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DESIGN AND MANUFACTURE OF HIGH PERFORMANCE CONCRET BY USING MICRO-SILICA AND ALCCOFINE

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Abstract: The growing need for long-lasting, environmentally friendly, and reasonably priced materials has drawn a lot of attention to the design and production of high-performance concrete (HPC) in the building sector. The goal of this study is to improve the qualities of concrete by adding Alccofine, a specific micro-fine substance, and micro-silica, also known as silica fume. Alccofine, which is renowned for its exceptional workability and strength enhancement, and micro-silica, a pozzolanic substance, are utilized as supplementary cementitious materials (SCMs) in concrete mixtures.

When these ingredients are combined, the concrete's permeability and shrinkage are decreased and its mechanical qualities—such as its compressive strength, tensile strength, and durability—are improved. The microstructure is strengthened by the extra calcium silicate hydrate (C-S-H) gel that is created as a result of the pozzolanic reactions between the micro-silica and the calcium hydroxide in the concrete matrix. By improving the mix's workability and offering superior finishing qualities, alccofine helps to lessen bleeding and segregation. This concrete mix is perfect for use in infrastructure projects that need long-term durability because it also provides enhanced resistance to harsh environmental factors like chemical attack, freeze-thaw cycles, and high temperatures.

The mix design, performance attributes, and possible uses of high-performance concrete utilizing micro-silica and Alccofine are described in this study, highlighting their contribution to the development of concrete technology toward more durable and sustainable building methods.

Keywords **:** High-Performance Concrete (HPC), Micro-Silica (Silica Fume), Alccofine, Cost-effective Concrete, Long-Term Durability.

1. INTRODUCTION

Concrete that is convectional can use more water, which raises the w/c ratio and lowers compressive strength. Therefore, adding GGBS and Alcofine to concrete as a mineral admixture will improve the concrete's initial and final setting times. The concrete mix's water content will be decreased by the binding qualities of GGBS and Alcofine, improving the concrete's qualities. It has high compressive strength, tensile strength, and flexural strength and is less expensive, making it suitable for low-budget building.

1.1 Need to find alternatives to cement –

The most widely used man-made substance worldwide is concrete. In India, a significant amount of natural sand is extracted for the production of concrete. According to Fig., which shows the cement consumption trend, the total cement consumption in India was estimated to be around 269 MMT in 2016. By 2018, it is anticipated to reach 298 MMT. The construction industry requires roughly six to seven times as much sand and gravel for every tone of cement (C. Koroneos, et al.). Accordingly, the amount of sand needed in 2018 will be close to 2100 MMT, and trends indicate that this amount will increase by at least 8% annually.

