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Utilization of Waste Material in Construction Industry

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ABSTRACT

In the modern scenario, desires from concrete have expanded exponentially, different physical parameters of concrete like strength, durability, serviceability and cost needs change i.e. how successfully we can save the cost of cement without bargain the strength and durability of cement [1]. To defeat the inflation, supplementary cementitious material is utilized as a part of conjunction with OPC so that the durability, maintainability and cost effective can be accomplished. In India, 7.8 million ton GGBS as a by-product obtain in the manufacturing in the blast furnace. As the project financial development and improvement in the steel businesses the measure of generation is probably going to increment numerous folds [2-3]. Because of exponential developing in urbanization and industrialization by item from the steel businesses, for example, GGBS is turning into an expanding worry for reusing and waste material. Being a result utilizing it successfully up to some degree fills in as a stage for a green situation and at a same time remembering that the quality of cement doesn't debased by the use of GGBS.

In this paper we presenting review of literatures related to experimental investigation of concrete.

Keywords : Concrete, GGBS, cement, strength, development, utilization of by product.

I. INTRODUCTION

It is a byproduct of the iron manufacturing industry. When raw materials are fed into the furnace and the subsequent molten slag floats over the molten iron having temperature range of around 1500°C to 1600°C [5]. The composition of molten slag having 30% to 40% SiO_2 and around 40% CaO, which is almost, like the chemical composition of Portland cement. After the molten iron is tapped off, the staying liquid slag, which comprises of for the most part siliceous and aluminous deposit, is then water extinguished and cooled quickly, bringing about the development of a polished crystalline granulates [6-7-8]. This glassy granulates appearance are dried and converted into powder form which is known as ground granulated blast-furnace slag (GGBS). When we talk about the replacement of Portland cement with GGBS will offers a carbon dioxide gas emission. GGBS is along these lines an environmental friendly construction

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material. It can be utilized to replace as much as 80% of the Portland cement utilized as a part of concrete.

II. LITERATURE REVIEW

Vijay Madhavrao Takekar and G. R. Patil (2017) focused on Grounded Blast Furnace Slag (GGBS) as a choice for binder and filler materials in case of ordinary Portland Cement (OPC). The experimental result analyses are investigated for structural houses of fiber reinforced concrete equipped with GGBS. Concrete grade M-50 became taken for have a look at. GGBBS with 0%, 10%, 20%, 30% and 40% with the aid of weight of normal cement turned into brought successively; also 1.5% of steel fiber turned into saved regular. Variables protected combination size (10mm, 12mm and 20mm) with percent of GGBS so that you can observe the impact on compressive energy, tensile electricity and flexural power. 150mmX150mmX150mm size of dice and 100mmX100mmX500mm length of beam have been examined for energy overall performance in shape of compressive and flexural electricity respectively. Samples with duplication of GGBS were cured for fifty six days in assessment to normal cement which calls for up to twenty-eight days. Experiments with these samples had been executed to study the strength characteristics of the concrete. Outcomes indicate that as the percentage of GGBS will increase, the workability of GGBS fiber reinforced concrete additionally increases. The result additionally consists of effect of price and compressive electricity for GBBS fiber reinforced concrete.

K.Vidhya et al. (2017) studied the steel fiber (Hooked end and crimpled) percentage in addition to the weight of cement. The Compressive strength, tensile strength and flexural behaviour of steel fiber reinforced concrete beam with the varying percentage of fiber of M40 grade of concrete.

Namani Saikrishna & Syed Moizuddin (2017) investigated the strength, split tensile strength tests have been performed by means of silica fume in various percentage of 5%, 7%, 10% and 15% to the weight of cement and 0.5%, 1%, 1.5%, and 2% of steel fibers to the weight of concrete of round crimped kind having aspect ratio 45.45 (length 25 & diameter 0.55) were used. Concrete cubes are examined at the age of 7, and 28 days of curing. Sooner or later, the strength performance of steel fiber concrete is compared with the performance of conventional concrete.

