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Comparative Study on Effect of GGBS & Fly Ash on Compressive Strength of Steel Fiber by Using Treated Water

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Abstract— *This paper investigates the compressive strength properties of concrete with Ground Granulated Blast Furnace Slag (GGBS) and Fly Ash in concrete by partial replacement of cement. The incremental demand of cement in the construction field is a concern for environmental degradation, in this regard; replacement of cement is carried out with waste materials by using GGBS and Fly Ash. On optimum level of GGBS and Fly Ash was assessed with varied percentage from 0 to 30% for different curing days. Replaced concrete were tested with the slump, compaction factor, Vee-bee and compressive strength. Cement to water ratio was maintained at 0.47 for all mixes. The compressive strength tests were conducted for 3, 7, 14 and 28 days of curing on a M25 grade concrete. The results obtained from the slump, compaction factor, Vee-bee and compressive strength of concrete containing GGBS and Fly Ash was increased as the curing time increases. The workability of replaced concrete improved when slump value achieved 30% as compared to controlled one SF0 and the compressive strength obtained 26.30% improvement at SF9 as compared to SF0. The outcomes indicated that the addition of GGBS and Fly Ash enhances the workability and compressive strength which eventually improved the mechanical properties of concrete.*

I. Introduction

Concrete is one of the most versatile building materials. It can be cast to fit any structural shape from a cylindrical water storage tank to rectangular beam or column in a high-rise building. The advantages of using concrete include high compressive strength, good fire resistance, high water resistance, low maintenance, and long service life. The disadvantages of using concrete include poor tensile strength, low strain of fracture and formwork requirement. The major disadvantage is that concrete develops micro cracks during curing. It is the rapid propagation of these micro cracks under applied stress that is responsible for the low tensile strength of the material. Hence fibres are added to concrete to overcome these disadvantages and fly ash helps an admixture for improving the workability of concrete.

The main reasons for adding steel fibres to concrete matrix is to improve the postcracking response of the concrete, i.e., to improve its energy absorption capacity and apparent ductility, and to provide crack resistance and crack control. Also, it helps to maintain structural integrity and cohesiveness in the material. FRC has developed new applications for control and reinforced concrete in the following properties: it has higher strength in flexural, tensile, shear, impact resistance and it also has special properties like crack resistance, failure toughness and better ductility. The purpose of this study is to understand the compressive strength and flexural strength of hardened concrete along with various mix proportions of steel fibres and fly ash.

1.1 GROUND GRANULATED BLAST FURNACE SLAG (GGBS)

Ground granulated blast furnace slag (GGBS) is a byproduct from the blast-furnaces used to make iron. These operate at a temperature of about 1,500 degrees centigrade and are fed with a carefully controlled mixture of iron-ore, coke and limestone. The iron ore is reduced to iron and the remaining materials form a slag that floats on top of the iron. This slag is periodically tapped off as a molten liquid and if it is to be used for the manufacture of GGBS it has to be rapidly quenched in large volumes of water. The quenching, optimises the cementitious properties and produces granules similar to a coarse sand. This 'granulated' slag is then dried and ground to a fine powder. The composition of minerals and physical properties of GGBS.

1.2 STEEL FIBER REINFORCED CONCRETE

SFRC (Steel fiber Reinforced Concrete) may be defined as a composite material made with Portland cement, aggregate, and incorporating discrete discontinuous fibres. SFRC is a natural extension of conventional concrete (normal concrete). This remarkable material exhibits enhancement for the concrete material properties. SFRC is also called ultrahigh performance fiber reinforced concrete (UHPFRC) when fiber is added in its composition. The additional of fiber is able to increase the SFRC strength and durability.

During the past four decades, researchers all over the world have been attempted to develop high performance cement-based materials, which include hot-pressed cement, macro-defect-free cement, densified with small particles and slurry infiltrated fibre concrete etc. Although these materials have excellent performance, they can hardly be used in practice because of complicated forming process and high costs.

