

PERFORMANCE AND EVALUATION FOR DURABILITY ENHANCEMENT OF SELF COMPACTING CONCRETE USING GROUND GRANULATED BLAST FURNACE SLAG

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KEY WORDS: M-sand, Ground Granulated Blast Furnace Slag (GGBFS), Self Compacting Concrete (SCC), Compressive strength, Tensile strength.

ABSTRACT:

As we know Ground granulated blast furnace slag (GGBFS) is a by Product and industrial-based pozzolanic substance with high silica content. Utilizing Natural River sand harms riverbanks, drastically alters the water table, and drives up the price of river sand daily. This experimental study utilizes manufactured sand (M-sand) and the by Product as Mentioned in above ground granulated blast furnace slag (GGBFS) which will develop a Special Concrete that is Self compacting concrete (SCC). M-sand is a synthesized material and GGBFS is a byproduct of industrial waste from steel industry. This substance has the potential to produce a sustainable building material. In this study, evolution and mechanical characteristics of SCC produced with M-sand and GGBFS are presented. Six different combinations of partial replacement of cement with GGBFS (0%, 5%, 10%, 15%, 20%, 25%, and 30%) are experimented. In addition to density comparisons, mechanical properties such as Compressive strength, Split Tensile strength, and Flexural strength and fresh quality characteristics such as test of Slump flow for flowability and L-Box Flow through Test for each mix have been compared for 7 days, 28 days, and 90 days' time periods.

1. INTRODUCTION

Self-Compacting Concrete was created for densely reinforced, skin-reinforced structures and deep shafts in Japan in 1988. Under its own weight, SCC can pass through dense reinforcement without segregating or bleeding. There is no need for vibration. It may flow and spread evenly across the space because of its own weight. A key component of construction is sand. The use of concrete is growing daily, and sand mining is following suit. The biodiversity is also at risk from this. Sand is heavily used, which causes river bottoms to lose their natural qualities and ground water levels to drop. Natural sand can be substituted with manufactured sand. It had a more angular and

cubical shape than natural sand, which increases its strength and ability for interlocking. It is far less expensive than natural sand. M-sand completely replaces natural river sand and exhibits a 19% increase in compressive strength and other mechanical parameters (B. Persson, 2001). GGBFS, a pozzolanic material renowned for its exceptional reactivity, is obtained as a by-product from industrial waste, often referred to as GGBFS. When subjected to combustion, GGBFS's abundant silicon content undergoes a transformation into silica and oxygen, with the resultant silica contributing significantly to the development of strength in various applications." GGBFS has a significant amount of silica. Utilizing GGBFS helps save money on building supplies.

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Due to GGBFS's lower density, concrete density also drops. Within 90 days, GGBFS improved the strength qualities and provided acceptable workability test results in accordance with EFNARC guidelines (Nan Su et al., 2001).

Self-compacting concrete (SCC) of the present can be categorized as a modern building material. As the name implies, complete compaction can be achieved without vibrating the material. Compared to traditional concrete, this has a number of advantages and benefits. These include increased concrete quality, less on-site repairs, quicker building timeframes, cheaper overall costs, and easier automation introduction into concrete construction. The SCC mixes' composition contains significant amounts of fine-grained inorganic minerals, which opens up the possibility of using mineral admixtures.

For the Consideration of mechanical properties of the Development of self-compacting concrete (SCC) and similarly sized properties of regularly using External compacting concrete, with the Special Characteristics need to be considered such as strength Parameters, Modulus of Elasticity, Shrinkage and Creep, were studied experimentally and computationally (B. Person 2001). The experiment investigations done on different mix proportions of Concrete, which includes 7 different Combinations along with the Conventional that is Normal Concrete were sealed or air-cured specimens and then Water Cured Binding ratios that is (w/b) ranging from 0.24 to 0.80. 50% of the mix Proportions and these are made up with SCC, and there main specimens are 50% are made up of NCC. And also considering The Concrete's age of at loading in this Concrete creep studies were observed in the range of range from 2 days to 90 days. Mainly three parameters Considered is Strength and also relative humidity were also observed and recorded. The results we anticipated which are almost Expected Region not significantly that the observed outcomes specially Modulus of Elasticity, Shrinkage and Creep of SCC where we used when compared with Conventional Concrete that is NCC.

Here there are so many methods to Composition of SCC, for this work (Nan Su et al., 2001) developed a novel method for the mix design for SCC. To guarantee that the completed concrete had the necessary SCC qualities, such as flow and self-compaction, the quantity of aggregates needed was initially calculated. And then the paste required to develop the Concrete especially binders was then used to fill the gaps created by the aggregates.

