A Review on Experimental Investigation on Partial Replacement of Cement with Ultrafine Material and Fine Aggregate with Foundary Sand

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***Abstract*—One of the most often utilized materials in the building industry is concrete. Cement is a major ingredient in concrete. The production of cement releases a significant amount of carbon dioxide into the atmosphere, which is a primary cause of the greenhouse effect and global warming. As a result, finding a substance to replace cement in concrete becomes essential. When making concrete, a variety of additional Supplementary Cementitious Materials (SCMs) have been utilized in place of some of the cement. Additionally, the need for high-performance concrete is growing daily. A new generation of ultrafine supplemental cementitious material is used in the manufacturing of environmentally friendly concrete that is strong and long-lasting. Alccofine is a new type of microfine concrete material that can be used in place of some of the cement in concrete. Concrete's properties can be enhanced by substituting some of the cement with alccofine. Additionally, Alccofine is simple to use and can be mixed right into cement. The impact of partially substituting alccofine for cement in concrete is the subject of this paper's evaluation of published works by a variety of writers. The strength and durability of concrete can be enhanced by partially substituting alccofine for cement. Waste foundry sand is a by-product that seems to have the ability to partially replace ordinary sand as a fine aggregate in concrete, giving them a chance to be recycled. A recent trend in low-cost concrete manufacturing is the replacement of fine sand with foundry sand, which successfully uses waste foundry sand as an engineering material while lowering disposal and environmental issues. Environmental issues are brought on by industry-generated waste. Therefore, it is important to stress the utilization of this waste. A by-product of the manufacture of both ferrous and nonferrous metal casting industries, foundry sand is a premium silica sand.**

***Index Terms*—Concrete, Cement, Foundry Sand, Alccofine, Supplementary Cementitious Materials (SCM's), strength and durability characteristics.**

I. INTRODUCTION

The most popular and extensively utilized building material is concrete. A uniform mixture of cement, sand, coarse material, water, and admixtures is called concrete. Cement, one of the main sources of carbon dioxide gas, is a significant part of concrete. The production of cement for concrete releases a significant amount of carbon dioxide into the atmosphere, which is a primary cause of the greenhouse effect and global warming. Additionally, as the demand for building materials in the construction industry rises, so does the need for high-performance concrete. As a result, finding a substance to replace cement in concrete becomes essential. Alccofine, a new generation ultrafine supplemental cementitious material, is used to partially replace cement in concrete in order to produce high-strength, long-lasting, environmentally friendly concrete. The construction industry has embraced this new ultrafine pozzolonic material, which has revolutionized the field of civil engineering. When Alccofine is used in place of some of the cement in concrete, there is a noticeable improvement in the concrete's qualities both during the fresh and hardened stages. Alccofine is simple to use and can be mixed straight into cement. Better and smoother surface finish is provided by Alccofine's ultrafine particles. In terms of cost, the concrete mix made with alccofine is less expensive than the concrete made without it for high strength

concrete. In addition to strength, Alccofine has the benefit of lowering the water/binder ratio. Alccofine material greatly improves flexural and compression strength.

Compared to the natural or high-quality extraction sands used on fill construction sites, the foundry sand is often of much higher quality. The outside shape of the mold cavity is formed by the sands. For generations, foundry sand has been used as a material for mold casting due to its great heat conductivity. Foundry sand's physical and chemical properties are largely determined by the type of casting method used and, consequently, the industry sector from which it comes. Comprehending the fundamentals of concrete is crucial for providing high-quality concrete. The materials used in concrete are covered in this publication, along with the fundamentals needed to manage and style concrete mixtures for quality structures.

II. LITERATURE REVIEW

The Following researchers have carried out the experimental study related to the dissertation topic.

1.Rafat Siddique (2009)- Examined the mechanical characteristics of concrete compositions when three percentages (10%, 20%, and 30% by weight) of discarded foundry sand were substituted for fine aggregate. The compressive strength, splitting tensile strength, flexural strength, and modulus of elasticity of fresh concrete were tested at 28, 56, 91, and 365 days. According to test results, increases in compressive strength ranged from 8% to 19% based on UFS percentage and testing age, while increases in splitting tensile strength ranged from 6.5% to 14.5%, flexural strength from 7% to 12%, and modulus of elasticity from 5% to 12%.

