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Performance of Self-Compacting Concrete by Amalgamating Waste Materials Using Absolute Volume Method

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Abstract: The growing emphasis on sustainable construction practices has led to the evolution of advanced concrete technologies, among which Self-Compacting Concrete (SCC) stands out due to its unique ability to flow and compact under its own weight without the need for mechanical vibration. While SCC offers superior workability and surface finish, its traditional composition heavily depends on cement and river sand, both of which have significant environmental implications, particularly due to high energy consumption, CO_2 emissions, and depletion of natural resources. In this study, an attempt has been made to partially replace natural fine aggregate (Bhandara sand) with various industrial and construction waste materials such as stone dust, brick powder, and glass powder, thereby improving the environmental profile of SCC while maintaining or enhancing its mechanical performance. The materials were used individually and in hybrid combinations, and the mixes were designed using the Absolute Volume Method (AVM), a rational mix design approach that ensures optimal volumetric proportions. Cube specimens were cast in standard molds and tested for compressive strength after 7 and 28 days of water curing. The results showed that replacing 25–35% of Bhandara sand with stone dust improved compressive strength, with a maximum of 33.51 N/mm² at 35% replacement after 28 days. Brick powder replacement, however, showed reduced strength values compared to conventional SCC, indicating limitations in its use as a sole replacement material. A hybrid mix comprising 25% stone dust, 25% brick powder, and 5% glass powder demonstrated moderate strength, suggesting potential for multi-material optimization. This study confirms that industrial by-products and construction waste can be effectively used in SCC to enhance sustainability while maintaining acceptable strength characteristics. The findings contribute to the growing body of knowledge aimed at reducing the carbon footprint of construction materials and promoting circular economy principles in concrete technology.
Keywords: Self-Compacting Concrete (SCC), Absolute Volume Method (AVM), Supplementary Cementitious Materials (SCMs), Sustainable Concrete, Industrial Waste, Agricultural Waste.

I. INTRODUCTION

The rising demand for high-performance and environmentally sustainable construction materials has led to significant advancements in concrete technology, with Self-Compacting Concrete (SCC) emerging as a key innovation. Characterized by its ability to flow under its own weight and fill complex formworks without the need for mechanical vibration, SCC offers improved workability and construction efficiency. However, conventional SCC production relies heavily on cement, which is associated with high energy consumption and substantial carbon dioxide emissions.

To address these environmental concerns, recent research has focused on incorporating industrial and agricultural waste materials—such as fly ash, ground granulated blast furnace slag (GGBS), silica fume, rice husk ash (RHA), marble dust, and recycled aggregates—as partial replacements for cement and natural aggregates. These supplementary materials, when appropriately selected and proportioned, not only reduce the environmental impact but can also enhance the fresh and hardened properties of SCC. Achieving optimal performance, however, requires a well-designed mix, and the Absolute Volume Method (AVM) offers a systematic and accurate approach by considering the true volumetric proportions of all concrete constituents. This research paper explores the influence of various waste materials on the performance of SCC using the AVM, with a focus on workability, strength, durability, and overall sustainability.

It also highlights existing research gaps and outlines future directions for optimizing sustainable SCC through volume-based mix design strategies.

II. LITERATURE REVIEW

Recent research underscores the growing emphasis on sustainability in concrete technology, particularly through the use of self-compacting concrete (SCC) incorporating recycled and industrial waste materials. Ahmed et al. (2023) demonstrated that 100% replacement of natural coarse aggregates with recycled concrete aggregates, alongside 20% metakaolin and 22% fly ash, yielded viable SCC mixes with enhanced ultimate load and flexural stiffness despite a slight drop in compressive strength. Bari et al. (2023) found that partial cement replacement with fly ash improved compressive strength, workability, and long-term durability. Rashid et al. (2022) highlighted SCC's evolution and its rheological advantages, while Kumar et al. (2019) and Ahmed M.I. et al. (2019) confirmed the beneficial roles of stone dust and fly ash in improving SCC performance and economy. Similarly, Bhange et al. (2018) emphasized the importance of mineral admixtures and aggregate grading in SCC mix design. The integration of waste glass powder (WGP), municipal solid waste incineration by-products (MSWI), and stone dust was explored by Budharapu Neha Guruswami et al. (2024), revealing optimal strength at specific replacement levels despite reduced workability. Fadi Althoey et al. (2023) highlighted the effectiveness of combining fly ash, WGP, and coconut fibers to enhance strength and crack resistance. Benyahia Amar et al. (2022) and Rekha Yadav et al. (2021) reported improved mechanical and durability characteristics with WGP and stone dust combinations. Samia Tariq et al. (2020) and Gokulnath et al. (2019) emphasized the durability and workability benefits of glass powder in SCC, while Bhargava et al. (2016), Rajathi et al. (2014), and others stressed the potential of glass powder despite some reductions in fresh properties. Studies on brick powder by Wolde et al. (2023), Iqbal et al. (2022), and Rather et al. (2019) indicated improved tensile strength and durability at optimal replacement levels, whereas Letelier et al. (2018) supported the simultaneous use of brick powder and recycled aggregates for sustainable SCC. Further, Lohani et al. (2016) and Ranjodh Singh et al. (2013) showcased the utility of brick kiln dust and marble powder in maintaining performance while promoting environmental sustainability. Collectively, these studies confirm the feasibility of incorporating diverse waste materials into SCC to enhance structural properties, reduce environmental impact, and support cost-effective construction.