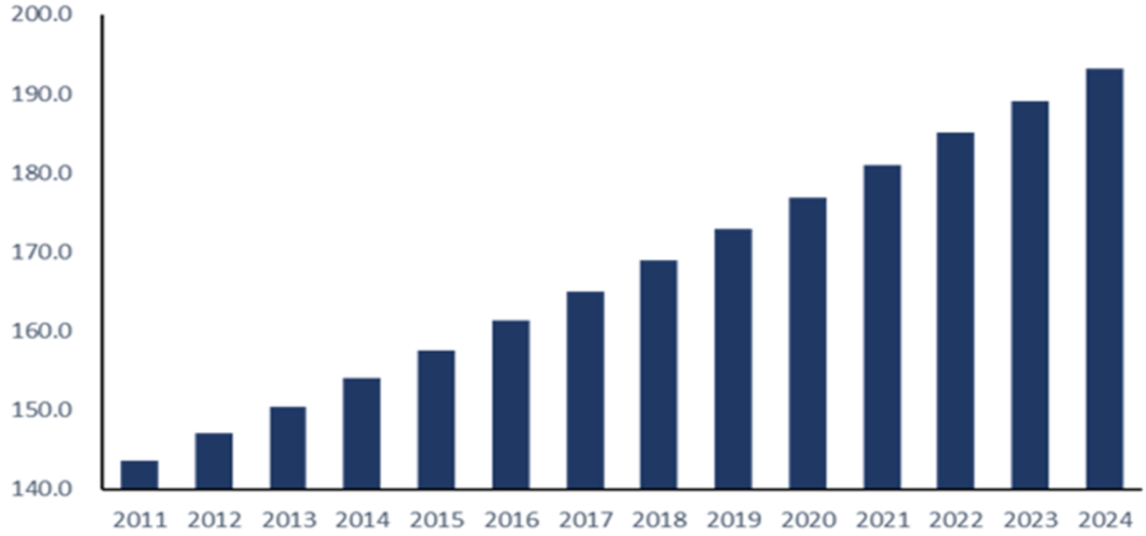


Fig: Cement Demand in India

Although natural sand has long been utilised as a fine aggregate in concrete, its supply is severely limited as a result of overexploitation, particularly in places like Pune, Mumbai, and others. Additionally, government organisations have stopped sand mining because of ecological problems like land erosion and river ecosystem imbalance, among others. Additionally, the supply of natural sand varies seasonally. The price of natural sand fluctuates a lot and rises overall as a result of this supply and demand imbalance.

It is increasingly essential for builders and civil engineers to look for alternatives to natural sand in order to meet the high demand for fine aggregates in concrete. Generally artificial sand is used to replace natural sand either partially or totally in the manufacture of concrete.

1.2 Alccofine (1203) -

Alccofine is a microfine mineral used in mortar and concrete. It enhances the pore structure's durability factors, lowers permeability, boosts pump performance, and keeps the concrete's pH stable to safeguard the steel reinforcement. increased strength gain rate in concrete mixtures containing a lot of pozzolanic materials, such as fly ash, GGBS, etc.

1.3 Ground granulated blast furnace slag (GGBFS) -

It is metal industry waste. It is a hydraulic form of cement, not a mineral additive. The mechanical characteristics of concrete that has been heated to 350 degrees Celsius and formed with ground granulated blast furnace slag (GGBFS). GGBFS was used to partially replace cement in the design of regular concrete with a compressive strength of 34 MPa.

1.4 SEM Analysis -

Destructive tests like as compression, flexure, and fracture notch specimen tests are most frequently used to ascertain the mechanical properties of concrete. Nonetheless, nondestructive methods like impact echo testing and ultrasonic pulse velocity are available for assessing the characteristics of concrete. Concrete's quasi-brittle nature, in contrast to steel, is one of its main problems. When tensile stresses build up, it has a tendency to desire to break. The interfacial transition zone, or ITZ, between the aggregate and cement paste is where these cracks typically form.

1.5 Ultra-fine GGBFS -

Due to its positive effects on performance qualities, the inclusion of pozzolanic and activated cementitious elements to high performance concrete is becoming more and more significant in the Indian construction sector. In this study, granulated blast furnace slag is activated using an air cyclone separator and mechanical grinding to produce "Microfine Granulated Blast Furnace Slag" (MFGGBS), a finished product with a predetermined microfine particle size distribution.

1.6 Micro silica -

Concrete with a higher compressive strength is becoming more and more in demand as pre-stressed concrete and high-rise constructions employ concrete more widely. The manufacturing of elemental silicons or silicon-containing alloys produces micro-silica, commonly known as silica fumes, in an electric arc furnace. Very fine, smooth, spherical silicon oxide particles with a very high surface area make up the majority of its composition. The typical cement particle is 100 times larger than micro-silica particles. Because of environmental considerations, its treatment and disposal are a matter of concern.

1.7 VSI Crusher -

In many quarries, mines, and construction sites, VSI crushers—also known as vertical shaft impact crushers—are used extensively for crushing and shaping aggregates and sands, particularly for road and building projects, hydropower stations, bridges, and tunnels.

For shaping the gravels used in high-strength concrete, a vertical shaft impact crusher is a great choice. Impact crushers are replaced in the fine crushing segment by VSI crushers, which perform significantly better according to key performance indicator.