1.3 WASTE WATER ON STRENGTH OF CONCRETE

The construction industry appears to be responsible for the consumption of huge amounts of fresh water. Approximately 150 liters of water is required for 1m3 of concrete without considering other applications of water at the concrete industry. The mixing of water which is fit for drinking purpose is fit for concreting, but about 97 percent of water is held in the oceans, while only 3 percent is fresh water. In that freshwater, only 1 percent is easily available as ground or surface water, the remains are stored in icecaps. Water is used for domestic and industrial purposes from surface water bodies and underground water surfaces. Concrete industry has a serious impact on the environment with regard to consumption of water. Therefore, we need to find the alternative source of fresh water in concrete industry. The ultimate and last option will be treating the wastewater and this treated wastewater is used for drinking purposes. So use of this treated wastewater in the construction industry and save the freshwater. The impurities present in the waste water may not affect all properties of concrete but some. The waste water was tested in the laboratory to find the chemical properties of water such as pH, TSS, hardness, BOD, COD. So, if we can use the treated waste water for above purposes in construction industry, we can save a lot of freshwater and try to spread awareness and importance of water.

II. LITERATURE SURVEY

EFFECT OF GGBS ON FIBRE REINFORCED CONCRETE

In this present study with the stipulated time and laboratory set up an afford has been taken to enlighten the use of so called pozzolanic material like ground granulated blast furnace slag, rice husk and ggbs in fibre reinforced concrete in accordance to their proficiency. Use of ggbs as cement replacement increases consistency. Although fineness greatly influenced on proper pozzolanic reaction still ggbs passing 75micron sieve giving good strength of mortar. Using ggbs of 7.5% in Portland slag cement the strength is high. With the use of super plasticiser, it possible to get a mix with low water to cement ratio to get the desired strength. As the replacement of cement with different percentages with ggbs increases the consistency increases. In case of opc the compressive strength is increasing as the percentage of ggbs increases from 0-10%.

STUDY ON STRENGTHEN PROPERTIES OF CONCRETE USING GGBS AND STEEL FIBRE AS PARTIAL REPLACEMENT OF CEMENT

In this Research Paper, We studied that, The compressive strength and Split tensile strength of concrete increased about 22% and 20% respectively. Considering all the test results it can be said that for M25 mix, 30% replacement of cement by GGBS and 1% Steel fiber is considered as optimum. The partial replacement of cement by GGBS not only provides the economy in construction but it also utilization of the GGBS which is generated in huge quantities.

STUDY ON MECHANICAL AND DURABILITY PROPERTIES OF CONCRETE WITH GGBS AND STEEL FIBRE

The study on the effect of steel fibre with GGBS can still be a promising work as there is always a need to overcome the problem of weakness of concrete. Marginal increase is observed in the workability, when adding GGBS and steel fibre in ordinary concrete. The compressive strength of the specimen is reached 95-100% at 28th day curing because of the addition of GGBS and steel fibre. There is a marginal increase of flexural strength around 25-66% after attaining the full strength due to the addition of the combination of 20%GGBS and 1% steel fibre in the ordinary concrete. The elastic modulus of concrete shows better increase in strength up to 15-28% after attaining the full strength of concrete.

EFFECT OF STRENGTH OF CONCRETE BY PARTIAL REPLACEMENT OF CEMENT WITH FLY ASH AND ADDITION OF STEEL FIBRES

Due to addition of fly ash there is considerable improvement in compressive strength of the concrete and not much improvement in tensile strength. With the replacement of cement in concrete by fly ash the concrete prepared is environment friendly and cost effective. The workability of concrete is improved considerably by addition of fly ash. With the addition of steel fibres and fly ash in concrete ductility is improved considerably. The ratio of tensile strength to compressive strength can be enhanced by reduction of fly ash and the reduction of steel fibres.