III. PROPOSED METHODOLOGY

A. *Materials Used for Self-Compacting Concrete*

1) Cement: Cement acts as the primary binding material in concrete. It is essential in the production of concrete, which is a fundamental construction material used in buildings, roads, bridges, dams, ports, and various other infrastructures. Additionally, cement-based concrete is employed in decorative applications such as patios, staircases, driveways, floors, and pool decks.
2) Aggregates: Aggregates play a critical role in the performance of Self-Compacting Concrete (SCC). Their properties significantly influence the flowability, stability, and strength of the mix. Although SCC uses aggregates similar to those in conventional concrete, special attention is paid to size, shape, texture, and grading to ensure that the mix can flow under its own weight without segregation or bleeding.
3) Water: The water used in SCC must conform to the standards applicable for reinforced and prestressed concrete. Potable water, free from harmful impurities, is typically recommended to ensure proper hydration and long-term durability of the concrete.
4) Chemical Admixtures: High-range water-reducing admixtures, commonly known as superplasticizers, are essential components in SCC to achieve the desired workability without increasing the water content. Additional admixtures such as air-entraining agents may be used to enhance freeze-thaw durability, while retarders can be added to control setting time, especially in hot weather conditions.
5) Stone Dust: Stone dust is a byproduct generated during the crushing of stones for producing coarse aggregates. Traditionally considered waste, this material has been explored as a partial replacement for river sand in concrete mixes. While it does not conform to standard specifications for fine aggregates, research has demonstrated its potential to be effectively used in SCC, thereby reducing environmental concerns associated with disposal and land degradation.
6) Glass Powder: Waste glass poses a long-term environmental challenge as it takes nearly a million years to decompose naturally. Its disposal in landfills consumes considerable space and reduces landfill lifespan. However, finely ground waste glass exhibits pozzolanic properties and can be used as a partial cement or fine aggregate replacement in concrete. This not only recycles waste but also conserves natural resources such as river sand and aggregates. Several construction industries have already begun incorporating waste glass powder in concrete, given its inert nature and compatibility with cementitious systems.
7) Brick Powder: Brick powder is a waste material generated from brick kilns and tile manufacturing industries, commonly in the form of dust, broken pieces, or brickbats. In many regions, these waste materials are disposed of in low-lying areas or discarded without effective use. Recent studies have focused on utilizing brick powder in concrete mixes, considering its pozzolanic properties and potential to reduce dependency on conventional raw materials.

B. Mix Design: Bhandara

1) Mix Proportioning of M30 grade of Self compacting Concrete

A) Stipulation for proportioning
   1) Grade of concrete: M30
   2) Type of cement: OPC 43 grade conforming to IS 269
   3) Nominal maximum size of aggregate :20mm
   4) Exposure Condition: Severe
   5) Slump flow class: SF3 (760mm-850mm)
   6) Degree of site control: Good
   7) Type of Aggregate: Crushed Angular Aggregate
   8) Maximum cement content: 450 kg/m^3

B) Test data for material.
   1) Cement used: OPC 43 Grade conforming to IS 269
   2) Specific gravity of materials
      i. Cement: **3.15**
      ii. Coarse aggregate: **2.58**
      iii. Fine aggregate: **2.23** (Bhandara) and **2.46** (Wardha)
      iv. Chemical admixture: **1.08**
   3) Water absorption of materials
      i. Coarse aggregate: **0.70%**
      ii. Fine aggregate: **1.10%** (Bhandara) and **1.50%** (Wardha)
   4) Fineness Modulus of material
      i. Coarse aggregate: **4.34**
      ii. Fine Aggregate: **2.47** (Bhandara) and **2.59** (Wardha)

2) Design Procedure:

Step 1: TARGET STRENGTH FOR MIX PROPORTIONING

$f'ck$ = fck+1.65 S

= 30+ 1.65*5

= 38.25 N/mm2

Step 2: APPROXIMATE AIR CONTENT

From table no. 03, The approximate amount of entrapped air to be expected in normal (Non-air-entrained) concrete is 1.0 percent for 20 mm nominal maximum size of aggregate.