- **Objectives** -

A. To use GGBS and ALCCOFINE (SP-1203) to provide concrete blocks an M-60 strength.
B. To ascertain the high-performance M-60 concrete cube's compressive strength.
C. To investigate the pH, temperature, and workability of fresh concrete.
D. To ascertain the engineering, index, and physical characteristics of cement, GGBFS, fine and coarse aggregates, PCE, Alccofine (1203), and water, among other materials.
E. To investigate how mixed concrete affects the environment.

2. LITERATURE REVIEW

A.T. mullick et al. [1] This essay identifies a number of causes that lead to conventional concrete's degradation and eventual breakdown during its useful life. High-Performance Concrete, or HPC, was developed as a solution to these problems. Permeation has been identified as the main factor contributing to the degradation of concrete structures.

Bhanja S, Sengupta B. et al. [4] High strength concrete, whose mechanical qualities are still being studied, is now required for large-scale building.This work aims to investigate the characteristics of high-strength concrete by varying the quantity of silica fume added to the cement weight. Concrete's flexural strength, splitting tensile strength, and compressive strength after seven and twenty-eight days are among its characteristics. In order to achieve this, the experiment was conducted on M60 grade concrete while keeping the water-to-cement ratio at 0.3 and adding silica fume in varying proportions to the cement weight (0%, 5%, 10%, and 15%).

C.Suryawanshi et al. [5] This essay identifies a number of causes that lead to ordinary concrete's degradation and eventual breakdown during its useful life. High-Performance Concrete, or HPC, was developed as a solution to these problems. Permeation has been identified as the main factor contributing to the degradation of concrete structures. In addition to improving its resistance to sulphate attack, embedded steel corrosion, abrasion, erosion, and cavitation, among other things, HPC development aims to minimise this issue with appropriate proportioning of available materials. There has also been discussion on the desired qualities of the materials used to create HPC1, such as cement, aggregate, admixtures, water, etc. In addition to these, quality control's involvement in concrete placement, compaction, and curing for better performance is also covered.

Santosh Kumar Karri et al. [10] With almost six billion tonnes produced annually, concrete is arguably the most widely used building material worldwide. In terms of usage per capita, it is only surpassed by water. Nonetheless, environmental sustainability is at risk due to the harm resulting from raw material exploitation as well as CO2 emissions during the cement manufacturing process. This put pressure on researchers to use supplemental materials to partially substitute cement in order to reduce cement consumption. These substances could be found in nature, as industrial waste, or as less energy-intensive byproducts. These substances, known as pozzalonas, exhibit cementetious qualities when mixed with calcium hydroxide. Fly ash, silica fume, metakaolin, and ground granulated blast furnace slag (GGBS) are the most often utilised pozzalonas. To guarantee a lower life cycle cost, this must assess how well the admixtures work when mixed with concrete. The goal of this research is to examine the properties of M20 and M40 grade concrete that has 30%, 40%, and 50% cement replaced with ground granulated blast furnace slag (GGBS). Compressive strength, split tensile strength, and flexural strength tests are performed on the cubes, cylinders, and prisms. Studies on durability using hydrochloric and sulphuric acids were also carried out.