OBJECTIVE OF STUDY

The objective of this work is given below-

1. To study the compressive strength, split tensile strength and flexural strength and workability of concrete.
2. To check compressive strength, split tensile strength and flexural strength of concrete with partial replacement ground granulated blast furnace slag (10%, 20% and 30%) by weight and addition of steel fibers with different aspect ratio of 79 & 55 in different percentage (0.5%, 1% and 1.5%) to the weight of concrete.
3. The optimum dosage for partial replacement of cement by ground granulated blast furnace slag and steel fiber will be study.
4. Maximum compressive strength split tensile strength and flexural strength at different percentage of GGBS and Steel fiber will be investigated.
5. The strength performance and durability of slag blended fiber reinforced concrete is compared with the performance of conventional concrete.
6. Economic analysis of GGBS and steel fiber concrete has been done and compared with the conventional concrete.

III. MATERIAL USED

In this experimental work, various materials are used like….

1. Cement

2. Fine aggregate
3. Coarse aggregate
4. Water
5. Steel fibers
6. GGBS

3.2.1 CEMENT

Ordinary Portland cement of 53 grade is used in this experimental work and its properties were tested as per Indian standards IS 4031. Ordinary Portland cement conforming to IS 12269:198711 with specific gravity 3.15 is used. Table 3.1 shows the properties of OPC

Table 3.1: Properties of ordinary Portland cement

Property	Value
Specific gravity	3.15
Normal consistency	30%
Initial setting time	30 min
Final setting time	600 min

Fig. 3.1: Cement used

FINE AGGREGATE

The sand used for this experimental work was locally procured and passing through 4.75mm sieve with specific gravity 2.80. It should have fineness modulus 2.50-3.50 and silt contents should not be more than 4%. It is also noteworthy that the material's gradation was determined by sieving analysis in the laboratory. The physical properties of fine aggregate were noted to predict the overall impact on the concrete mix.

The properties of Fine Aggregate are shown in below table

Table 3.2 : Properties of fine aggregate

Property	Value
Bulk density	1490 Kg/m^3
% of voids ratio	34.23 %
Voids Ratio	0.58
Specific Gravity	2.258
Fineness modulus	2.9

Fig. 3.2 : Fine Aggregate

3.2.1 COARSE AGGREGATE

Crushed aggregate of maximum size 20mm & minimum 10mm are used in the present study. Its specific gravity is 2.85. Locally available coarse aggregate are used. It should be hard, strong, dense, durable and clean. It must be free from vein, adherent coatings and injurious amount of disintegrated pieces, alkalis, vegetable matters and other deleterious substances. It should be roughly cubical in shape. Flaky pieces should be avoided. It should confirm to IS 2838(I). Coarse aggregates for all concrete mixes are used as per IS 456:2000. The gradation of the coarse aggregates was done as specification that Coarse aggregates of 20 mm and 12 mm sizes were used in 60:40 ratios. The physical and mechanical properties of the material were also obtained to know its impact on the concrete.

The properties of Fine Aggregate and coarse aggregate are tested as per I.S. 383: 1970.The coarse aggregates properties shown in below table.

Table 3.3 : Properties of coarse aggregate

Property	Test Results
Specific Gravity	2.74
Bulk density(Kg/m^3)	1600
Fineness Modulus	7.17

Fig. 3.3: Coarse Aggregate

3.2.2 WATER

Fresh water free from any organic matter and potable water was used. Water is an important ingredient of concrete as it actively participates in the chemical reaction with cement. Water which is suitable for drinking is satisfactory for use in concrete. Water should be free from acids, oils, alkalis, vegetables or other organic impurities. Soft waters also produce weaker concrete. Water used in preparation of concrete should have PH range 6-7.5. It was tested and checked for permissible limit as per the IS: 3025 and IS: 456-2000.

3.2.3 GGBS

Blast furnace slag is a by-product of pig iron manufacture. The main components of blast furnace slag are CaO (30-50%), SiO_2 (28-38%), Al_2O_3 (8-24%), and MgO (1-18%). Using GGBS for cement replacement gives more water tightness, chemical resistance and low heat of hydration. The fineness modulus of GGBS using Blaine' fineness is 320m²/kg and other properties of GGBS. GGBS material was procured from Bhutda Corporation, Bhopal.