Step 3: SELECTION OF WATER-CEMENT RATIO

The free water-cement ratio required for the target strength of 38.25 N/mm2 is 0.43 for OPC 43 grade curve. This is lower than the maximum value of 0.45 prescribed for 'severe' exposure for reinforced concrete as per Table 5 of IS 456. 0.43< 0.45, hence O.K.

Step 4: SELECTION OF WATER CONTENT AND CEMENT CONTENT

The class of slump flow is specified to be SF3 having a slump flow between 750 and
850 mm. To start with, a water content of 180 kg/m3 along with a superplasticizer @ 0.6 percent by mass of cementitious material content is selected for the initial mix.

However, the water content can be reduced further by increasing the dose of superplasticizer.

This water content of 180 kg/m3 will correspond to a cement content of 419 kg/m3 for water. We take 35% fly ash,

Fly ash = 419-35% Fly ash = 147 kg/m3 Cement = 305 kg/m3

Step 5: SELECTION OF ADMIXTURE CONTENT

Taking an admixture dose of 0.6 percent by mass of cementitious material, the mass of admixture = 0.6/100 × 419 = 2.51 kg/m3.

Step 6: SELECTION OF POWDER CONTENT AND FINE AGGREGATE
CONTENT

The powder content (fines < 0.125 mm) required for SCC is generally in the range of 400 to 600 kg/m3. Therefore, a powder content of 500 kg/m3 is selected. This powder content will constitute the entire OPC.

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Fines required to be contributed by fine aggregate = Total powder content – (Fly ash content + cement content) = 500 – (147+305) = 48 kg/m3.
The fine aggregate has 8% materials < 0.125 mm. Therefore, the fine aggregate quantity =48/0.08 = 600 kg/m3.
Step 7: SELECTION OF COARSE AGGREGATE CONTENT
Let,
Vca be the volume of coarse aggregate.
Assuming 1 m3 of concrete, Vca = (1 - Air content) - (Vol of water + Vol of cement + Vol of fly ash + Vol of admixture + Volume of fine aggregate)
Vca = (1-0.01) [180/(1×1000)+305/(3.15×1000)+147/2.2×1000+2.51/1.08×1000)+ (600/2.23×1000)]
= 0.374 m3
Mass of coarse aggregate
= Vca x specific gravity of coarse aggregate × 1000
= 0.374 × 2.58 × 1000
= 964.92 kg/m3
Step 8: CALCULATION OF VOLUME OF POWDER CONTENT
Vol of powder content = Vol of OPC + Vol of fly ash +Vol of portion of fine aggregate < 0.125 mm
= 305/(3.15× 1000) +147/(2.2×1000) + 48/(2.23× 1000)
= 0.185 m^3
Ratio of water to powder by volume =
0.180/ 0.185 = 0.97
Step 9: MIX PROPORTION
1. Cement = 305 kg/m^3
2. Fly ash = 147 kg/m^3
3. Water (net mixing) = 180 kg/m^3
4. Fine aggregate = 600 kg/m^3
5. Coarse aggregate = 964.92 kg/m^3
6. Chemical admixture = 2.51 kg/m^3
7. Water-cement ratio=0.43
8. Powder content = 500 kg/m^3
9. Water powder ratio by volume = 0.97

C. Quantities of Material: Bhandara Cubes
1) Conventional Self Compacting

Table 3.2.1: Conventional Self Compacting Concrete

Sr. No	Materials	Quantity (3 Cubes)
1	Cement	4.371 kg
2	Water	1879 ml
3	Fine Aggregate	10.686 kg
4	Coarse Aggregate	9.267 kg
5	Super Plasticizer	45 ml

2) Stone Dust (25%) replacement

Table 3.2.2: Stone Dust (25%) replacement

Sr. No	Materials	Quantity (3 Cubes)
1	Cement	3.276 kg
2	Water	1879 ml
3	Fine Aggregate	8.016 kg
4	Coarse Aggregate	9.267 kg
5	Chemical Admixture	57 ml
6	Fly ash	1.092 kg
7	Stone dust	2.670 kg

