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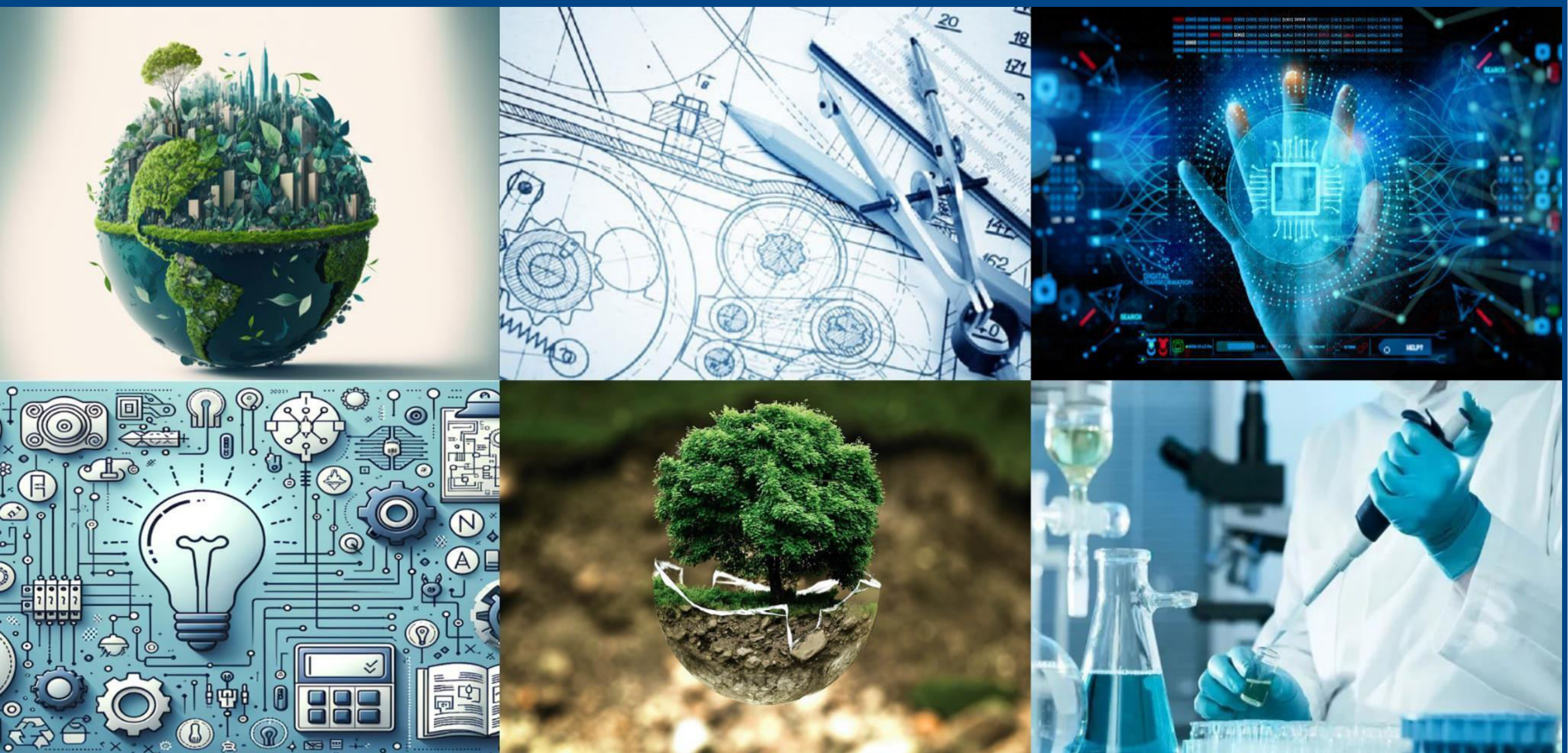

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An Investigation of Multi-Blended Concrete Mix with Iron Powder, Granite Powder, and Silica Fume