Fig. 3.4: GGBS

Table 3.4: Physical Properties of GGBS

Physical Properties	GGBS
Colour	Off-White
Specific gravity	2.9
Bulk density	1200 kg/m^3
Fineness	>350 m^2/kg

3.2.1 STEEL FIBRE

Steel fiber having low carbon and hook end type were used. The steel fiber which is used in concrete is of density 7900 kg/m^3. The steel fibers can be of any shape like a crimped wire, hooked or a flat and are described as a parameter called aspect ratio. Steel fiber properties such as, crack resistance etc. It is of short length of steel having aspect ratio in the range of 30 to150. It reduces the workability and improves the concrete properties with the addition of steel fiber. The steel fibers have dimensions of 0.45 x 25 mm, aspect ratio of 45, and density of 7.85 g/cm^3. Collect from Arvind Industries Pvt. Ltd. Bhopal.

Table 3.5: Properties of steel fiber used in concrete

Fibre type	L_f, mm	D_f, mm	Aspect ratio	F_{uf}
RC 80/ 30 BP	30	0.38	79	2300
ZP 305	30	0.55	55	1300

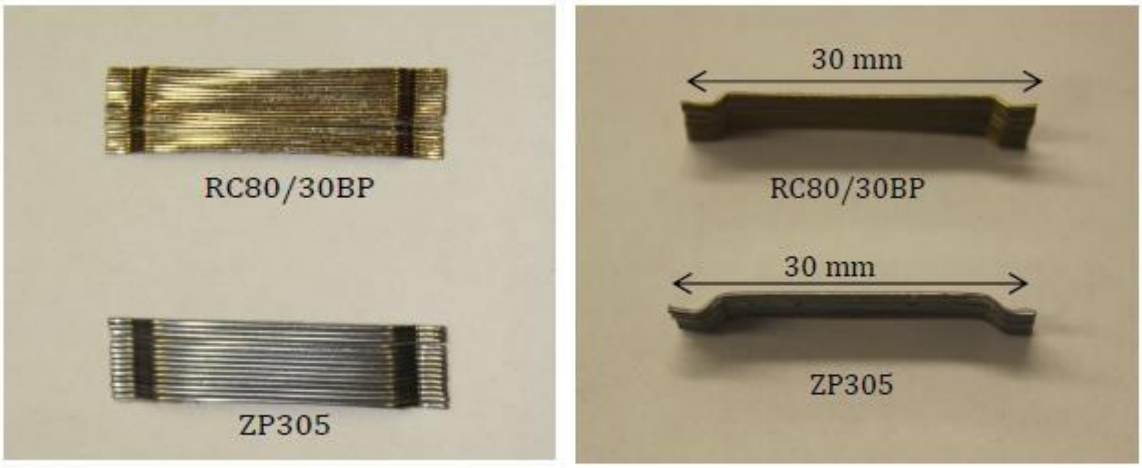

Fig. 3.5: Hook end steel fibers

Table 4.1: Slump Test Result

Sample	Slump, mm
0SF0GGBS0	58
79SF0.5GGBS10	54
79SF1.0 GGBS20	44
79SF1.5GGBS30	39
55SF0.5GGBS10	35
55SF1.0GGBS20	33