3) Stone Dust (35%) replacement

Table 3.2.3: Stone Dust (35%) replacement

Sr. No	Materials	Quantity (3 Cubes)
1	Cement	3.276 kg
2	Water	1879 ml
3	Fine Aggregate	6.945 kg
4	Coarse Aggregate	9.267 kg
5	Chemical Admixture	57 ml
6	Fly ash	1.092 kg
7	Stone dust	3.738 kg

4) Brick Powder (25%) Replacement

Table 3.2.4: Brick Powder (25%) replacement

Sr. No	Materials	Quantity (3 Cubes)
1	Cement	3.276 kg
2	Water	1879 ml
3	Fine Aggregate	8.016 kg
4	Coarse Aggregate	9.267 kg
5	Chemical Admixture	57 ml
6	Fly ash	1.092 kg
7	Brick powder	2.670kg

5) Brick Powder (35%) Replacement

Table 3.2.5: Brick Powder (35%) replacement

Sr. No	Materials	Quantity (3 Cubes)
1	Cement	3.276 kg
2	Water	1879 ml
3	Fine Aggregate	6.945 kg
4	Coarse Aggregate	9.267 kg
5	Chemical Admixture	57 ml
6	Fly ash	1.092 kg
7	Brick powder	3.738 kg

6) Hybrid

Table 3.2.6: Hybrid (SD, BP &GP) replacement

Sr. No	Materials	Quantity (3 Cubes)
1	Cement	3.111 kg
2	Water	1879 ml
3	Fine Aggregate	5.343 kg
4	Coarse Aggregate	9.267 kg
5	Chemical Admixture	57 ml
6	Fly ash	2.184 kg
7	Stone dust	2.670 kg
8	Glass powder	0.163 kg
9	Brick powder	2.670 kg

D. Quantities of Material: Bhandara Beams

1) Conventional Self Compacting

Table 3.3.1: Conventional Self Compacting Concrete

Sr. No	Materials	Quantity (3 Beam)
1	Cement	6.432 kg
2	Water	2766 ml
3	Fine Aggregate	15.726 kg
4	Coarse Aggregate	13.641 kg
5	Super Plasticizer	55 ml

2) Stone Dust (25%) Replacement

Table 3.3.2: Stone Dust (25%) replacement

Sr. No	Materials	Quantity (3 Beam)
1	Cement	4.824 kg
2	Water	2766 ml
3	Fine Aggregate	11.793 kg
4	Coarse Aggregate	13.641 kg
5	Chemical Admixture	84 ml
6	Fly ash	1.603 kg
7	Stone dust	3.930 kg

3) Stone Dust (35%) Replacement

Table 3.3.3: Stone Dust (35%) replacement

Sr. No	Materials	Quantity (3 Beam)
1	Cement	4.824 kg
2	Water	2766 ml
3	Fine Aggregate	10.221 kg
4	Coarse Aggregate	13.641 kg
5	Chemical Admixture	84 ml
6	Fly ash	1.608 kg
7	Stone dust	5.502 kg

4) Brick Powder (25%) Replacement

Table 3.3.4: Brick Powder (25%) replacement

Sr. No	Materials	Quantity (3 Beam)
1	Cement	4.824 kg
2	Water	2766 ml
3	Fine Aggregate	11.793 kg
4	Coarse Aggregate	13.641 kg
5	Chemical Admixture	84 ml
6	Fly ash	1.603 kg
7	Brick powder	3.930 kg

5) Brick Powder (35%) replacement

Table 3.3.5: Brick Powder (35%) replacement

Sr. No	Materials	Quantity (3 Beam)
1	Cement	4.824 kg
2	Water	2766 ml
3	Fine Aggregate	10.221 kg
4	Coarse Aggregate	13.641 kg
5	Chemical Admixture	84 ml
6	Fly ash	1.608 kg
7	Brick powder	5.502 kg

6) Hybrid

Table 3.3.6: Hybrid (SD, BP & GP) replacement

Sr. No	Materials	Quantity (3 Beam)
1	Cement	4.581 kg
2	Water	2661 ml
3	Fine Aggregate	7.863 kg
4	Coarse Aggregate	13.641 kg
5	Chemical Admixture	84 ml
6	Fly ash	1.603 kg
7	Stone dust	3.930 kg
8	Glass powder	0.240 kg
9	Brick powder	3.930 kg

E. Quantities of material: Bhandara Cylinder

1) Conventional Self Compacting

Table 3.4.1: Conventional Self Compacting Concrete

Sr. No	Materials	Quantity (3 Cylinder)
1	Cement	6.867 kg
2	Water	2953 ml
3	Fine Aggregate	16.79 kg
4	Coarse Aggregate	14.56 kg
5	Super Plasticizer	60 ml