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ABSTRACT: Cement concrete is the most extensively used construction material in the world. The reason for its extensive use is that it provides good workability and can be turn it to any shape. Normal concrete gives a very low tensile strength, restricted ductility and small amount of resistance to cracking. Internal small cracks lead to brittle failure of concrete. The use of these materials aims to reduce the consumption of natural resources (sand and coarse aggregate) and OPC, thereby lowering the environmental footprint and production cost effectiveness of concrete. in this research revealed that, at the ideal replacement percentage, Iron powder, Granite powder and Silica Fume concrete exhibits an improved dense and compact concrete matrix. M30 concrete by partial replacement of Granite powder with Coarse aggregate in proportions of 0%, 20%, 40%, 60%,80% ,100% and Iron powder with Fine aggregate in proportions of 0%, 10%, 20%, 30%,40% and 50%. For Binder material, OPC 43 grade of cement by partial replacement of Silica Fume with in proportions of 0%, 5%, 10%, 15%, 20% and 25%.

To study the effect of Iron powder, Granite powder and Silica Fume on compressive strength, splitting tensile strength and flexural strength for M30 grade of concrete. The workability of the addition of Iron Powder, Granite Powder, and Silica Fume as partial replacement of sand, coarse aggregate and OPC cement Mix design C85-SF15-FA70-IP30-CA70-GP30 slump value is 61mm with 3.39 %. and the compressive strength of 13.55 % and 10.19 % Increase in strength at 7 and 28- days Cubes of curing. The flexural strength is 5.65 MPa with 14.14 % Increase in strength at 28 days Beams of curing. the Splitting tensile strength is 4.15 MPa with 23.51% Increase in strength at 28 days Cylinders of curing.

KEYWORDS: Mix Design of M30 grade of concrete, Sand, OPC 43 grade of cement, Strength, Iron powder, Granite powder, Silica Fume, compressive strength, flexural strength and splitting tensile strength.

I. INTRODUCTION

Iron Powder as a partially replacement of sand

The utilization of iron powder as a partial replacement for natural sand in construction materials like mortar and concrete has been extensively studied for its potential to enhance mechanical properties, durability, and address environmental concerns associated with waste materials. Recycled iron powder (RIP) is a byproduct of industrial processes such as grinding, cutting, and milling of iron products, generated in significant quantities globally . Its use as a fine aggregate alternative offers a sustainable solution to the depletion of natural sand resources and the management of industrial waste.

Effect of Iron Powder on Concrete Properties

Similar to mortar, the incorporation of iron powder (specifically nano-Fe_2O_3) into concrete has shown varied effects on its properties. A study investigating partial replacement of Portland cement with iron powder (Fe_2O_3) at percentages ranging from 1.5% to 5% found that compressive strength increased, with the maximum improvement achieved at 2.5% replacement. At this level, the 28-day compressive strength increased by 27.03%. This improvement is attributed to the micro-fine size of iron powder particles, which fill pores and lead to a more compact microstructure, enhancing the

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bond between aggregates and the cement matrix . The rapid consumption of Ca(OH)2 due to the high reactivity of nano-Fe2O3 particles also contributes to early strength gain.

For tensile strength, the study observed an increase of 4.63% at 1.5% iron powder replacement, but tensile strength decreased when the replacement level exceeded 1.5%. This suggests an optimal range for tensile strength enhancement that differs from compressive strength.

Workability, measured by slump, generally decreased as the amount of iron powder increased. This is likely due to the fineness and high-water absorption of iron powder, which reduces the flowability of the fresh mixture.

Granite Powder as a partially replacement of Coarse aggregates

The use of granite powder as a partial replacement for coarse aggregates in concrete and mortar mixtures has been explored as a sustainable solution to manage industrial waste and enhance material properties. Granite, a widely used building material, generates significant amounts of powder waste during processing, posing environmental and health concerns if not properly disposed of. This waste material, often ending up in landfills, can lead to lung silicosis and eye infections due to airborne dust particles.

The utilization of granite powder in construction materials offers several benefits, including waste reduction, cost savings, and potential improvements in material characteristics, Research indicates that granite powder can serve as a viable substitute for both cement and fine aggregates in various applications, particularly in masonry mortars and concrete.