55SF1.5GGBS30	30

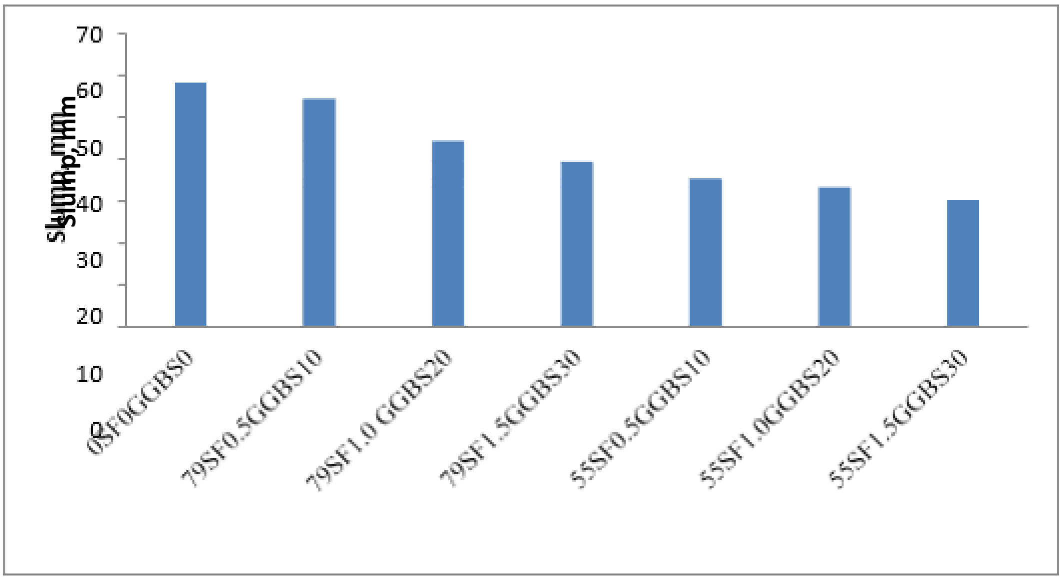

Fig. 4.1: Slump Test Result

4.1 WORKABILITY TEST

This test was conducted to find out the degree of workability of GGBS and steel fiber based concrete. Table 4.1 below shows that with increase in GGBS percentage, workability of concrete increases. It was observed that as percentage of fiber increases workability reduces. The reduction in workability is due to more water required to lubricate more amount of fiber. As amount of fiber increases less space is available for movement of fiber. Results are highlighted in the Table 4.1 below:-

Table 4.1: Slump Test Result

Sample	Slump, mm
0SF0GGBS0	58
79SF0.5GGBS10	54
79SF1.0 GGBS20	44
79SF1.5GGBS30	39
55SF0.5GGBS10	35
55SF1.0GGBS20	33
55SF1.5GGBS30	30

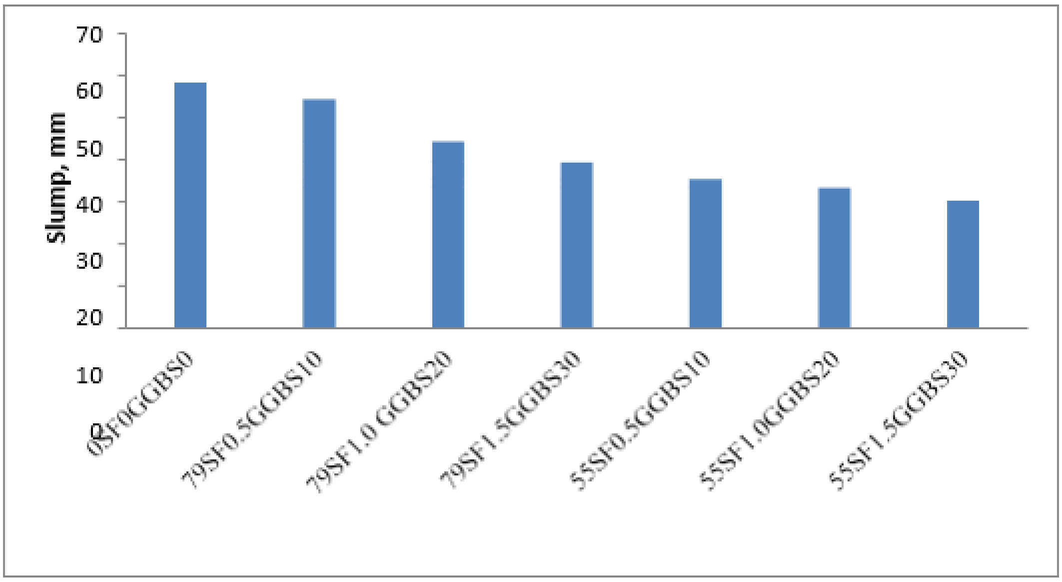

Fig. 4.1: Slump Test Result

4.1 COMPRESSIVE STRENGTH TEST

This test generally provides a general picture of the quality and performance of concrete because strength is directly related to the structure of the hydrated cement paste.