2) Stone Dust (25%) replacement

Table 3.4.2: Stone Dust (25%) replacement

Sr. No	Materials	Quantity (3 Cylinder)
1	Cement	5.140 kg
2	Water	2210 ml
3	Fine Aggregate	12.59 kg
4	Coarse Aggregate	14.56 kg
5	Chemical Admixture	89.49 ml
6	Fly ash	1.71 kg
7	Stone dust	4.19 kg

3) Stone Dust (35%) Replacement

Table 3.4.3: Stone Dust (35%) replacement

Sr. No	Materials	Quantity (3 Cylinder)
1	Cement	5.140 kg
2	Water	2210 ml
3	Fine Aggregate	10.91 kg
4	Coarse Aggregate	14.56 kg
5	Chemical Admixture	89.49 ml
6	Fly ash	1.71 kg
7	Stone dust	5.87 kg

4) Brick Powder (25%) Replacement

Table 3.4.4: Brick Powder (25%) replacement

Sr. No	Materials	Quantity (3 Cylinder)
1	Cement	5.140 kg
2	Water	2210 ml
3	Fine Aggregate	12.59 kg
4	Coarse Aggregate	14.56 kg
5	Chemical Admixture	89.49 ml
6	Fly ash	1.71 kg
7	Brick powder	4.19 kg

5) Brick Powder (35%) Replacement

Table 3.4.5: Brick Powder (35%) replacement

Sr. No	Materials	Quantity (3 Cylinder)
1	Cement	5.140 kg
2	Water	2210 ml
3	Fine Aggregate	10.91 kg
4	Coarse Aggregate	14.56 kg
5	Chemical Admixture	89.49 ml
6	Fly ash	1.71 kg
7	Brick powder	5.87 kg

6) Hybrid

Table 3.4.6: Hybrid (SD, BP &GP) replacement

Sr. No	Materials	Quantity (3 Cylinder)
1	Cement	4.890 kg
2	Water	2103 ml
3	Fine Aggregate	8.39 kg
4	Coarse Aggregate	14.56 kg
5	Chemical Admixture	89.49 ml
6	Fly ash	3.43 kg
7	Stone dust	4.19 kg
8	Glass powder	0.26 kg
9	Brick powder	4.19 kg

IV. RESULTS & DISCUSSION

A. Compressive Strength Test

For the determination of compressive strength, concrete cube specimens of dimensions 150 mm × 150 mm × 150 mm were prepared. The freshly mixed concrete was placed into the molds in layers and properly compacted to eliminate any voids or air pockets. After 24 hours, the molds were carefully removed, and the specimens were submerged in water for curing. To ensure uniform load distribution during testing, the top surfaces of the cubes were leveled and smoothed by applying a layer of cement paste evenly across the entire surface. Compressive strength testing was carried out using a compression testing machine after curing periods of 7 and 28 days. The load was applied gradually until failure occurred. The compressive strength was then calculated by dividing the maximum load at failure by the cross-sectional area of the specimen.

Fig.4.1: Concrete Cube After Test

Fig.4.2: Compressive Strength Testing

BHANDARA SAND (CUBES)

1) M30 grade of Conventional Self Compacting Concrete (28 days):

Table 4.1.2: Conventional Self Compacting Concrete (28 days)

Cube sample (Bhandara)	Weight (Kg)	Load (KN)	Compressive Strength (N/mm^2)
Cube 1	7.23	700.88	30.15
Cube 2	7.96	748.80	31.24
Cube 3	8.02	729.23	30.01

2) M30 grade of self compacting concrete with Stone Dust 25% replacement (28 days)

Table 4.1.4: Stone Dust 25% replacement (28 days)

Cube sample (Bhandara)	Weight (Kg)	Load (KN)	Compressive Strength (N/mm^2)
Cube 1	10.15	688.92	31.64
Cube 2	9.54	712.58	31.67
Cube 3	10.63	697.05	31.98

3) M30 grade of self compacting concrete with Stone powder 35% replacement (28 days)

Table 4.1.6: Stone powder 35% replacement (28 days)

Cube sample (Bhandara)	Weight (Kg)	Load (KN)	Compressive Strength (N/mm^2)
Cube 1	9.85	773.10	34.36
Cube 2	10.25	732.15	32.54
Cube 3	10.38	745.65	33.63

4) M30 grade of self compacting concrete with Brick powder 25% replacement (28 days)

Table 4.1.8: Brick powder 25% replacement (28 days)

Cube sample (Bhandara)	Weight (Kg)	Load (KN)	Compressive Strength (N/mm^2)
Cube 1	9.44	347.63	19.45
Cube 2	9.45	284.63	16.45
Cube 3	9.60	230.18	18.40