2.Yogesh Aggarwal et.al (2010. Presented the creation of concrete mixtures that use up to 40% of leftover foundry sand in place of fine particles. Compressive strength and split tensile strength are two examples of the mechanical characteristics that are assessed. The concrete's ability to withstand carbonation and chloride penetration is also assessed. The flexural strength has grown by 27.6%, according to test findings that show curing has been completed. It serves as a filler so that concrete made from industrial waste can be strong and long-lasting enough to replace regular concrete. Split tensile and compressive strengths were measured after 28, 90, and 365 days. A comparison of the strength development of the foundry sand mixes with the control mix—that is, the mix without foundry sand—was noted. This suggests that foundry sand can be effectively used as a substitute material to partially replace fine particles in concrete.

3.J.M. Khatib et.al (2010)- Examined the fresh and hardened characteristics of concrete that used 0–100% fine aggregate in place of waste foundry sand (WFS). For every mix, the ratio of water to cement was maintained. The majority of the hardened property testing was done at 14, 28, and 56 days. The findings demonstrate that adding leftover foundry sand to concrete resulted in systematic reductions in workability, ultrasonic pulse strength and velocity, and an increase in water absorption and concrete shrinkage. They also stated that foundry sand can be used to produce concrete with a suitable strength.

4.Kumbhar P.D. (2011)- Examined the different mechanical characteristics of concrete that contains leftover foundry sand. Concrete was made by substituting different amounts of UFS (10%, 20%, 30%, and 40%) for natural sand. Based on the test results, they came to the following conclusions: workability decreases as UFS content increases; at 28 days, compressive strength, splitting tensile strength, and flexural tensile strength increase for various UFS replacement levels, while flexural tensile strength decreases for UFS content greater than 20%; at 28 days, the modulus of elasticity values increases with UFS replacement up to 20%. Additionally, they came to the conclusion that up to 20% of ordinary sand in concrete might be substituted with UFS.

5.Gurpreet Singh and Rafat Siddique (2011) - conducted an experimental study in which natural sand was partially substituted with (WFS) to assess the strength and durability characteristics of concrete mixtures. Five percent (0%, 5%, 10%, 15%, and 20%) of WFS by weight were substituted for natural sand. Concrete's strength characteristics were assessed at 7, 28, and 91 days of age using compression and splitting tensile strength tests. According to test results, adding WFS in place of some of the fine aggregate somewhat improves the strength characteristics of plain concrete.

6.Sohail Md, et.al (2013) - conducted experiments to assess the durability and strength characteristics of concrete mixtures that partially substituted (WFS) for natural sand.All concrete mixtures underwent the solidification/stabilization (S/S) process after regular M sand was substituted with percentages (0%, 15%, and 35%) of WFS by weight. Every test was performed at 7, 28, and 56 days of age. According to test results, waste foundry sand can be successfully substituted for traditional river sand as a fine aggregate in concrete. The compressive strength of plain concrete increased by up to 90% when waste foundry sand was substituted for fine aggregate, after which the strength slightly decreased. After seven days, concrete had reached its maximum strength when 40% and 50% of the sand was replaced with leftover foundry sand. The split tensile strength of plain concrete increased by up to 70% when waste foundry sand was substituted for fine aggregate, after which the strength slightly decreased.

7.Dushyant Rameshbhai Bhimani et al. (2013)- They conducted an experiment on the subject of "Foundry Sand's Strength Behaviour on Modified High Strength Concrete." In concrete, 0, 15, 25, and 35% of WFS by weight was used in place of fine aggregate. Tests for flexural strength, split tensile strength, and compressive strength were used to assess the concrete's strength characteristics. According to their results, a 25% replacement results in greater strength. Additionally, they claimed that using foundry sand instead of land filling would be more successful and efficient for construction projects.

8.Saurabh Gupta et.al (2015)- Presented a review on Alccofine, a supplemental cementitious material, was reviewed. Because they are bringing about a technical revolution in the field of civil engineering, supplementary cementitious materials (SCM) are gaining popularity in the construction sector. The purpose of this research is to emphasize the significance of alccofine as a supplemental cementitrious material in the building sector. Because of its ultrafine size and high calcium oxide (Cao) concentration, this can be used as an SCM. Alccofine 1203 is crucial for lowering heat of hydration and strength at every stage, while Alccofine 1101 can be used for grouting

9.Amitkumar D. Raval, et.al. (2015)- Investigated the use of fine aggregate as a partial substitute to create sustainable concrete. In this study, foundry sand was utilized to replace fine aggregate with M25 (1:1.10:3.38) mix proportion and w/c ratio (0.48). The percentage of foundry sand used for replacement was 0%, 10%, 20%, 30%, 40%, and 50% by weight of fine aggregate. Based on the test findings, they came to the conclusion that, in comparison to a regular mix without foundry sand at 28 days, the compressive strength improves up to 30% of replacement and abruptly declines at 40% replacement. It is desired and economical to replace up to 30% of natural sand with spent foundry sand.