4.1.1 FOR 7 DAYS OF CURING

It is observed that with increasing aspect ratio compressive strength increases. With the addition of steel fiber results in increase of compressive strength by fascinating progression of cracks due to established bond of steel fiber and cement paste. The maximum value of compressive strength recorded at 10 % GGBS and 1.5 % fiber with aspect ratio 79 is 23.79 N/mm^2. Hence 10 % GGBS and 1.5 % fiber with aspect ratio 79 is the maximum percentage of the GGBS and steel fiber on the replacement of cement for achieving maximum strength.

Table 4.2: Compressive Strength of M30 grade at 7days

Sample	Compressive Strength, (MPa)
0SF0GGBS0	20.65
79SF0.5GGBS10	22.42
79SF1.0GGBS20	23.53
79SF1.5GGBS30	23.79
55SF0.5GGBS10	22.56

55SF1.0GGBS20	22.14
55SF1.5GGBS30	21.32

4.1 FLEXURAL STRENGTH TEST

With different percentages of GGBS and steel fibers 14 beams of size 100 mm × 100 mm × 500 mm were casted. As the concrete sets in mould a temping rod was used. When concrete sets beams were demoulded and immersed in the water for a curing period of 28 days to guarantee enough curing. After 28 days of curing, each beam was tested. Result shows that the beam gave good performance at 10 % GGBS and 1.5 % fiber with aspect ratio 79 whichis more than normal concrete.

Table 4.5: Flexural Strength of M30 grade at 28 days

Sample	Flexural Strength, (MPa)
0SF0GGBS0	4.98
79SF0.5GGBS10	5.25
79SF1.0GGBS20	6.08
79SF1.5GGBS30	8.23
55SF0.5GGBS10	5.43
55SF1.0GGBS20	6.51
55SF1.5GGBS30	7.79