5) M30 grade of self compacting concrete with Brick powder 35% replacement (28 days):

Table 4.1.10: Brick powder 35% replacement (28 days)

Cube sample (Bhandara)	Weight (Kg)	Load (KN)	Compressive Strength (N/mm^2)
Cube 1	9.80	259.65	18.35
Cube 2	8.75	217.13	15.62
Cube 3	10.01	235.13	16.30

6) M30 grade of self compacting concrete with Hybrid replacement (Stone Dust, Brick Powder & Glass Powder) (28 days):

Table 4.1.12: Hybrid replacement (28 days)

Cube sample (Bhandara)	Weight (Kg)	Load (KN)	Compressive Strength (N/mm^2)
Cube 1	9.75	255.60	18.43
Cube 2	9.84	303.75	19.35
Cube 3	9.75	275.40	19.82

B. Flexural Strength Test

For Beam test specimens of 50 cm X 10 cm X 10 cm are used. The flexural strength test measures a material's ability to resist bending when subjected to a load. In this test, a beam-shaped sample is placed on two supports, and a load is applied at the center or multiple points along the beam. The material bends under the applied force, with the tensile stress on one side and compressive stress on the other. The test determines the point at which the material fractures or yields, and the flexural strength is calculated using the maximum applied load, the span between supports, and the beam's dimensions. This test helps assess a material's durability and performance in applications subjected to bending forces, such as structural components.

Fig.5.3: Flexural Strength Test

BHANDARA SAND (BEAM)

1) M30 grade of Conventional Self Compacting Concrete (28 days):

Table 4.2.1: Conventional Self Compacting Concrete (28 days)

Beam sample (Bhandara)	Weight (Kg)	Load (KN)	Flexural Strength (N/mm^2)
Beam 1	15.50	12.54	1.21
Beam 2	14.85	13.62	1.20
Beam 3	15.24	14.86	1.90

2) M30 grade of self compacting concrete with Stone Dust 25% replacement (28 days):

Table 4.2.2: Stone Dust 25% replacement (28 days)

Beam sample (Bhandara)	Weight (Kg)	Load (KN)	Flexural Strength (N/mm^2)
Beam 1	14.60	9.98	1.99
Beam 2	15.50	10.09	2.10
Beam 3	15.10	9.12	2.05

3) M30 grade of self compacting concrete with Stone Dust 35% replacement (28 days):

Table 4.2.3: Stone dust 35% replacement (28 days)

Beam sample (Bhandara)	Weight (Kg)	Load (KN)	Flexural Strength (N/mm^2)
Beam 1	15.15	9.18	2.32
Beam 2	14.50	9.02	2.30
Beam 3	14.80	9.15	2.34

4) M30 grade of self compacting concrete with Brick powder 25% replacement (28 days):

Table 4.2.4: Brick powder 25% replacement (28 days)

Beam sample (Bhandara)	Weight (Kg)	Load (KN)	Flexural Strength (N/mm^2)
Beam 1	14.88	5.09	0.58
Beam 2	14.47	5.13	0.50
Beam 3	14.54	5.10	0.55

5) M30 grade of self compacting concrete with Brick powder 35% replacement (28 days):

Table 4.2.5: Brick powder 35% replacement (28 days)

Beam sample (Bhandara)	Weight (Kg)	Load (KN)	Flexural Strength (N/mm^2)
Beam 1	13.96	3.15	0.44
Beam 2	13.74	5.00	0.26
Beam 3	13.89	4.12	0.34

6) M30 grade of self compacting concrete with Hybrid replacement (28 days):

Table 4.2.6: Hybrid replacement (28 days)

Beam sample (Bhandara)	Weight (Kg)	Load (KN)	Flexural Strength (N/mm^2)
Beam 1	14.75	9.99	1.85
Beam 2	13.69	7.60	1.90
Beam 3	14.98	8.11	1.65

C. For Flexural strength testing, cylindrical specimens of size 150 mm diameter and 300 mm height are used. The test evaluates the concrete's ability to withstand axial compressive loads. In this method, the cylinder is placed vertically between the platens of a compression testing machine, and a uniform load is applied until the specimen fails. The compressive strength is determined by dividing the maximum load carried by the specimen by its cross-sectional area. This test is crucial for assessing the concrete's load-bearing capacity, ensuring it meets structural and safety requirements for various construction applications.