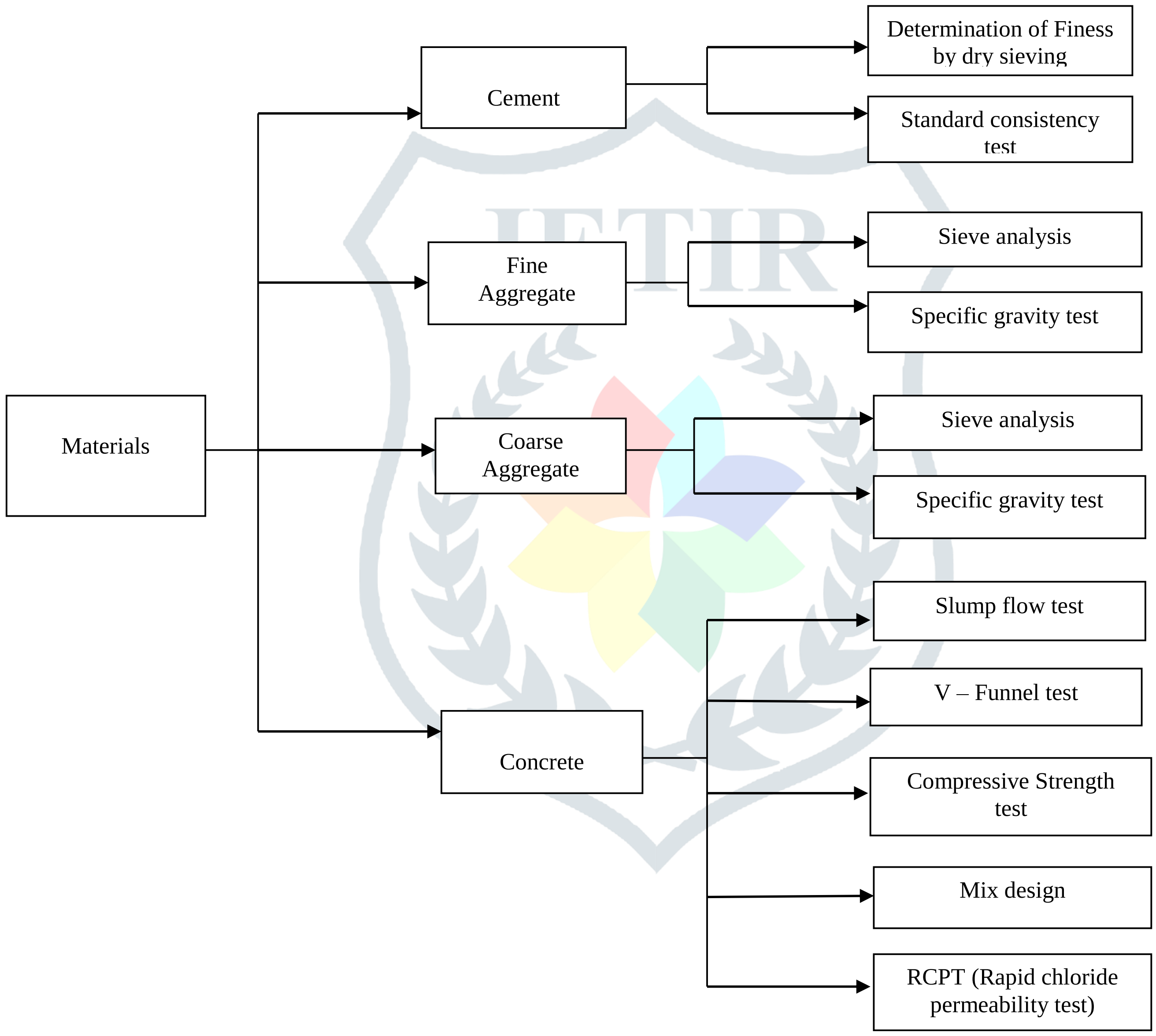
Setunge, S., Attard, M.M., and Darvall, P.Le P. [11] The experimental program created to investigate the basic properties of high strength concrete and the flexural behaviour of simply supported high strength concrete beams under two point loading is presented in this work. Large span and taller structures with high strength concrete have fewer dead loads. 108 specimens of plain cement concrete, including cubes, beams, and cylinders of grades M30, M60, M70, and M80, are being cast as part of the current experimental study. These specimens undergo 28-, 56-, and 90-day tests to determine their compressive and flexural strengths. The outcomes of the High Strength Concrete tests are contrasted with those of the plain cement concrete of M30 grade. The concrete's strength (60–80 MPa) and the specimen's age were the primary variables taken into account in this study. Robot Structure Analysis, a finite element program, was used to assess the specimens for ultimate load.

