelletizer, and then adding water mixed with calcium hydroxide. The newly formed pellets were stored at an ambient temperature for a duration of 24 hours, after which they underwent a process of water immersion for a period of 28 days. The mix design for M40 concrete was conducted according to the specifications stated in IS 10262:2009. The flyash clumps had a spherical shape. The characteristics of fly ash aggregates are listed in the table. An investigation was conducted to compare the properties of normal concrete and fly ash concrete. The use of rounded flyash particles resulted in improved workability of the concrete in comparison to angular crushed aggregates. A decrease of 15% in the density of flyash concrete was observed in comparison to ordinary concrete. The compressive strength of fly ash concrete is 48% lower than that of conventional concrete, however it still meets the minimum requirements for being utilized as structural lightweight concrete.

Kayali O (2008) conducted an experiment to investigate the characteristics of various coarse aggregates. The study utilized granite, dacite, commercially available pelletised flyash aggregates (SP), and artificially created flyash aggregates made from flyash (FAA) as the coarse aggregates. Four distinct concrete mixtures were created utilizing the aforementioned coarse particles. The concrete containing commercially produced fly ash pellets was labeled as SP concrete, while the concrete containing artificially created fly ash aggregates was labeled as FAA concrete. The workability test was conducted on all four concrete mixtures using a slump cone. The slump of self-compacting concrete (SP) and flowable aerial ash (FAA) concrete exhibited a greater degree of deformation compared to the slump of concrete incorporating granite and dacite materials. Utilizing flyash aggregates resulted in a decrease in the density of the concrete. Therefore, both self-placing (SP) concrete and fiber-reinforced polymer (FRP) concrete exhibited lower density in comparison to traditional concrete. The compressive strength of the SP concrete was lower than that of the other concrete. Granite-infused concrete. However, the compressive strength of FAA concrete exceeded that of conventional concrete. The enhanced compressive strength can be attributed to the lower crushing value of FAA in comparison to SP. Both SP and FAA concrete exhibited higher indirect tensile strength. Furthermore, the modulus of elasticity of SP concrete exhibited a significantly lower value in comparison to both ordinary concrete and SP concrete itself. The modulus of elasticity of concrete is contingent upon the modulus of elasticity of aggregates. Due to the higher stiffness of FAA aggregates compared to SP concrete, the modulus of elasticity of SP concrete was lower than that of FAA concrete.

Türkel and Civelek (2012) examine the impact of fly ash and natural pozzolan on the mechanical Features of high-performance concrete (HPC) in their research. By conducting thorough experiments and analysis, they evaluate the impact of adding fly ash and natural pozzolan on important mechanical Features, such as strength, durability, and microstructure, of high-performance concrete (HPC). "Fly ash and natural pozzolan are types of materials that can be added to cement to improve the performance and sustainability of concrete. They achieve this by reducing the amount of cement used and enhancing the long-term durability of the concrete. Türkel and Civelek's evaluation of the impact of these materials on the mechanical Features of HPC offers useful insights for optimising HPC mix designs to achieve greater performance and durability. Their research enhances sustainable concrete technologies by advocating for the efficient utilisation of supplemental cementitious ingredients in the production of high-performance concrete (HPC), resulting in the creation of more durable and eco-friendly concrete structures." By comprehending the impact of fly ash and natural pozzolan on the Features of high-performance concrete (HPC), engineers and construction professionals can make well-informed choices about selecting and incorporating these materials into concrete mixtures. This will ultimately result in the construction of infrastructure that is more long-lasting and environmentally friendly.