Fig.5.4: Split Tensile Strength Test

BHANDARA SAND (CYLINDER)

1) M30 grade of Conventional Self Compacting Concrete (28 days):

Table 4.3.2: Conventional Self Compacting Concrete (28 days)

Cylinder sample (Bhandara)	Weight (Kg)	Load (KN)	Tensile Strength (N/mm^2)
Cylinder 1	13.48	62.20	3.52
Cylinder 2	13.10	63.45	3.59
Cylinder 3	12.99	53.29	3.01

2) M30 grade of self compacting concrete with Stone Dust 25% replacement (28 days):

Table 4.3.4: Stone Dust 25% replacement (28 days)

Cylinder sample (Bhandara)	Weight (Kg)	Load (KN)	Tensile Strength (N/mm^2)
Cylinder 1	12.90	69.82	3.95
Cylinder 2	13.25	75.61	4.25
Cylinder 3	13.46	78.66	4.45

3) M30 grade of self compacting concrete with Stone Dust 35% replacement (28 days):

Table 4.3.6: Stone dust 35% replacement (28 days)

Cylinder sample (Bhandara)	Weight (Kg)	Load (KN)	Tensile Strength (N/mm^2)
Cylinder 1	13.35	82.84	4.69
Cylinder 2	12.98	82.91	4.70
Cylinder 3	13.43	82.29	4.65

4) M30 grade of self compacting concrete with Brick powder 25% replacement (28 days)

Table 4.3.8: Brick powder 25% replacement (28 days)

Cylinder sample (Bhandara)	Weight (Kg)	Load (KN)	Tensile Strength (N/mm^2)
Cylinder 1	12.74	68.53	3.88
Cylinder 2	13.42	65.76	3.72
Cylinder 3	13.35	68.03	3.85

5) M30 grade of self compacting concrete with Brick powder 35% replacement (28 days):

Table 4.3.10: Brick powder 35% replacement (28 days)

Cylinder sample (Bhandara)	Weight (Kg)	Load (KN)	Tensile Strength (N/mm^2)
Cylinder 1	13.15	69.30	3.92
Cylinder 2	12.65	70.55	3.99
Cylinder 3	13.47	69.48	3.93

6) M30 grade of self compacting concrete with Hybrid replacement (28 days):

Table 4.3.12: Hybrid replacement (28 days)

Cylinder sample (Bhandara)	Weight (Kg)	Load (KN)	Tensile Strength (N/mm^2)
Cylinder 1	12.22	104.26	5.90
Cylinder 2	13.76	70.55	3.99
Cylinder 3	13.35	88.00	4.98

➢ Comparison between Experimental & Analytical calculation

BHANDARA SAND - 28 DAYS - EXPERIMENTAL				
	COMPRESSION STRENGTH (CUBE) in N/mm2	FLEXURAL STRENGTH in N/mm2 (BEAM)	TENSILE STRENGTH in N/mm2 (CYLINDER)	DEFLECTION OF BEAM in mm
Conventional concrete	30.46	1.20	3.37	1.98
Stone dust 25%	31.76	2.05	4.22	1.75
Stone dust 35%	33.51	2.32	4.68	1.45
Brick powder 25%	18.01	0.54	3.81	1.96
Brick powder 35%	16.79	0.35	3.94	2.25
Hybrid	19.2	1.80	4.95	1.50

BHANDARA SAND - 28 DAYS - ANALYTICAL				
	COMPRESSION STRENGTH (CUBE) in N/mm2	FLEXURAL STRENGTH in N/mm2 (BEAM)	TENSILE STRENGTH in N/mm2 (CYLINDER)	DEFLECTION OF BEAM in mm
Conventional concrete	32.28	3.02	3.54	2.05
Stone dust 25%	31.09	3.79	4.36	1.85
Stone dust 35%	33.35	3.81	4.73	2.05
Brick powder 25%	12.77	2.58	3.94	1.98
Brick powder 35%	10.54	2.14	3.99	2.30
Hybrid	12.36	4.95	4.98	2.00

V. CONCLUSION

The compressive strength of Self-Compacting Concrete (SCC) was evaluated using various combinations of waste materials as partial replacements for Bhandara sand. The control mix using 100% Bhandara sand achieved an average compressive strength of 20.27 N/mm² at 7 days and 30.46 N/mm² at 28 days. When 25% of Bhandara sand was replaced with stone dust, the compressive strength slightly increased to 20.61 N/mm² at 7 days and 31.76 N/mm² at 28 days. Further increasing the replacement level to 35% stone dust yielded even higher strength values, with 20.87 N/mm² at 7 days and 33.51 N/mm² at 28 days, indicating improved performance over the control mix. In contrast, the incorporation of brick powder as a partial replacement led to a noticeable reduction in strength. At 25% replacement, the compressive strength dropped to 15.88 N/mm² at 7 days and 18.10 N/mm² at 28 days, while 35% replacement further reduced the values to 13.43 N/mm² and 16.75 N/mm², respectively. A hybrid mix containing 25% stone dust, 25% brick powder, and 5% glass powder exhibited the lowest early strength at 10.67 N/mm² after 7 days, but showed some improvement with a 28-day strength of 19.20 N/mm².