Suchita Hirde and Pravin Gorse: The workability of fresh GGBS fibre reinforced concrete increase with increase in GGBS content for FRC. The wet density of concrete increases with increase in the GGBS replacement level. The compressive strength of cubes increases with 20% GGBS replacement in every group of aggregate. For 10mm aggregate 61.09 MPa strength achieved at 20% replacement level, for 12 mm aggregate 61.01 MPa strength achieved at 20% replacement of cement with GGBS and for 20m aggregate with 20% GGBS shows 61.91 MPa compressive strength. Results showed 20% replacement of GGBS shows significantly increase in strength and also it has same cost as compared to normal concrete and 14% less cost as compared to fibre reinforced concrete for 10 mm aggregate concrete. 40% replacement gives comparatively less strength as compared to normal concrete but it reduces cost 16% with respect to Normal concrete and 28% less cost with respect to FRC.

EFFECT OF USING WASTEWATER ON THE PROPERTIES OF HIGH STRENGTH CONCRETE

This paper investigates the effect of using wastewater on the properties of high strength concrete. Wastewater samples were collected from three car washing stations in the muscat area. The collected wastewater samples were mixed together, and chemical analysis was carried out. Four water samples, including controlled potable (tap) water were analysed for PH, total dissolved solids (TDS), chloride, hardness, alkalinity, and sulphates. Chemical analysis results showed that although the chemical compositions of wastewater were much higher than those parameters found in tap water, the water composition was within the

ASTM standard limits for all substance indicating that the wastewater produced can be used satisfactorily in concrete mixtures. High strength concrete mixtures were prepared using different proportions of wastewater and waterto-cement ratio of 0.35. The percentage of wastewater replaced ranged between 25100% of tap water used in concrete. For each concrete mixture, six 150mmx150mmx150mm cubes, three 300mmx150mm dia. Cylinders and three 100mmx100mmx500mm prisms were cast. Slump, compressive, tensile and flexural strengths were determined at 28-day of curing. Cube compressive strength was also determined at 7-day of curing. Also, initial surface absorption test was conducted at 28day of curing in order to assess the durability of concrete. Results indicated that the strength of concrete of the mixtures prepared using wastewater was comparable with the strength of the control mixture. Also, the water absorption of concrete is not affected when wastewater was used.

STRENGTH AND DURABILITY OF FIBRE REINFORCED CONCRETE WITH PARTIAL REPLACEMENT OF CEMENT BY GROUND GRANULATED BLAST FURNACE SLAG

When the GGBS content was increased, the workability of concrete improved by up to 40%, and the mixture was also found to be stiffer. Shear failure was observed as the GGBS content was increased. The workability of steel fibre reinforced concrete is lower than that of conventional concrete. Because of the high pozzolanic quality of GGBS and its ability to fill voids, the mechanical properties of GGBS-based concrete are greatly improved. GGBS in concrete has two advantages: (i) thick packing and (ii) avoiding the porous nature of the material. The concrete mixture, with replacement of cement by GGBS up to 40%, has shown excellent properties compared to the control concrete. But above 40%, there is decrease in the strength of the concrete. Further at 60%, the strength has been reduced. It may be due to unreacted GGBS; it would have acted as filler material.

III. METHODOLOGY

3.1 MATERIALS:

Materials used for mix designing of steel fibre reinforced concrete by adding fly ash and GGBS as a partial replacement of cement are OPC, fly ash, steel fibre, GGBS, crushed sand, Coarse aggregate, fine aggregate, admixture, water.

3.1.1 CEMENT:

In this present work ultra tech cement of 53 grade ordinary Portland cement (opc) is used for casting cubes and for all concrete mixes. The cement is of uniform colour i.e. Grey with light greenish shade and is free from any hard lumps. The various tests conducted on cement are specific gravity, initial and final setting time. Testing on cement is done as per is codes. The properties of Portland cement are reported in below

Particulars	Experimental Results	IS Limits (IS456:2000)
Specific Gravity	3.14	–
Initial setting time	125 Minutes	Not less than 30 min
Final setting time	210 Minutes	Not more than 600 min

3.1.2 FLY ASH

Fly ash use in concrete improves the workability of plastic concrete, and the strength and durability of hardened concrete. Fly ash use is also cost effective. When fly ash is added to concrete, the amount of Portland cement may be reduced. It improves workability, decreases water demand, reduces heat of hydration. The source of the fly ash used in this present work is Parali, Maharashtra

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3.1.3 STEEL FIBRES

Steel fibres are produced from premium grade cold drawn steel wires. Steel fibres are a discontinuous, 3-dimensionally orientated, isotropic reinforcement, once they are mixed into the concrete. Steel fibres bridge the crack at very small crack openings, transfer stresses and develop post crack strength in the concrete.