The main variables which effect on the properties of SCC are the number of aggregates, and the filler materials such as binders, and correct proportion of utilizing the water for the mixing and also the special Consideration for the dosage and Characteristic type of super plasticizer to be used. The SCC's performance was examined using compressive strength, L-flow, U-box, V-funnel, and slump flow tests. The results showed that the recommended approach could be implemented successfully. This method is less complicated, faster to implement, and which requires lesser time consuming than the one compared with the one more method that is Japanese Ready-Mixed Concrete Association (JRMCA). Because it requires less binder material, it also saves money effectively generate SCC of the highest quality.

Drying shrinkage, according to (Safiuddin et al., 2011) happens when concrete hardens and goes through drying at a young age. These tiny fissures, which are caused by drying shrinkage, enable harmful substances access and ultimately reduce the

durability of concrete. When compared to regular concrete, conventional concrete's (CC) drying shrinkage exhibits very little variance. Self-compacting concrete (SCC) may actually experience even less drying shrinkage, according to maximum amount of studies. In general, it is projected that SCC will experience more drying shrinkage because to the reduction in coarse aggregate content and the rise in cementing material. However, concrete's porosity also has a big impact on drying shrinkage. Especially for this Self Compacting Concrete, which is reduction content in porosity counteracts the negative impacts of the aggregates and binder, reducing the effect on drying shrinkage. Additionally, drying shrinkage tends to be a smaller amount in SCC due to the system's limited supply of free water. Additionally, SCC has few empty spaces visible on the superficial of the concrete, which is a major factor in drying shrinkage.

The effect of the water-to-cement (w/c) ratio on the characteristics of SCC when it was fresh and after it had hardened were examined (Felekoglu et al., 2008) in their study. The author highlights that the proportioning of SCC combinations must account for modifying the w/c ratio and superplasticizer dosage. In this study, combinations of fine mixes with different w/c ratios and super plasticizer doses were the focus of the investigation. The optimal w/c ratio for the production of SCC, according to the study's findings, is between 0.84 and 1.07 by volume. The mixture may block or segregate depending on the ratio above and below this range.

From the literature we understand that the (Bui et al., 2002) completely focused on a simple Procedure to assess the fighting against the segregation characteristics of self-compacting concretes. Many different types of paste, and various combinations of course as well as finer aggregates, which is sand, and water-binder ratios, and mineral admixture kinds and concentrations remained used in the thorough testing of SCC. The experiment helped identify the tools and procedures for measuring SCC's resistance to segregation in both vertical and horizontal directions.

For typical Portland cement (NPC), (Cengiz et al., 2005) used SCC in varying ratios of 0%, 50%, and 70% in place of one more admixture that is fly-ash. He investigated the high-volume fly ash (HVFA) self-compacted concrete's strengths. Both moist and dry curing conditions were used to cure the concrete with different mixtures which is produced with the combination of water cementation material ratios ranging from 0.28 to 0.43. He looked into the mixture's strength characteristics and found a link between the different strengths like flexural tensile strength of concrete and also compressive strength of concrete and the study demonstrated that by adding an appropriate super plasticizer, RCC (zero slump) concrete may be transformed into a workable concrete.

This experimental study utilizes manufactured sand (M-sand) and one more admixture that is GGBFS) to develop the self-compacting concrete (SCC) Samples. M-sand is a synthesized material and GGBFS is a byproduct of industrial waste from steel industry. This substance has the potential to produce a sustainable building material.

2. MATERIALS

PORTLAND CEMENT: Typically, powdered cementations are made by finely grinding alumina, iron oxide, lime, magnesia, and silica, then burning the mixture in the kiln. And also, whenever combined with the Solvent Like Water to make

a paste and Fine aggregate used in this work which is sand (Manufacture Sand or Gravels), which becomes the masonry materials to make mortar concrete and after the continue series of internal processes, it hardens into stones. The British bricklayer Joseph Aspdin (1779–1855) gave this substance its name in 1824 which comes from the fact that it resembles famous Portland limestone, which has historically been used to construct churches, mansions, and palaces. This limestone is sourced from the various quarries on the Isle of land like Portland. In the experiment, regular Portland cement of a typical brand that is readily available in local markets was employed. The cement in use has passed several IS 12269-1987 requirements after being examined for an amount of characteristics in accordance with IS 4031-1988. The 53 Grade cement had a specific gravity of 2.91.

Ordinary Portland Cement's Physical and Chemical Characteristics as shown in Table 1.