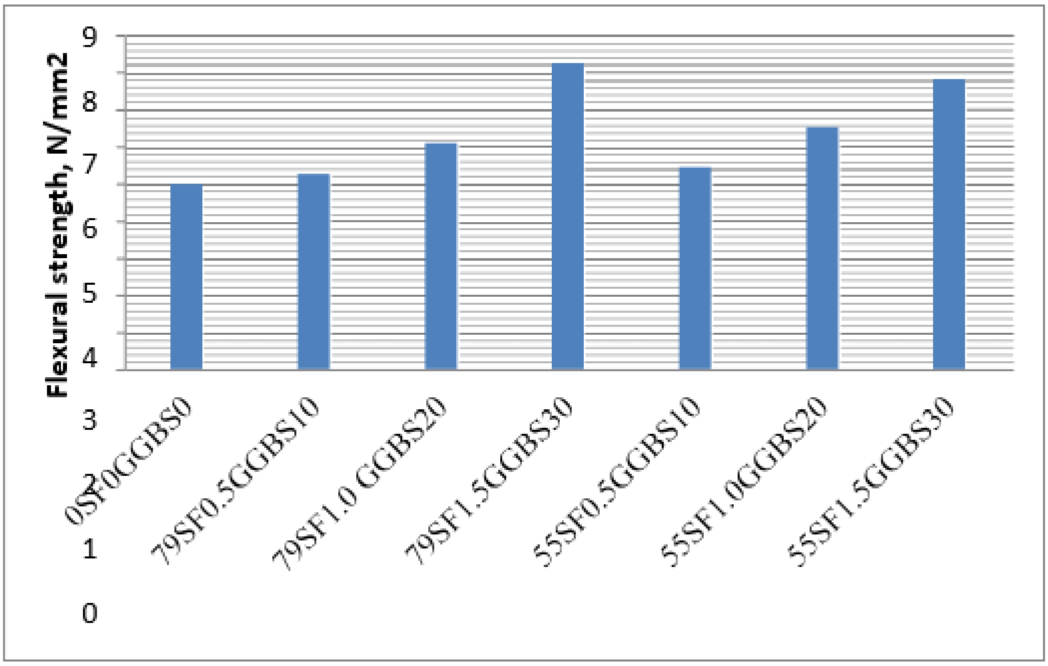

Fig. 4.5: Flexural Strength of M30 grade at 28 days

The maximum value of flexural strength at 10 % GGBS and 1.5 % fiber with aspect ratio 79 is 8.23 N/mm2. With the addition of GGBS flexural strength increases. So the maximum percentage of the GGBS and steel fiber on the replacement of cement should be 10 % GGBS and 1.5 % fiber with aspect ratio 79.

4.4 SPLIT TENSILE STRENGTH TEST

The split tensile strength is the indirect measurement to determine the strength of concrete. For this test various cylinders having 150 mm diameter and 300 mm height were casted for various percentages of GGBS and steel fiber. The test results shows that there is an increase in the strength only up to 10 % GGBS and 1.5 % fiber with aspect ratio 79 beyond the strength decreases and it was also observed that the strength showed increased only after 28 days of curing period.

Table 4.6: Split Tensile Strength of M30 grade at 28 days

Sample	Split Tensile Strength, (MPa)
0SF0GGBS0	3.12
79SF0.5GGBS10	3.64
79SF1.0GGBS20	5.55
79SF1.5GGBS30	6.90
55SF0.5GGBS10	5.36
55SF1.0GGBS20	4.23
55SF1.5GGBS30	3.42

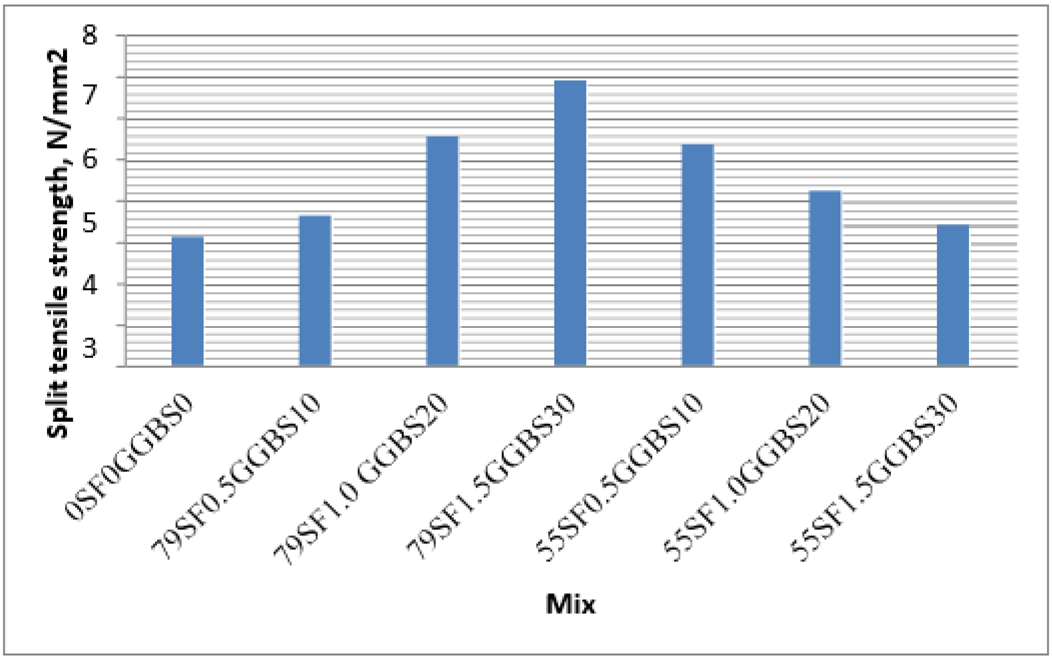

Fig. 4.6: Split Tensile Strength of M30 grade at 28 days

The maximum value of split tensile strength at 10 % GGBS and 1.5 % fiber with aspect ratio 79 is 6.90 N/mm². So the maximum percentage of the GGBS and steel fiber on thereplacement of cement should be 10 % GGBS and 1.5 % fiber with aspect ratio 79.