10. Eknath P. Salokhe et al. (2015)- Investigated on the topic"Application of Foundry Sand in Manufacture of Concrete" was the subject of their investigation. They used concrete of M20 grade for their experiment. In 10, 20, and 30%, they substituted foundry sand for fine aggregate. They examined the concrete specimen's tensile and compressive strengths. They came to the conclusion that split tensile strength reaches its maximum at 20% replacement based on their test results. Nonetheless, ferrous WFS provides marginally more strength than non-ferrous WFS. For ferrous and nonferrous WFS, the maximal compressive strength occurs at 10% and 30% replacement, respectively.

11.Rvindra N. Patil et.al(2015)-. Investigated both groups of concrete, the amount of leftover foundry sand increases the concrete's compressive strength relative to ordinary concrete. 15% replacement was the limit. Split tensile strength rises as the percentage of leftover foundry sand increases up to 15% replacement, beyond which it falls. The flexural strength of the beam model was negatively impacted, but it was still within acceptable bounds when compared to regular concrete. The concrete from the second group, which contains WFS and artificial sand, has better outcomes than the concrete from the first group. Concrete made from leftover foundry sand is an environmentally friendly building material since it lessens the amount of trash produced by the metal industry. The issues of land filling disposal and upkeep are lessened. Innovative building materials and the construction industry are developed as a result of this study's application. When 15% of the waste foundry

sand is replaced, the percentage cost change decreases by up to 3.5. This demonstrates that the concrete produced is cost-effective.

12.Rajesh Kumar S(2015)- Studied an experimental study on the mechanical properties of high-grade concrete based on alccofine" was studied. Compressive strength on concrete cubes after 3, 7, 14, and 28 days of water curing are the mechanical characteristics examined here.The research concluded that at a 10% cement replacement level, the alccofine material significantly boosts the strength.

13.S. RamakrishnaRaju et al(2016): Studied prepared samples of foundry sand in weight proportions of 0, 25, 50, 75, and 100 percent to replace fine aggregate. His study's findings demonstrated that while strength increases as the percentage of foundry sand increases, workability decreases. The best outcome was obtained by replacing 25% of the foundry sand with sand.

14.K. Gayathri, et.al (2016)- Investigated the cementing effectiveness and durability of alccofine in concrete. In this study, a novel ultrafine material called Alccofine is tested for partial replacement. By substituting different percentages of Alccofine for cement, such as 5%, 10%, 15%, and 20%, M20 grade concrete is designed to investigate the durability and cementing efficiency of Alccofine in concretes. As previously mentioned, the design mix is made for M20 grade, and cubes were cast with different percentages of alccofine. The findings are examined and presented. In comparison to other mix percentages, it has been found that replacing 15% of the alccofine with cement produces good strength. Additionally, it is found that alccofine has good cementing efficiency in older concrete.

15.Dr. Sinha Deepa A et al. (2016)- Examined the performance of concrete that contained additional cementitious elements such alccofine and fly ash. The performance of concrete mixtures in terms of compressive strength, flexural strength, split tensile strength, residual compressive strength at high temperatures, and chlorine attack test at different ages is examined in this study.It has been noted that as the percentage of alccofine in concrete grows, so does its resistance to chloride attack and its ability to promote slump flow.

16.B. Kaviya,et.al (2017)- Investigated the use of alccofine to partially replace cement. Alccofine's mechanical characteristics have been investigated. Alccofine 1203 is a carefully prepared product made by controlled granulation that has a high glass content and strong reactivity. Because alccofine material is present, concrete achieves excellent strength at a very young age. Compressive strength on concrete cubes after seven and twenty-eight days of curing and split tensile on cylinders after seven and twenty-eight days of water curing are the mechanical characteristics examined here. The results show that at a 15% replacement level of cement, the alccofine material significantly boosts the strength

17.S.S. Jadhav et al. (2017)- This study examined the performance of newly mixed and cured concrete that substituted fine aggregate with discarded foundry sand. After 28 days, the compressive strength of a control concrete mix reached 25 MPa. In other concrete mixtures, clean/new foundry sand and used foundry sand were substituted for regular concrete sand by 25% and 35%, respectively. The concrete's performance was assessed using its compressive strength.The study's findings demonstrated that the concrete's compressive strength dropped when more used foundry sand was substituted for regular concrete sand. The compressive strength of the concrete with a 25% replacement of old foundry sand was 23 MPa, but the concrete with a 35% replacement had a 21 MPa compressive strength.