Sl No	Characteristics of the materials	The code's requirement Is as per IS: 12269-1987	Results
1	Fitness of cement in (m ² /kg)	225(m ² /kg) (minimum)	298m ² /kg
2	Specific Gravity of the cement Sample	-----	3.18
3	Setting Time of Cement observed in (min) Initial and Final time	30min (minimum) & 600min (maximum)	85min 244min
4	Soundness of cement by the Le Chatelier apparatus in (mm)	10mm	3mm

Table 1. Observed and Recorded Different Characteristics Ordinary Portland Cement (OPC)

FINE AGGREGATE (FA): In this current experiment, the nearby available type of small stones which easily accessible river sand was utilized as the main source of FA. And the completely washed and pure quality of FA which is passed through the various tests and the number of Various Characteristics which includes specific gravity, Modulus of Fineness(k) and bulk modulus, and is in compliance with industry standards. A fine aggregate is made of M-sand. In Table 3 their characteristics are listed.

Sl No	Characteristics of Aggregates	Fine Aggregates (FA)	Coarse Aggregates (CA)
1	Specific gravity	2.61	2.63
2	Bulk Density(kg/m ³)	1700	1560
3	Fineness Modulus Of Aggregates	2.514	6.55

Table 2. Observed and Recorded Characteristics of Coarse Aggregate's (CA) and Fine aggregates (FA)

COARSE AGGREGATE (CA): for this work As a Role of Coarse material, 10 mm-sized chunks of crushed angular granite

metal from a nearby quarry were employed. The cleaned coarse aggregate underwent testing for a number of characteristics, including bulk modulus, fineness modulus, and specific gravity. For the creation of SCC, when crushing the aggregates, a maximum particle size of an aggregate is 12 mm is used and the qualities of the considered coarse aggregates are tabulated in the Table 3. All aggregate tests are carried out in accordance with IS: 2386 (Part-3)-1963 code provisions.

ADMIXTURE GROUNDGRANULATED BLAST FURNACE SLAG (GGBFS): JSW Cement, which is situated in the location of Vijayanagar district, provided ready-to-use Ground granulated blast furnace slag (GGBFS). The physical and chemical characteristics of GGBS comply with code of Indian standard that is IS: 16714A by-product of the blast furnaces used to make iron is called blast furnace slag. The granulated blast furnace as shown in figure 1 is produced by slag, which is having highly pozzolanic content. Slag has significantly greater cement replacement values than other pozzolanic materials like micro silica, fly ash and silica fume. In general, GGBS contains more CaO than other pozzolanas. Ground granulated blast-furnace slag (GGBFS), which is picked up at by the closest steel plant. It has a 2.8 Specific Gravity as indicated below in table 2.

Sl No	Property	Value
1	Specific Gravity of GGBS	2.92
2	Color	Half white
3	Setting Time (min)	30 (min) 600 (max)

Table 3. Lists the GGBS's chemical characteristics



Figure1. Admixture Ground Granulated Blast Furnace Slag (GGBFS)

SUPER-PLASTICISER: The super-plasticiser uses FOSROC Super-plasticiser AUROMIX 400. It is in accordance with IS 9103-IS 2645.



Figure 2. Super Plasticizer

VISCOSITY MODIFYING ADMIXTURE (VMA): The two viscosity-modifying agents utilized were Sika and Glenium Stream. It gives the SCC mix more viscosity and prevents segregation.

ACIDS: THE acids utilized in investigations on durability are HCl, H₂SO₄, and Na₂SO₄.

WATER: CONCRETE Samples are prepared and cured using fresh portable water that fulfils with IS: 3025 - 1964 part 22, part 23, & IS: 456 - 2000 code.

3. METHDOLOGY

SCANNING ELECTRON MICROSCOPY (SEM) ANALYSIS

One of the potent methods which used to examination for the microstructure like materials and Molecular interaction and which provides Behaviors of concrete Bonding with the material's used. It enables scientists and engineers to closely investigate the surface morphology and microstructure of concrete. Here is how concrete is normally subjected to SEM analysis:

PREPARATION OF A SAMPLE: The concrete sample has been broken up into small-small pieces or parts, which are then prepared for SEM analysis. The samples are frequently decreased in size, usually to a size of $1\text{ cm} \times 1\text{ cm}$, then mounted on a stub or specimen holder. In order to avoid charging effects (electrons building up on the sample's surface),

INSTRUMENTATION: The SEM chamber, which is kept at a high vacuum, is filled with the prepared sample. A focused electron beam is emitted by the SEM apparatus and is directed towards the sample's surface.

IMAGING: Atoms on the concrete sample's surface are affected by the electron beam. This contact produces secondary electrons and backscattered electrons. Secondary electrons reveal specifics about the surface topography, whereas backscattered electrons reveal details about the material's atomic structure and density.