3.1.4 GROUND GRANULATED BLAST FURNACE SLAG

Ground granulated Blast furnace slag is obtained by quenching molten iron slag (a byproduct of iron and steel making) from a blast furnace in water or steam, to produce a glassy, granulated product that is then dried and ground into a fine powder. In the present work GGBS is procured from JSW cement Limited.

3.1.5 CRUSH SAND

Sand is a vital ingredient of concrete as a fine aggregate. Although the sand is an inert material in the concrete mix, its role cannot be neglected. Followings are the important functions of sand in the concrete mix. Offers requisite surface area for the film of binding material to adhere and spread. Increases the volume of mortar & consequently makes mortar more economical. Well-graded sand adds to the density of mortars and concrete. Prevents excessive shrinkage of mortar. Since it is an inert material, it renders structure more resistant against atmospheric agencies.

Property of Crush Sand	Result
Specific gravity	2.72
Water absorption	3.41%

3.1.6 AGGREGATES

Aggregates are the main components of the concrete which greatly influences the Strength, density and other properties of the concrete. Different types of aggregates Were used in this project i.e., fine and coarse aggregate. Aggregate materials help to Make concrete mixes more compact. They also decrease the consumption of cement And water and contribute to the mechanical strength of the concrete, making them an Indispensable ingredient in the construction and maintenance of rigid structures. It helps to prevent possible segregation of paste and coarse aggregate particularly during the transport operation of concrete for a long distance.

3.1.7 WATER

Water is an integral part of construction. If the water quality is not maintained, the building gets damaged easily and it can be easily visible. Water is important in every step of construction. Cement concrete is the backbone of construction. Water plays a major role in cement concrete production. Water governs the hydration of cement, strength, workability and overall durability of concrete.

Durability of concrete is one of the important properties of sustainable concrete. Curing has a major role in developing microstructure. Water used in construction and curing should be free from salts and solid particles. Potable tap water is generally used in making concrete. Water is used in many activities in the construction process. The water used for mixing and curing should be clean and free from injurious quantities of alkalis, acid, oils, salt, sugar, organic materials, vegetable growth and other substances that may be deleterious to bricks, stone, concrete or steel. Potable water is generally considered satisfactory for mixing. The pH value of water should be not less than 6. It has been observed that certain common impurities in water affect the quality of mortar or concrete. Many times, in spite of using best material i.e. cement, coarse sand, coarse aggregate etc. in cement concrete, required results are not achieved. Most of Engineers/Contractors think that there is something wrong in cement, but they do not consider quality of water being used.

TESTS ON WATER:

- pH value test
- Limits of acidity test
- Limits of alkalinity test
- Percentage of solids
- Chlorides
- Suspended matter
- Sulphates Inorganic solids
- Organic solids

3.2 TEST ON MATERIALS:

Sr. No	Materials	Test on Material
1.	Cement	Fineness test
2.	Fly ash	Fineness test
3.	Aggregate	Sp. Gravity, Dry Loose Bilk Density, Water absorption, Flakiness, Elongation Index, Sieve Analysis, Impact Value,
4.	Admixture	Specific gravity
5.	water	pH value test, Limits of acidity test, Limits of alkalinity test, Percentage of solids, Chlorides, Suspended matter, Sulphates Inorganic solids, Organic solids

3.2.1 Sieve Analysis

Sieve analysis or a gradation test is an important method for assessing the particle size distribution of granular material. Particle size influences material properties like flow and conveying behaviour (for bulk materials), reactivity, abrasiveness, solubility, extraction and reaction behaviour, taste, compressibility, and many more. Particle size determination is therefore, essential for a wide range of industries, such as food, construction, plastics, cosmetics, and pharmaceuticals, to optimize process engineering and to ensure the quality and safety of final products.