4.2 COST ANALYSIS

Material estimation includes costs for water, cement, natural sand, GGBS, steel fiber and coarse aggregate for a particular design mix. According to the mix design calculation we achieved the weight of water, cement, natural sand, GGBS, steel fiber and coarse aggregate for concrete. As the water is largely available in India, its costs can therefore be neglected. Current study shows that replacement of cement using GGBS and steel fiber can be made as much as 10 % and 1.5 % (by weight). Analysis of the cost of concrete with and without GGBS and steel fiber for M30 grade is given below in Table 5.2.

Calculation:-

Ratio = 1: 1.87: 3.37

Total = 1 + 1.87 + 3.37 = 6.24

Vol. of cement = (1/6.24) x 1.57 = 0.2516 m³1m³ of cement = 1440 Kg

For 1m³of M30 grade cement requires= 0.2516 x 1440 = 362.3 KgNo. of cement bags= 362.3/50 = 7.24 = 7.5 bags

Vol. of sand = (1.87/6.24) x 1.57 = 0.4704 m³

For 1m³ of M30 grade sand requires= 0.4704 x 1600 = 752.79 KgVol. of coarse aggregate= (3.37/6.24) x 1.57 = 0.796 m³

For 1m³of M30 grade coarse aggregate requires = 0.796 x 1600 = 1274.91 Kg

Table 4.7: Quantities per unit volume of concrete constituents for M30

Concrete Constituent	Quantities per unit vol.
	1: 1.87: 3.37
Cement	362.3 Kg (7.5 bags)
Fine Aggregate	0.4704 m³
Coarse Aggregate	0.796 m³

Quantity of GGBS = 362.3 Kg x 0.1 = 36.23 Kg

Cement quantity after replacement = 326.07 kg = 6.52 bag

Table 4.8: Cost of material per cubic meter of concrete for M30

Material	Rate	Conventional Concrete		M 30 (Optimum Steel fiber (2.5 %) and GGBS (25 %) Concrete)		% Saving
		Quantity	Cost	Quantity	Cost	
Cement	Rs 400 per bag (50 Kg)	7.5 bags	Rs 3000	6.5 bags	Rs 2600	2.2 %
Steel fiber	Rs 12/ Kg	0	0	5.43 Kg	Rs 65.16	
GGBS	Rs 6/Kg	0	0	36.23 Kg	Rs 217.38	
Fine Aggregate	Rs 860/m³	0.4704 m³	Rs 404.54	0.4704 m³	Rs 404.54	
Coarse Aggregate	Rs 2400/m³	0.796 m³	Rs 1910.4	0.796 m³	Rs 1910.4	
			Rs 5314.94		Rs 5197.48	

We can save 2.2 % cost by the addition of GGBS and steel fiber in concrete as compared to normal cement concrete for one cubic meter of volume. This is a significant saving of money. There are good prospects of obtaining a good concrete strength at relatively cheaper cost even while replacing part of the cement GGBS and steel fiber. Figure 4.7 shows the comparison of costs between conventional concrete and M30 mixture.