Silica Fume as a partially replacement of OPC 43 grade of cement

The partial replacement of Ordinary Portland Cement (OPC) 43 grade with silica fume offers significant benefits in concrete production, primarily enhancing its mechanical properties and durability. Silica fume, also known as micro silica, is an amorphous polymorph of silicon dioxide, a byproduct of the production of silicon or ferrosilicon alloys. Its extremely fine particle size and high pozzolanic activity make it an excellent supplementary cementitious material (SCM).

Furthermore, the use of silica fume contributes to sustainable construction practices by utilizing an industrial byproduct, thereby reducing the carbon footprint associated with cement production, which is a significant emitter of CO_2.The chemical reaction involved can be simplified as:

SiO2(silica fume)+Ca(OH)2(from cement hydration)→C-S-H gel (additional)

This reaction consumes the free calcium hydroxide, which is a weak link in the cement paste, transforming it into a strong, binding C-S-H gel, thus enhancing the overall strength and durability of the concrete matrix.

II. PROBLEM STATEMENTS

1. The experimental research used in this study demonstrated that Iron powder with Fine aggregate, Granite powder with Coarse aggregate and Silica Fume with OPC 43 grade of cement, in this study in specified percentages, the mechanical properties of concrete improved.
2. The compressive strength, flexural strength, and splitting tensile strength of materials have been shown to increase when Iron powder, Granite powder and Silica Fume concrete are used in specific proportions.
3. Additionally, by partially replacing sand with these powders, the construction industry will use less sand, protecting more of these natural resources. These byproducts' environmental and health risks can be reduced by recycling them and using them in concrete.
4. Granite powder and iron powder industrial byproducts resulting from the granite stone crushing and polishing and from the steel production respectively. These byproducts can be used as partial replacement of sand and coarse aggregate in concrete.

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III.METHODOLOGY & MIX DESIGN

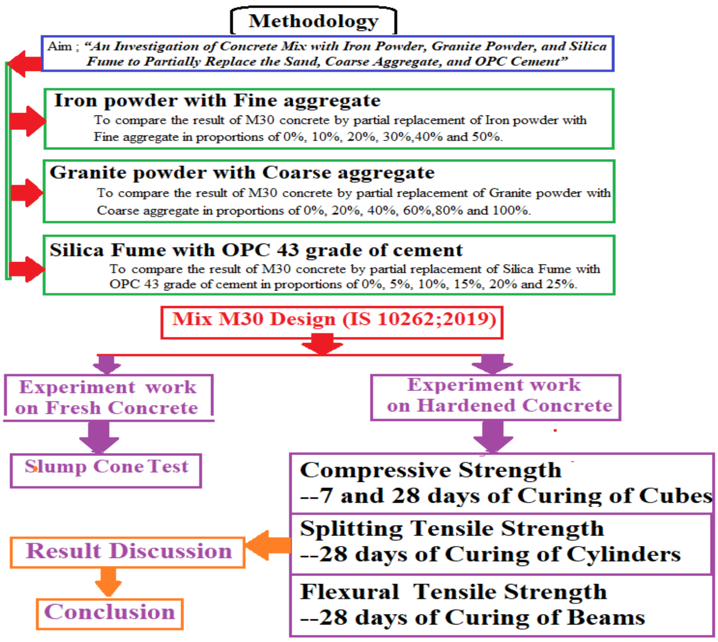

Figure no. 1; Flowchart of Methodology

Mix Design M30 Grade of concrete

The mix design is carried out according to (Mix design code) IS code 10262:2019 Through following step – As per IS Code 10262:2019 (New revised code)

Step I - Design Stipulation

Grade Designation = M30
Type of Cement = OPC 43 Grade; IS 2269:1987
Max. Nominal Size = 20 mm to 12 mm (Mixed in ratio 60:40)
Shape of Coarse Aggregate = Angular
Min. Cement Content = 320 kg/m3
Max. W/C Ratio = 0.50
Workability = 50 mm to 100 mm Slump
Exposure Condition = Moderate
Chemical admixture = not used