Sieve Analysis [IS: 2386 Part 1-1963 (Reaffirmed 2016)]								
Sr. No.	**IS Sieve mm**	**Weight retained**	**% retaine d**	**cum.% retaine d**	**Cum % Passin g**	**IS Limits for 20mm**	**IS Limits for 20mm**	**IS Limits for 10mm**
1.	40	--			100	100		
2.	25	0	0	0	100	--		
3.	20	98	4.9	4.9	95.1	85-100		
4.	16	--				--		--
5.	12.5					--		100
6.	10	1901	95.05	99.95	0.05	0-20	0-45	85-100
7.	4.75	1	0.05	100	0	0-5	0-10	0-20
8.	2.36					--	--	0-5
9.	PAN	0		100		….	….	….
	Total	2000						

3.2.2 Aggregate Impact Value

The impact test on aggregate is carried out to know the response of aggregates to different kinds of loads that the aggregates will be subjected to during their service life. The need impact value test is used to measure the toughness of aggregates which is nothing but the ability of aggregates to resist the sudden loading or impact loading. Finding out the impact resistance of aggregate is important because, during service life, the aggregates will be actually subjected to this type of load. This method of test is used to measure the impact value of aggregate use in the construction of Highway pavement and concrete structures.

Sr No	**Description**	**Sample Nos**	
		1	**2**
1.	Weight of oven dried sample passing though 12.5mm	368	375
2.	Weight of fraction passing 2.36mm IS Sieve	26	30
3.	Aggregate Impact Value (%) =B/A*100	7.07	8.00
		Average (%)	7.53

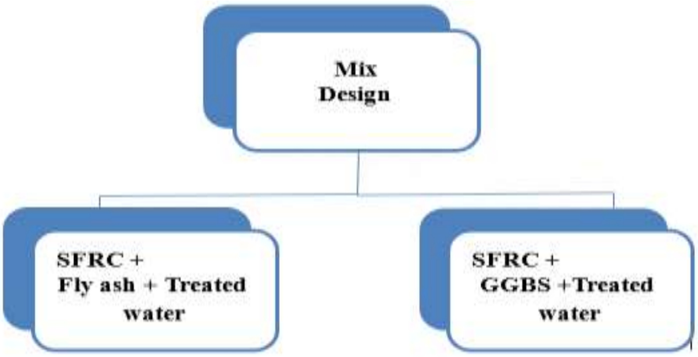
3.2.3 Aggregate Crushing Value

Aggregate crushing value test on coarse aggregates gives a relative measure of the resistance of an aggregate crushing under gradually applied compressive load. Coarse aggregate crushing value is the percentage by weight of the crushed material obtained when test aggregates are subjected to a specified load under standardized conditions. Aggregate crushing value is a numerical index of the strength of the aggregate and it is used in construction of roads and pavements. Crushing value of aggregates indicates its strength. Lower crushing value is recommended for roads and pavements as it indicates a lower crushed fraction under load and would give a longer service life and a more economical performance. The aggregates used in roads and pavement construction must be strong enough to withstand crushing under roller and traffic. If the aggregate crushing value is 30 or higher' the result may be anomalous and in such cases the ten percent fines value should be determined instead.

Sr No	**Description**	**Sample Nos**	
		1	**2**
1.	Weight of oven dried sample passing though 12.5mm	3826	3830
2.	Weight of fraction passing 2.36mm IS Sieve	376	398
3.	Aggregate Crushing Value (%) =B/A*100	9.83	10.39
		Average (%)	10.11

3.3 MIX DESIGN

The mix design method used to produce grade M-30 concrete in the current work corresponds to IS.10262-2009(2019) and IS:456-2000(2019).