IMAGE CAPTURE: These signals are gathered by the SEM apparatus, which then makes use of them to produce sharp images of the concrete surface. These photos can be saved for further study and viewed on a computer screen.

EVALUATION OF ELEMENTS: For elemental analysis, Energy-Dispersive Specially for X-ray Spectroscopy (EDS) and SEM can be used together. When the electron beam interacts with materials used in sample and also helpful for examine the distinctive X-rays are released, and those rays are found out by the machine EDS and reveals the concrete's elemental makeup.

ANALYSIS OF THE MICROSTRUCTURE: The concrete matrix's porosity, aggregate distribution, and the presence of any gaps and Cracks or other flaws can all be determined with SEM which can also be used to examine the bond between cement paste-aggregate, which is important for the strength of concrete.

QUANTITATIVE EXAMINATION: Particle size distribution and also pore size distribution, and phase composition are just a few examples of concrete microstructure characteristics that may be quantified using image analysis tools. Understanding the microstructure of concrete requires SEM analysis, which may then be used to improve concrete mix designs, evaluate the impacts of various additives, and look into the reasons why concrete structures degrade or collapse. It offers insightful data that advances the development of concrete products and building techniques.

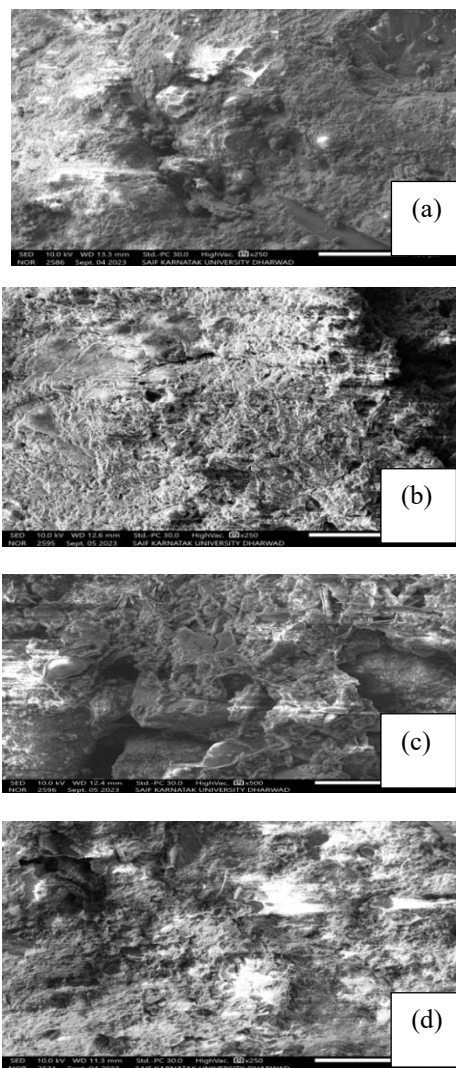


Figure 3. Sample Images Recorded from Scanning Electron Microscopy (SEM)

The Figure 3 shows how hydrated cement paste of various mix proportions forms and distributes its hydration products. Examination and comparison of the microstructures of different mixes in which GGBFS is replaced by cement with the standard mix was carried out. From the basis of observed hydrated products which is produced after the 28 days of proper water curing, and the microstructural and strength dependent characteristics were examined for the mixes with GGBFS replacement. The reason for the strength of the concrete was identified from the basis of the analysis and justification of the growth of hydration products which is observed in the microstructure images of different concrete mixtures.

TEST RESULTS:

Workability Character Test Results for the Self Compact Concrete of Observed M20 Grade Concrete (SCC): bwp-is calculated by weight of powder utilized Bwc-is calculated by weight of cement utilized (figures 4 and 5, table 4).

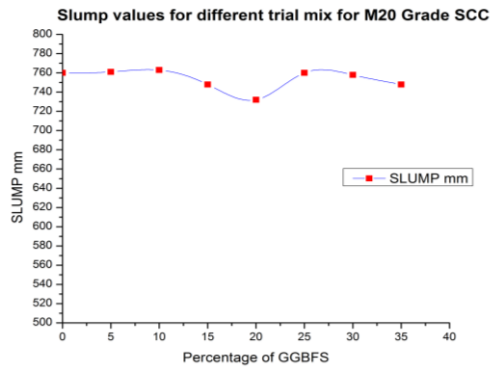


Figure 4. The graph above illustrates how the slump value of M20 grade SCC varies depending on the mix proportions that GGBFS replaces