These results suggest that stone dust can enhance the strength of SCC when used appropriately, while the use of brick powder may require optimization due to its negative impact on compressive strength. The hybrid combination, although initially weaker, presents potential for long-term strength development and sustainability benefits.

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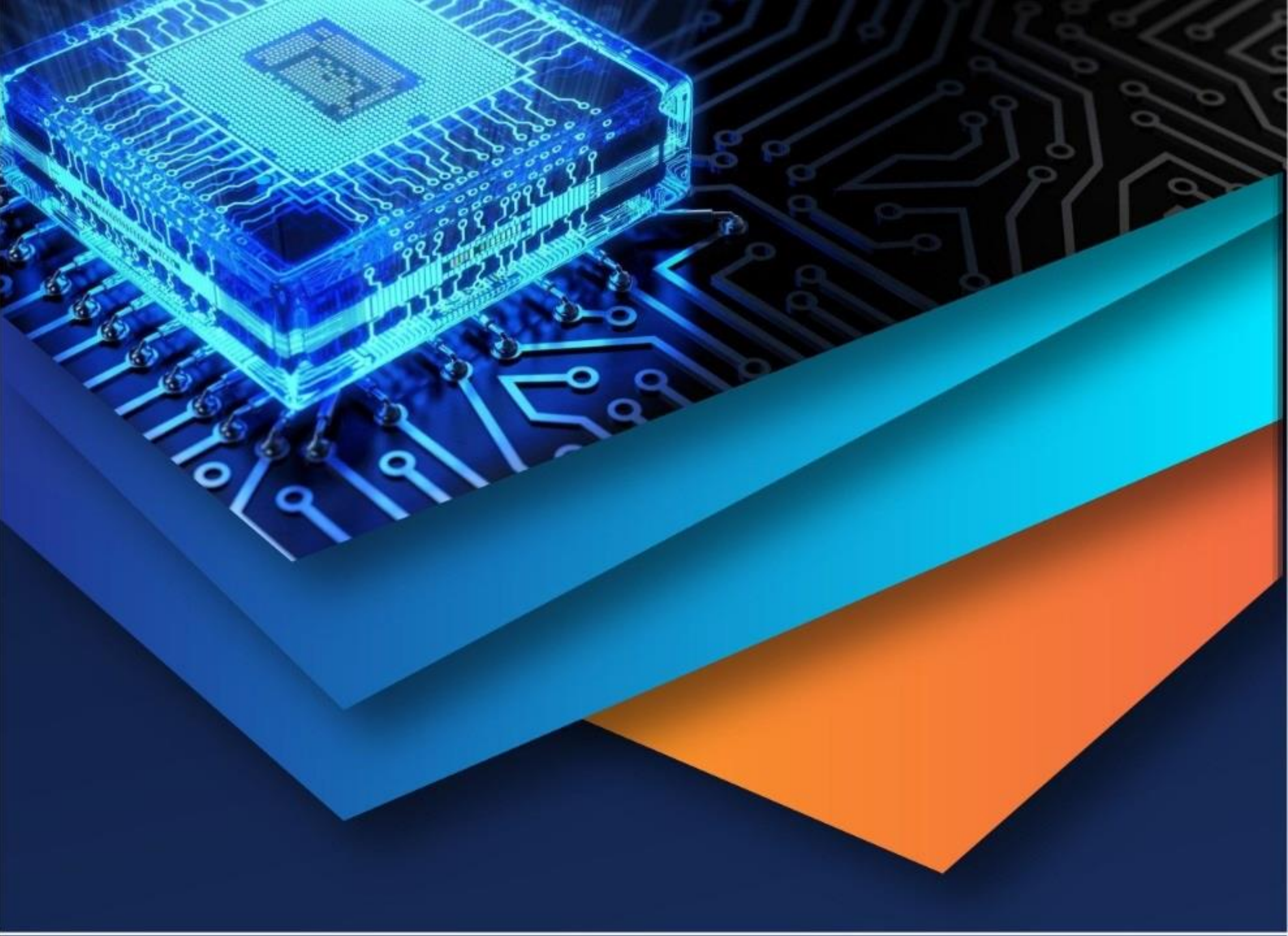

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