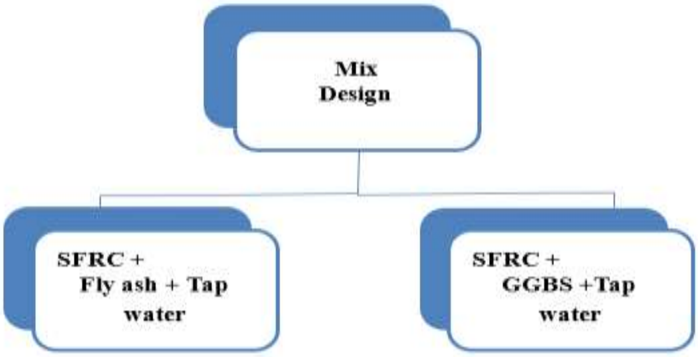


Table:M30 mix proportion for SFRC with GGBS.

Material	Supplier	Dry Wt.	W.A. %	M.C. %	Batch Wt. (1m3)	Water Adjustment	Batch Wt.
Cement	UltraTec h	230			320.0		10.580
Fly ash	parali	74			74		3.256
M Silica	normal	10			10.0		0.440
Crush sand	talegaon	840	3.23	0	812.87	27.13	35.766
Agg. (10mm)	talegaon	381	1.08	0	376.89	4.11	16.583
Agg. (20mm)	talegaon	722	0.84	0	715.94	6.06	31.501
Admixture	chrsyo	4.71			4.71		0.207
water	borewell	166			203.3	37.31	8.946
Density		2517.7 1			2517.7 1		110.77 9
Dosage used	1.20						

Table. M30 mix proportion for SFRC with Fly Ash.

Material	Supplier	Dry Wt.	W.A. %	M.C. %	Batch Wt. (1m3)	Water Adjustme nt	Batch Wt.
Cement	UltraTec h	230			320.0		10.580
GGBS	JWS	150			150.0		6.900
M Silica	Normet	10			10.0		0.460
Crush sand	Talegaon	828	3.23	0	801.09	26.74	36.850
Agg. (10mm)	Talegaon	364	1.08	0	359.63	3.93	16.543
Agg. (20mm)	talegaon	768	0.84	0	761.06	6.45	35.009
Admixtur e	chryso	3.51			3.51	37.31	0.161
water	Treatme nt Plant	171			208.1	37.31	9.573
Density		2517.7 1			2523.4 1		116.07 7
Dosage used	0.90%						

3.4 CASTING

The M30 mix proportion was produced for SFRC with ggbs & fly ash accordance with the IS456-2000. The concrete was produced by mixing all the ingredients homogeneously. To this dry mix, required quantity of water was added (w/c=0.44 & w/c=0.41) and the entire mass was again homogeneously mixed. This wet concrete was poured into the moulds which was compacted through hand compaction in three layers, the specimens were given smooth finish. After 24 hours the specimens were demoulded and transferred to curing tanks where they were allow to cure for required number of days. For evaluating compressive strength, specimens of dimensions 150x150x150 mm were prepared. They were tested on 3000kN capacity compressing testing machine as per IS:456-2000.

3.5 TESTING

The compressive strength of the concrete cube test provides an idea about all the characteristics of concrete. By this single test one judges whether Concreting has been done properly or not. A concrete cube test or concrete cylinder test is generally carried out to assess the strength of concrete after 7 days, 14 days, or 28 days of curing. The compressive strength of GGBS and Fly Ash were determined at 7, 14, and 28 days. The results showed increased of the strength with time coherently. This is because mainly two reasons behind the strength development of GGBS and Fly Ash. First and foremost, reason is the higher percentage of slag content, which trigger higher strength and secondly is the gel formation which increases with curing time and results in higher strength. Depending on the variables of GGBS and Fly Ash properties on source their performance with high volume of mixes utilizing varied material sources may vary accordingly. In comparison, GGBS likely be more consistent in chemical composition and physical characteristics. Therefore, GGBS tend to cater more gradually uniform results. Whereas, Fly Ash chemical and physical characteristics depends on the source availability and performance of highvolume Fly Ash may vary accordingly. The compressive strength has clearly shown improvement as the curing days gradually increased from 7 days to 28 days.