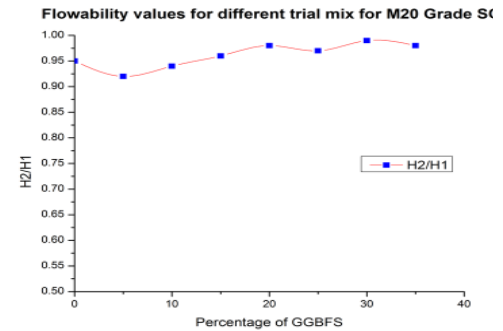


Figure 5. The graph above illustrates how the Flowability value of M20 grade SCC varies depending on the mix proportions that GGBFS replaces

		S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8
GGBFS in % (bwc)		0	5	10	15%	20	25	30	35
Cement Kg		550	500g	450	425	400	375	350g	325
Coarse Aggregate in Kg		740	740	740	740	740	740	740	740
Fine Aggregate in Kg		820	820	820	820	820	820	820	820
Water in Kilograms		180	180	180	180	180	180	180	180
GGBFS in Kilograms		0	55	95	133	178	215	252	298
S.P %(bwp)		1	1.23	1.18	0.98	0.94	0.84	0.80	0.76
VMA %		0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
SLUMP TEST	SLUMP mm	730	770	740	755	765	740	750	755
V FUNNEL	T-50 sec	3.25	3.15	3.68	3.19	3.60	3.90	4.21	4.32
	T ₀ sec	6.56	6.20	6.28	6.22	6.25	6.80	6.96	6.90
	T _{5min} sec	8.38	8.16	8.54	7.94	8.10	8.26	8.45	8.44
L BOX	T ₂₀ sec	3.18	2.59	3.28	3.00	3.15	3.69	4.00	3.99
	T ₄₀ sec	5.80	5.15	5.35	5.20	5.18	5.62	6.28	6.23
	H2/H1	0.94	0.96	0.98	0.97	0.99	0.94	0.86	0.89

Table 4. Workability character tested resultsfor the Various Samples of Self compacting concrete of M20Grade Concrete (scc)

Workability Character Test Results for Self Compacting Concrete of M50 Grade Concrete (SCC): bwp-is calculated by

weight of powder utilized Bwc-is calculated by weight of cement utilized (Table 5).

		S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8
GGBFS in % (bwc)		0	5	10	15	20	25	30	35
Cement Kg		550	500	450	425	400	375	350	325
Coarse Aggregate in Kg		740	740	740	740	740	740	740	740
FineAggregate in Kg		820	820	820	820	820	820	820	820
Water in Kilograms		180	180	180	180	180	180	180	180
GGBFS in Kilograms		0	55	95	133	178	215	252	298
S.P %(bwp)		1	1.23	1.18	0.98	0.94	0.84	0.80	0.76
VMA %		0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
SLUMP TEST	SLUMP mm	730	770	740	755	765	740	750	755
V FUNNEL	T-50sec	3.25	3.15	3.68	3.19	3.60	3.90	4.21	4.32
	T ₀ sec	6.56	6.20	6.28	6.22	6.25	6.80	6.96	6.90
	T _{5min} sec	8.38	8.16	8.54	7.94	8.10	8.26	8.45	8.44
L BOX	T ₂₀ sec	3.18	2.59	3.28	3.00	3.15	3.69	4.00	3.99
	T ₄₀ sec	5.80	5.15	5.35	5.20	5.18	5.62	6.28	6.23
	H2/H1	0.94	0.96	0.98	0.97	0.99	0.94	0.86	0.89

Table 5. Workability character tested resultsfor the Various Samples of Self compacting concrete of M50Grade Concrete (scc)

Table 4 and 5 demonstrates the workability characteristics of M20 and M50 grade SCC by varying percentage of finer

particles ie., GGBFS replaced with binding material (cement).

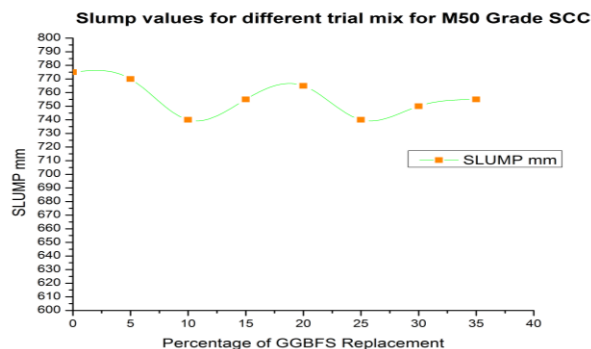


Figure 6. The graph above illustrates how the slump value of M20 grade self-compacting concrete (SCC) varies depending on the mix proportions that GGBFS replaces