Vinayak Awasare, and Prof. M. V. Nagendra et al. [12] The impact of a large amount of GGBS on the characteristics of structural concrete is discussed in this work. In this work, GGBS is partially substituted with cement in a weight-to-weight ratio of 10% to 90% after being physically and chemically characterised. Compressive strength, split tensile strength, and modulus of elasticity are tested, as are the new properties of GGBS concrete, such as slump test. Furthermore, carbon footprints are computed, and the annual savings per person for reducing cement use are established. The test findings showed that, up to a certain point, the fresh and hardened qualities of GGBS concrete increase as the percentage of GGBS replacement increases.

3. METHODOLOGY

• Materials :

1. Cement - OPC 53 grade brad – ACC confirming IS 269
2. Fine aggregates - Artificial sand is made from locally accessible basalt
3. VSI - Vertical shaft impact
4. Coarse aggregates – crushed stones having sizes 20mm & 10mm as per is sieve size
5. Water – portable water available Having pH more than 7.
6. Alccofine (1203) – It is a patented mineral addition based on low calcium silica.
7. Ground granulated blast furnace slag (GGBFS) brand JSW GGBFS
8. Admixtures – Very high ultra-range water reducer having chemical form of poly carbolic ether (Hyper-fluid R-100) (Brand CAC)



A) Selection of Materials:

- Cement: The foundation material should be Portland Pozzolona Cement (PPC).
- Additional Cementitious Substances: Add Alccofine and micro-silica (silica fume) to the concrete to improve its qualities.
- Water and Aggregates: For mixing, use potable water and clean fine and coarse aggregates.

B) Mix Design:

- Add micro-silica at 5%, 10%, and 15% by cement weight and Alccofine at 10%, 20%, and 30% by cement weight to concrete mixtures.
- For maximum strength, keep the water-to-cement ratio between 0.3 and 0.4.
- To ensure appropriate workability and make any necessary water content modifications, use slump tests. To retain workability, do slump tests as soon as possible after mixing and modify the water content as necessary to reach the appropriate slump range, which is usually 75–100 mm.

C) Manufacturing Process:

- First, dry mix the Portland Pozzolana Cement (PPC), micro-silica, and Alccofine until they are well combined. Add the coarse and fine particles after that. While mixing, gradually add water until the required consistency is reached.
- To remove air spaces and guarantee the right density, compact the mixture using a vibration table for a certain amount of time (for example, 30 to 60 seconds per mould) once the moulds are filled.
- To guarantee proper hydration, cure the concrete specimens for 3, 7, 14, and 28 days at 25 ± 2°C in a moist atmosphere. Samples should be kept in water after demolding until testing.

D) Testing and Assessment:

- Compressive Strength: At 3,7, 14, and 28 days, measure the compressive strength.
- Flexural and Tensile Strength: Evaluate the material's resistance to bending and tensile stress by conducting tests on beams and cylinders.
- Durability: To evaluate long-term performance, consider shrinkage, water absorption, and chloride ion penetration.
- Workability: To assess how easy it is to handle and place the concrete, do slump tests.

E) Optimization:

Examine the test findings to ascertain the ideal ratios of Alccofine and micro-silica that provide the best possible balance of workability, durability, and strength.

F) Comparative Analysis:

To show how high-performance concrete (HPC) performs better in terms of durability and mechanical qualities than regular concrete, compare the two.

G) Sustainability and Cost:

Analyse the financial viability of employing Alccofine and micro-silica, as well as the environmental advantages of improved sustainability and a smaller carbon footprint in the manufacturing of concrete.

4. CONCLUSION

The final findings from the experimental program, economic analysis, test result analysis, and dissertation study are listed below.

A) Strength will rise when the water-to-cement ratio falls.
B) Concrete's content rises in tandem with its specific gravity.
C) The third percentage mix in the rate analysis was up to 16.59% less expensive than regular concrete.
D) The second-percentage mix concrete's workability increased by 13.61% compared to ordinary concrete.
E) There is no need for any additional treatment to regulate the concrete's temperature because it stays constant.
F) Since the ratio of water to cement is less than 0.5, no carbonation action is produced.
G) Additionally, we consume up to 48.50% of the CO_2 emissions from concrete.

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