Step II - Test Data for Material

Specific gravity of Cement = 3.15
Specific gravity of Silica Fume = 2.29
Specific gravity of Fine aggregate = 2.859
Specific gravity of Iron Powder = 2.599
Specific gravity of coarse aggregate = 2.830
Specific gravity of Granite Powder = 2.783
Free surface moisture of sand = 0.31%
Free surface moisture of coarse aggregate = 0.69%
Water absorption of coarse aggregate = 0.98%
Water absorption of sand = 1.38 %

Target Mean Strength Calculation

The target mean strength (f target) is calculated to account for variations in concrete strength. The formula used is:

$$F\ target = f\ ck + 1.65 \times S$$

Or

$$F\ target = f\ ck + X$$

Where:
•f ck = Characteristic compressive strength (30 MPa).
•S = Standard deviation (obtained from Table 1 of IS 10262:2019). If no test data is available, a standard deviation of 5 N/mm2 is often used for M30 concrete.
•X = Factor based on the grade of concrete as per table 1 of IS 10262: 2019

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Therefore,

$$F\ target = f\ ck + 1.65 \times S$$
$$Ftarget = 30 + 1.65 \times 5 = 38.25\ N/mm2$$
Or
$$F\ target = f\ ck + X$$
$$30 + 6.5 = 36.5\ N/mm2$$

The higher value is adopted, so the target strength is 38.25 N/mm2

Table no.1 Mix proportion of M30 Grade of concrete

Cement	Water	Fine aggregate	Coarse aggregate
359 kg	158 lts	756.34 kg/m3	1123.12 kg/m3
1	0.44	2.11	3.13

IV. RESULT DISCUSSION

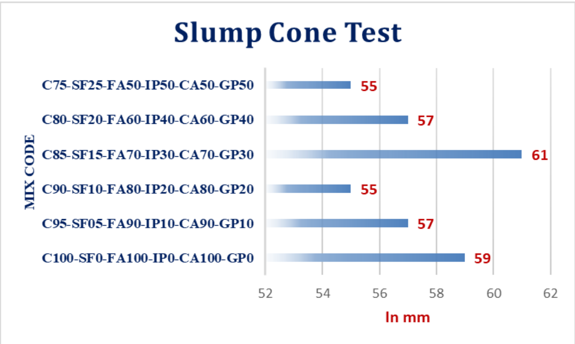

Figure no. 2; Workability testing of fresh concrete with mix Iron Powder, Granite Powder, and Silica Fume.

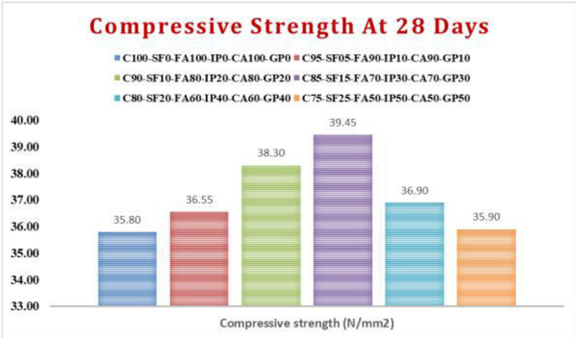

Figure no. 3; Compressive Strength of concrete with mix Iron Powder, Granite Powder, and Silica Fume at 28 days of Curing.

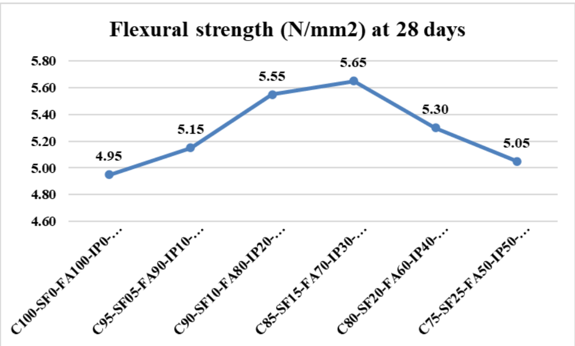

Figure no. 4; Flexural Tensile Strength of concrete with mix Iron Powder, Granite Powder, and Silica Fume at 28 days of Curing.