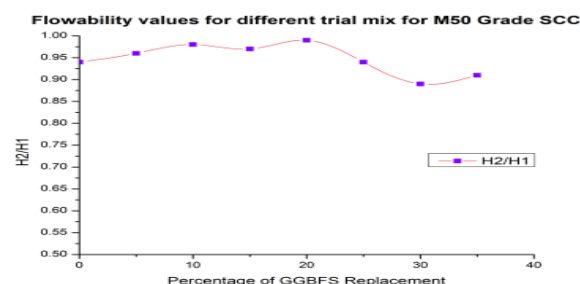


Figure 7. The graph above illustrates how the slump value of M50 grade self-compacting concrete (SCC) varies depends on the mix proportions that GGBFS replaces

From figure 7, the passing ability test results of SCC M50 grade for different % of GGBFS replaced with cement meets the requirements of SCC grade.

Split tensile strength of concrete (SCC): The Maximum capacity of concrete Sample to withstand against the tensile (pulling or stretching) force on concrete is Stated as its tensile strength. Concrete is relatively weak in tension, in contrast to compressive strength, which assesses a material's resistance to compression (pressing or squeezing). This indicates that when exposed to tensile loads, concrete are vulnerable to cracking and failure. Either the split tensile test or the direct tension test techniques require applying a tensile strain to a cylindrical or prismatic concrete specimen until it breaks, for prismatic specimens, the standard size is 150x150x300 mm, whereas for cylindrical specimens, the standard size used are as fallows 150mm in diameter which is circular & 300 mm in length/height wise. With the help of below listed formula which is determined the value of Split tensile strength of Concrete (ts):

$$\sigma_{ts} = 2P / (\pi * d * h)$$

Where:

σ_{ts} is Concrete's splitting tensile strength (measured in MPa)

P is Maximum Load at Specimen Breaks

d is Considered as the specimen's diameter in meters.

h is considered as the specimen's height or length (in meters).

The concrete's split tensile strength was tested at SCC mixtures' split tensile strength at varying percentages GGBFS At all ages, the combination 30%GGBFS yields the highest strength. The results in Graph 8 and 9, According to the findings shown in Graph of 8 and 9, the split tensile strength values are observed

and it clearly shows that rise as the proportion of GGBFS was raised at every 5% increment and For mix the mix of 30% Replacement of GGBFS, we have got maximum values and after 30% replacement Strength values starts decreasing the graph shows there is a decline in strength, although by observing we get to know that recorded Values are greater than control mix at all the different ages. Almost 35%-40% Strength is increased and recorded after 28 days of proper water curing. From figure 6, the slump values for different % of GGBFS replaced with cement meets the requirements of SCC grade. Below Tables 7, for the tested Splitting tensile strength at 28 days for M20 and M50 grades SCC, respectively. Table 7 indicates the average tensile strength for SCC samples.

Mix. Sample No	Percentage of GGBFS Replacement	Average Tensile strength of SCC Samples at 28 days in MPa
S-1	0%	2.12
S-2	5%	2.09
S-3	10%	2.9
S-4	15%	2.48
S-5	20%	2.74
S-6	25%	2.89
S-7	30%	3.09
S-8	35%	2.64

Table 7. Average Tensile strength of SCC Samples after 28days of curing tested from UTM Machine for M20 grade of SCC

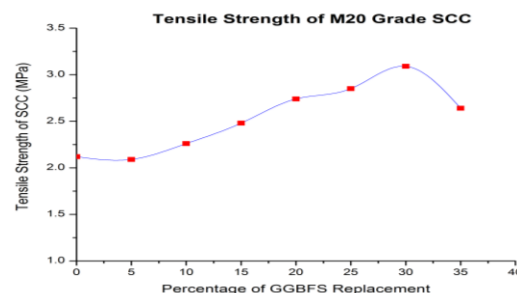


Figure 8. After 28Days of curing Split Tensile strength variation of M20 Grade of SCC for various GGBS replacement percentages

Mix. Sample No	Percentage of GGBFS Replacement	Split Tensile strength at 28 days in Mpa
S-1	0 %	3.55
S-2	5 %	4.01
S-3	10 %	4.28
S-4	15 %	4.31
S-5	20 %	4.41
S-6	25 %	4.78
S-7	30 %	4.82
S-8	35%	4.55

Table 7. Average Split Tensile strength of SCC Samples after 28 days of water curing tested from UTM Machine for M50 grade of SCC

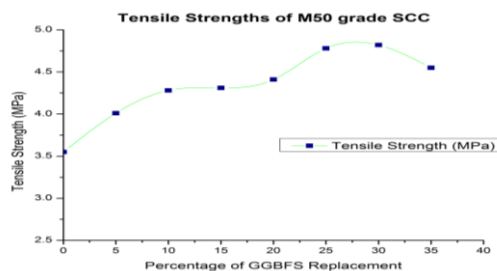


Figure 9. After 28 Days of water curing Split Tensile strength variation of M50 Grade of SCC for various GGBFS replacement percentages