18.Malvika Gautam (2017)- Reviewed the impact of alccofine on the strength properties of concrete in various grades. The literature of numerous scholars who have studied the durability of high-performance concrete containing Alccofine is examined in this work. The need for high-performance concrete has also grown due to the needs of the construction sector. Concrete's strength and durability may be enhanced by substitutes for cement as well as chemical and mineral admixtures, according to recent efforts to increase concrete's performance.

19.P.R. Kalyana Chakravarthy et al. (2017)- The primary goal of this work is to determine the concrete's compressive strength when some cement is substituted with Alccofine. The project's main goal is to investigate concrete experimentally by substituting

different percentages of Alccofine for cement. 0%, 4%, 8%, 16%, 17%, 20%, 25%, 50%, 75%, and 100% for seven and twenty-eight days. Throughout the trial, M25 was used as the design mix. When compared to conventional methods, the percentage increase in compressive strength for 7 and 28 days of curing was found to be at its highest at 16% replacement, with values of 50.95% and 60.95%.

20.A.Naveen Arasu et.al (2017)- The results of this experimental study showed that when the WFS ratio increased. Five percentages (0%, 5%, 10%, 15%, and 20%) of WFS by weight were used in place of natural sand. The five concrete mix proportions (M-1, M-2, M-3, M-4, and M-5) with and without WFS were cast to determine how to improve fresh concrete's workability and decrease slump. Concrete's compressive strength has been tested at 7, 14, 21, and 28 days of age. According to test results, adding WFS in place of some of the fine aggregate increases the compressive strength of plain concrete. Additionally, the outcomes meet the American Concrete Institute's (ACI) approved limitations.

21.Pendhari Ankush R.(2017)- Examined the fresh and cured characteristics of concrete that contained 0–100% fine aggregate in place of waste foundry sand (WFS). For every mix, the ratio of water to cement was maintained. The majority of the hardened property testing was done at 14, 28, and 56 days. The findings demonstrate that adding leftover foundry sand to concrete resulted in systematic reductions in workability, ultrasonic pulse strength and velocity, and an increase in water absorption and concrete shrinkage. They also stated that foundry sand can be used to produce concrete with a suitable strength.

22. Aniket Abasaheb Bandal et al. (2020)- In this study through a examination of various research publications on the topic, this study also investigates the potential of employing waste foundry sand as a partial replacement for fine sand in cementitious concrete. The report summarizes the outcomes of tests conducted on concrete for a variety of qualities, such as strength and durability, and includes all pertinent data. Based on prior research and our own findings, the essay illustrates both favourable and unfavourable changes in concrete characteristics brought about by replacing fine sand with waste foundry sand. Our research indicates that using leftover foundry sand in construction could lead to the creation of stronger, more ecologically friendly concrete.

III. OBSERVATIONS FROM LITERATURE REVIEW

1.Studies have consistently shown that alccofine contributes to early strength gains in concrete, particularly within the initial curing period. Water immersion curing period.Water Immersion curing has been identified as the most effective curing method.

2.The literature also discusses the Alccofine -based concrete exhibits resilience against various environmental factors such as chloride attack, sulphate attack and acid attack,resulting in lower weight loss and higher compressive strength compared to traditional concrete mixes.

3.There are limitations to increasing the percentage of of alccofine beyond a certain threshold, as it may begin to compromise the strength of the concrete, primarily acting as a filler material rather than a strength-enhancing additive.

4.The use of foundry sand as partial replacement of fine aggregates in making concrete increases the compressive strength at all replacement levels.

5.The performance of foundry sand and Alccofine as partial substitutes for fine aggregate and cement across different proportions 20%,40% and 60% for foundary sand and 3%,6% and 10% for ultrafine. Tests were conducted for compressive strength on cubes, split tensile strength on cylinders and flexural strength on beams, with curing durations of 7 and 28 days. Durability test includes water permeability test, water absorption test and chloride content test.

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