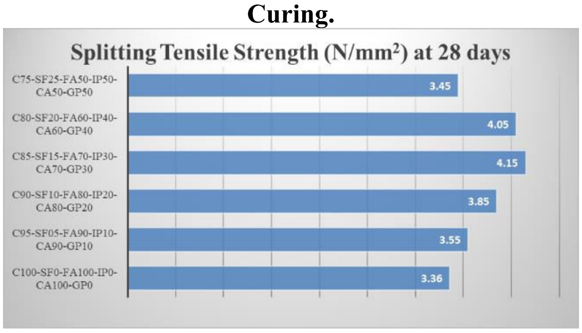

Figure no. 5; Splitting Tensile Strength of concrete with mix Iron Powder, Granite Powder, and Silica Fume at 28 days of Curing.

IV. CONCLUSION AND FUTURE WORK

1.The concrete mix made using Iron Powder, Granite Powder, and Silica Fume as partial replacement of sand, coarse aggregate and OPC cement showed good workability and Fluidity similar to normal concrete mixes.

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2.The workability of Mix design C100-SF0-FA100-IP0-CA100-GP0 is 59 mm and the addition of Iron Powder, Granite Powder, and Silica Fume as partial replacement of sand, coarse aggregate and OPC cement Mix design C85-SF15-FA70-IP30-CA70-GP30 slump value is 61mm with 3.39 % Increase in strength for fresh concrete.
3.The compressive strength of Mix design C100-SF0-FA100-IP0-CA100-GP0 is 25.10 MPa and the addition of Iron Powder, Granite Powder, and Silica Fume as partial replacement of sand, coarse aggregate and OPC cement Mix design C85-SF15-FA70-IP30-CA70-GP30 flexural strength (N/mm2) is 28.50 MPa with 13.55 % Increase in strength at 7 days Cube of curing.
4.The compressive strength of Mix design C100-SF0-FA100-IP0-CA100-GP0 is 35.80 MPa and the addition of Iron Powder, Granite Powder, and Silica Fume as partial replacement of sand, coarse aggregate and OPC cement Mix design C85-SF15-FA70-IP30-CA70-GP30 flexural strength (N/mm2) is 39.45 MPa with 10.19 % Increase in strength at 28 days Cubes of curing.
5.The flexural strength of Mix design C100-SF0-FA100-IP0-CA100-GP0 is 4.55 MPa and the addition of Iron Powder, Granite Powder, and Silica Fume as partial replacement of sand, coarse aggregate and OPC cement Mix design C85-SF15-FA70-IP30-CA70-GP30 flexural strength (N/mm2) is 5.65 MPa with 14.14 % Increase in strength at 28 days Beams of curing.
6.The Splitting tensile strength of Mix design C100-SF0-FA100-IP0-CA100-GP0 is 3.36 MPa and the addition of Iron Powder, Granite Powder, and Silica Fume as partial replacement of sand, coarse aggregate and OPC cement Mix design C85-SF15-FA70-IP30-CA70-GP30 Splitting Tensile Strength (N/mm2) is 4.15 MPa with 23.51% Increase in strength at 28 days Cylinders of curing.

The future scope

1.The future scope of concrete mixes incorporating iron powder, granite powder, and silica fume as partial replacements for sand, coarse aggregate, and Ordinary Portland Cement (OPC) respectively, is highly promising due to their potential to enhance various concrete properties and contribute to sustainable construction practices.
2.This approach addresses several critical aspects of modern concrete technology, including improved mechanical performance, durability, and environmental impact reduction.
3.Research indicates that optimal replacement levels need to be determined to avoid potential issues like increased drying shrinkage or corrosion of the iron particles within the alkaline concrete environment.
4.Silica fume, a highly pozzolanic material, is well-established for its ability to significantly enhance the strength and durability of concrete when used as a partial replacement for OPC.

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