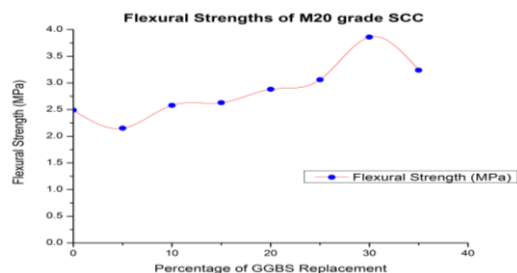


Figure 10. After 28 Days of curing Flexural strength of concrete variation of M20 Grade of SCC for various GGBFS replacement percentages

Flexural Strength: The greatest stress a material can withstand against when the concrete is subjected to a perfect bending or flexural loading is known as flexural strength, often which is referred as modulus of rupture. Flexural strength, as it relates to concrete, is the capacity of a concrete specimen (beam) to withstand bending or cracking under an applied load. This test measures a concrete beam resistance to bending under two point tests. Test specimens for flexural strength had dimensions of 100 mm X 100 mm X 500mm. Flexural strength test results were carrying out in agreement with IS 516:1959 using two-point loading across an effective span of 400mm. Apply the following equation to determine the flexural strength of concrete samples (modulus of rupture): $\sigma = (3 * P * L) / (2 * b * d^2)$.

Where:

σ = is considered as the flexural strength of concrete which is expressed (in MPa), P stands for the greatest load at Specimen becomes failure (in N), L stands for the span length (in mm), B is the specimen's width (in millimeters), d is the specimen's depth (in millimeters).

The concrete Specimens to determine Flexural strength was tested at SCC different mixes flexural strength at varying percentages of GGBFS At all ages, the combination 30% GGBFS yields the highest strength. The results in Graph 5. According to the results in Graph shows the flexural strength rise as the proportion of GGBFS was raised at every 5% increment and For mix the mix of 30% Replacement of GGBFS, we have got maximum values and after 30% replacement Strength values starts decreasing by referring the graph come to know that there is a decreasing values in strength, although the above Results considering maximum when comparing with the control mixed samples at all water cured samples. Almost 35%-40% Strength is increased after 28 days of curing.

Mix. Sample No	Percentage of GGBFS Replacement	Avg Flexural strength of concrete after 28 days in Mpa
S-1	0 %	2.49
S-2	5 %	2.15
S-3	10 %	2.58
S-4	15 %	2.63
S-5	20 %	2.88
S-6	25 %	3.06
S-7	30 %	3.86
S-8	35 %	3.24

Table 8. Average Flexural strength of SCC Samples after 28days of curing tested from Machine for M20 grade of SCC

Mix. Sample No	Percentage of GGBFS Replacement	Avg Tensile strength of Concrete at 28 days in Mpa
S-1	0 %	3.92
S-2	5 %	4.13
S-3	10 %	4.49
S-4	15 %	4.43
S-5	20 %	4.56
S-6	25 %	4.72
S-7	30 %	5.23
S-8	35	4.88

Table 9. shows 28 Days Flexural strength variation of M50, Grade for different percentages of GGBFS replacement

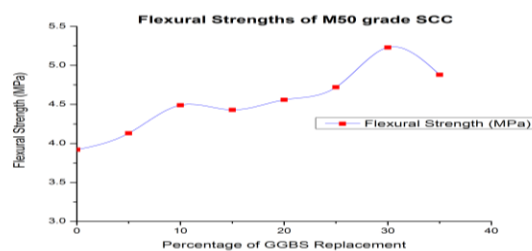


Figure 11. After 28Days of water curing Flexural strength of Concrete variation of M50 Grade of SCC for various GGBFS replacement percentages

Compressive Strength: The One of the most significant characteristics for concrete strength parameter of concrete that is its compressive strength, which evaluates a concrete specimen's capacity for withstanding axial loads or stresses that tend to compress or crush the substance. Mega pascals (MPa) are common unit of measurements. By pouring concrete into cube molds with the required dimensions, concrete cube examples are prepared. For standard testing, typical measurements are 150x150x150 mm, in order to eliminate air spaces and guarantee correct compaction, compact the concrete in the molds using a tamping rod, vibrator, or other suitable techniques. By using the following formula to calculate compressive strength: $\sigma = P / (A)$ of concrete. In the above empirical formula σ is denoted by compressive strength, expressed in MPa. The Ultimate load at failure (P) is expressed in N or kN. A is defined by cross-sectional area of the cube specimen, which can be computed by multiplying the length by the width (in square meters).