Chindaprasirt and Jaturapitakkul (2013) examine how the fineness of fly ash affects the penetration of chloride in concrete. They highlight the importance of fly ash Features in reducing corrosion caused by chloride in concrete structures. Chloride-induced corrosion is a significant durability issue for reinforced concrete structures, particularly in maritime and coastal regions or areas where de-icing salts are employed. Fly ash, when used as a supplemental cementitious material, has been proven to enhance the durability of concrete by reducing its permeability and improving its resistance to chloride penetration. This is attributed to the pozzolanic reactivity of fly ash. Nevertheless, the degree of fineness of fly ash can have a substantial impact on its effectiveness in reducing the penetration of chloride. Chindaprasirt and Jaturapitakkul conduct a thorough investigation and analysis to evaluate the effect of

different levels of fly ash fineness on the concrete's resistance to chloride penetration. Their research offers vital insights into optimising the Features of fly ash to enhance the durability of concrete structures that are exposed to environments with high chloride content. Engineers and construction professionals can enhance their decision-making process regarding the use of fly ash in concrete mixtures by comprehending the impact of fly ash Features on chloride resistance. This understanding ultimately results in the creation of more resilient and enduring infrastructure in chloride-exposed environments.

M.N. Haque, H. Al-Khaiat, and O. Kayali in 2004, two types of sand lightweight concrete were tested. These concretes were composed of lytag aggregates with compressive strengths of 35 N/mm² and 50 N/mm², and were referred to as SLWC35 and SLWC50, respectively. Furthermore, experiments were conducted by substituting the sand in SLWC35 and SLWC50 with fine lytag, which was specifically specified as

Table -1: Properties of fly ash aggregates

S No	Authors	Type of aggregate	Specific Gravity	Bulk Density (kg/m ³)	Water absorption (%)
1	A.Arokiaprakash,V.Thenarasan	CA	1.72	917	13
2	Priyadharshini.P, Mohan Ganesh.G, Santhi.AS	CA	2.12	1247	13.23
3	S.Viveka, R.Renuka	CA	1.727	924.8	11.84
		FA	1.74	1067	9.54
4	Kayali.O	CA	1.72	831 (dry)	8.5
		CA	1.69	848 (dry)	3.4

3. CONCLUSIONS

The literature study offers valuable insights into the application of lightweight coarse aggregates (LWC) and fly ash in concrete mixtures, elucidating numerous factors such as density, strength, durability, workability, and environmental considerations.

Two proportions of lightweight coarse aggregates, namely LWC35 and LWC50, were analyzed. The aggregates demonstrated reduced densities in comparison to traditional concrete, with SLWC35 and SLWC50 densities measured at 1775 kg/m³ and 1800 kg/m³ respectively. Despite the lower density, the concrete with Lightweight Coarse Aggregate (LWCA) exhibited similar strength to regular concrete for the first 270 days of curing. SLWC50 exhibited a 12% greater modulus of elasticity in comparison to SLWC35, indicating the possibility of enhancing structural performance by using higher quantities of LWCA. In addition, the use of sand as fine aggregate in concrete resulted in less water penetration and carbonation depth, hence improving its longevity.

Fly ash aggregate concrete demonstrated a decreased density in comparison to traditional concrete, suggesting its capacity to decrease the weight of structures. The use of fly ash coarse aggregates did not impact the workability of concrete, ensuring convenience in building. Nevertheless, the concrete produced with fly ash aggregates exhibited a notable decline in strength, accompanied by a reduction in modulus of elasticity when compared to conventional concrete. Moreover, the moisture level of fly ash aggregates has a substantial impact on the durability of concrete. The durability of concrete made using dry fly ash aggregates was shown to be superior than that of concrete made with pre-saturated fly ash aggregates. This highlights the significance of effectively managing moisture during the manufacturing of concrete. Moreover, the utilization of fine aggregates derived from fly ash was discouraged because of its detrimental impact on water permeability and the extent of carbonation in concrete. Although there are difficulties associated with the loss of strength and decreased modulus of elasticity, the use of fly ash aggregate in concrete is seen as an efficient method of conserving natural resources that are often utilized as ingredients in concrete. This emphasizes the significance of implementing sustainable practices in the building industry, which is in line with wider environmental goals. To summarize, the literature highlights the possible advantages and difficulties of using lightweight coarse particles and fly ash in concrete compositions. Although alternative materials have benefits like as lower density and the potential to preserve resources, it is crucial to carefully evaluate their impact on the strength, durability, and other attributes of concrete before using them in construction projects.

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