IV. RESULT

4.1 COMPRESSION TEST ON CUBES

Compression is a major characteristic property of concrete. To test the compressive strength, cube specimens of dimensions 150 x 150 x 150 mm were casted for M30 grade of concrete. After curing of specimen for 7, 14 and 28 days, their testing was done with the help of Compressive Testing Machine. The load was applied on the specimen till the specimen failed. The failure load was noted. For each test 3 specimens were prepared and tested and their average value is taken as final value. The compressive strength was calculated according to following formulae,

Compressive strength (MPa) = Failure load / cross sectional area.

Fig: Cube placed for testing in compression testing machine

The table below shows the overall results of compressive strengths of Steel Fiber Reinforced Concrete made with fly ash and GGBS as a partial replacement of cement.

4.2 RESULTS:

Testing Period	Cubes	SFRC+Fly Ash		SFRC+GGBS	
		Load (KN)	Compressive Strength (N/mm^2)	Load (KN)	Compressi ve Strength (N/mm^2)
7 Days	FC-1, GC-1	576.7	27.10	705.4	31.63
	FC-2, GC-2	614.4	25.83	670.9	29.69
	FC-3, GC-3	574.4	26.45	682.8	30.31
Average Value		588.5	**26.46**	686.36	**91.63**
14 Days	FC-1, GC-1	883.4	39.28	883.6	42.98
	FC-2, GC-2	845.4	38.8	846.3	38.28
	FC-3, GC-3	811.2	36.98	810.3	39.98
Average Value		846.66	**38.34**	846.73	**40.41**
28 Days	FC-1, GC-1	1010	40.56	825.0	39.56
	FC-2, GC-2	1020	45.62	1006.78	44.98
	FC-3, GC-3	1006.2	46.05	1010	45.10
Average Value		1012.06	**44.07**	947.26	**43.21**

The compressive strength of GGBS and Fly Ash was assessed at 7, 14, and 28 days, and the corresponding results are depicted in the figure.The findings revealed a progressive increase in strength over time, consistently observed across all partial percentages of GGBS and Fly Ash. This can be attributed to two primary factors contributing to the strength development of GGBS and Fly Ash. Firstly, the higher proportion of slag content played a crucial role in enhancing the strength. Secondly, gel formation, which intensifies with the duration of curing, led to higher strength outcomes.

V. CONCLUSION

When investigating the samples, we investigated simple concrete samples. It showed a typical crack pattern. However, since it was added steel fibres in the concrete, cracks has decreased due to the Ductility behaviour of steel fibres. When comparing a concrete sample with 40% cement replacement with GGBS and a concrete sample with 20% cement replacement with fly ash, the sample with GGBS gave the best results i.e. Compressive strength 46.69MPa.The addition of fly ash or GGBS as partial replacements for cement in concrete has been observed to yield positive outcomes in both fresh and hardened states. This means that incorporating fly ash or GGBS can provide benefits in terms of workability and strength of the concrete. In fresh conditions, these supplementary cementitious materials can enhance the flowability and cohesiveness of the concrete mix. In hardened conditions, they contribute to improved compressive strength, durability, and resistance to various forms of deterioration such as Sulfate attack or alkali-silica reaction. Overall, the utilization of fly ash or GGBS as partial cement replacements is considered advantageous for concrete performance in both its fresh and hardened states. The combination of these two materials is more beneficial when used as a stabilizer than when used alone. Looking back on this project, the overall outcome of results to be observed.

- In high volume replacement Mix (40%GGBS+60%OPC) gives more compressive strength than Mix (20%Fly Ash+80%OPC).
- Incorporation of Fly ash and GGBS as a partial replacement of cement in concrete gives good results in both fresh and hardened state.
- Making concrete with the combination of Fly ash and GGBS and cement with different percentages gives good results compared to control concrete. So, the best way to use these materials is in combination.
- Due to environmental issues in the production of cement, industrial by products like fly ash and GGBS are used as supplementary materials in concrete and it saves cost of production of concrete, and makes it eco-friendly.

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