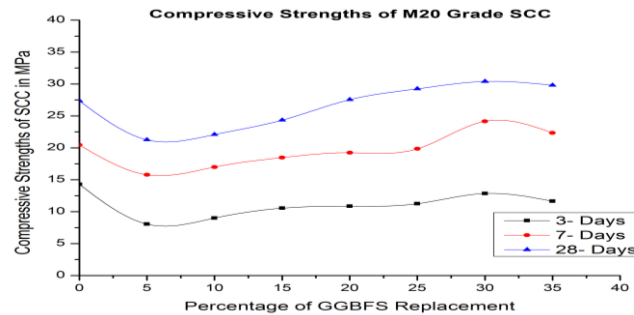


Figure 12. After 3 days, 7days, and 28Days of curing Compressive strength variation of M20 Grade of SCC for various GGBFS replacement percentages

Mix. Sample No	Percentage of GGBFS Replacement	Avg Compressive strength at 3 days in Mpa	Avg Compressive strength at 7 days in Mpa	Avg Compressive strength at 28 days in Mpa
S-1	0 %	18.92	30.24	27.35
S-2	5 %	15.02	27.68	21.25
S-3	10 %	15.24	27.84	22.08
S-4	15 %	16.98	29.24	24.33
S-5	20 %	16.54	29.34	27.54
S-6	25 %	15.24	32.74	29.24
S-7	30 %	15.33	28.81	30.40
S-8	35%	15.20	27.95	29.80

Table 10. Average Compression strength of SCC Cube Samples after 3 days, 7days and 28days of Water curing for M20 grade of SCC

Mix. Sample No	Percentage of GGBFS Replacement	Avg Compressive strength at 3 days in Mpa	Avg Compressive strength at 7 days in Mpa	AvgCompressive strength at 28 days in Mpa
S-1	0 %	18.92	30.24	50.02
S-2	5 %	15.02	27.68	51.26
S-3	10 %	15.24	27.84	50.95
S-4	15 %	16.98	29.24	52.19
S-5	20 %	16.54	29.34	52.74
S-6	25 %	15.24	32.74	53.65
S-7	30 %	15.33	28.81	54.17
S-8	35%	15.20	27.95	53.25

Table 11. Average Compression strength of SCC Cube Samples after 3 days, 7days and 28days of Water curing for M50 grade of SCC

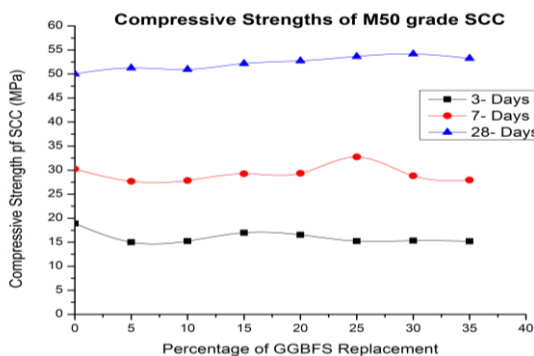


Figure 13. After 3 days, 7days, and 28Days of curing Compressive strength Results variation of M50 Grade of SCC for various GGBFS replacement percentages

3. CONCLUSIONS

When Specimens are subjected to a 28-day water curing process, it was found that the observed Tensile Strength of Concrete, Flexural Strength of concrete, and Compressive Strength of concrete especially Self Compacting Concrete (SCC) formed with the combination of industrial waste GGBFS as an admixture in different percentages varied. The Strength values continuously increasing while increasing percentage of GGBFS content is replaced by cement and reaches its maximum values and starts decrease of Tensile strength, and the optimum values and best results is found at 25% -30% replacements respectively as compared with the reference mix.

1. Similar observations are made when SCC with above combination of admixtures is subjected to Flexural strength and compressive strength and found that 25% gives best results.

2. By Considering both grades M20 and M50 Partial replacement of GGBFS with cement is suitable 25-30% for SCC.

3. SCC's workability declines as the proportion rises. GGBFS is used in place of cementitious material. All mixes, with the exception of M-6, meet the SCC fresh requirements according to EFNARC rules.

4. Utilizing GGBFS because each 5% replacement of GGBFS results in a 0.56% weight reduction, the structure's own weight similarly drops. 3. Strength variants demonstrating unequivocally that the Mix S-4 that is 30% Replacement is superior for long-term strength requirements.

5. The most suggestible mixture is one that has 15% replacement, and it weighs 1.7% less than a standard mixture.

6. The most suggestible mixture is one that has 15% replacement, and it weighs 1.7% less than a standard mixture.

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