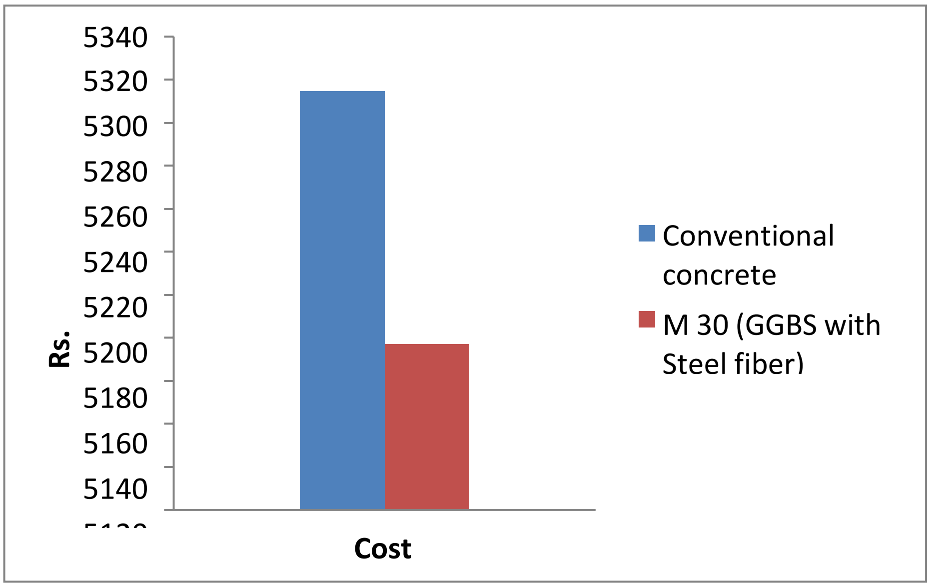

Fig. 4.7: Cost Comparison

IV.CONCLUSION

In my thesis I have performed a planned experiment and the result shows that the variation in the compressive, flexural and tensile strength with respect to changes in the GGBS and fiber content. The purpose of introducing GGBS and steel fibers by partial replacing cement is to increase strength and performance of the concrete. And also durability properties of concrete can be enhanced by introducing the steel fibres.

The following conclusions could be drawn from the present investigation.

1. Slump cone test shows that with increase in GGBS content, the workability increases but addition of steel fiber in concrete decreases the slump value.
2. Addition of GGBS and steel fibers in concrete leads to low workability.
3. Use of GGBS as cement replacement increases consistency.
4. Increment of GGBS and steel fiber content up to 10 % and 1.5 % shows worthy results in terms of compressive, split tensile and flexural strength.
5. Increase in the steel fibers results in increasing the tensile strength and toughness of the composite
6. Plain concrete is a brittle material and fails suddenly. Concrete ductility can be developed by the accumulation of steel fibers. Also in this study we noticed that compressive strength, split tensile strength and flexural strength of concrete improves with the addition of fibers.
7. Also with the addition of steel fibers, it will reduce bleeding and it advances the surface integrity of concrete. Hence the probability of cracks can be greatly reduced.
8. This experimental investigation helps to know the properties and behaviour of steel fiber reinforced concrete.
9. From the mechanical properties, the optimum replacement by GGBS and steel fiber was found to be 10 % & 1.5 % with aspect ratio 79 and beyond all the strength values decreased when compared to normal concrete.
10. The maximum values of compressive strength at 10 % GGBS and 1.5 % fiber are 23.79, 27.64 and 38.15 N/mm2 at the age of 7, 21 and 28 days.
11. The maximum values of flexural strength at 10 % GGBS and 1.5 % fiber are 8.23 N/mm2. Accordingly the optimum percentage of the GGBS and steel fiber which can be used for the replacement of cement is 10 % and 1.5 %.
12. The maximum values of split tensile strength at 10 % GGBS and 1.5 % fiber are 6.9 N/mm2. So the maximum percentage of the GGBS and steel fiber on the replacement of cement should be 10 % and 1.5 %.
13. With increase in amount of fibers, flexural strength increases while flexural deflection decreases with increase in addition of steel fiber as compared to the normal concrete.
14. We can save 2.2 % cost by the addition of GGBS and steel fiber in concrete as compared to normal cement concrete for one cubic meter of volume. This is a significant saving of money. There are good prospects of obtaining a good concrete strength at relatively cheaper cost even while replacing part of the cement GGBS and steel fiber.
15. We can save maximum cost in mass concrete work or in construction where large volume of concrete is used by replacing the cement by GGBS and steel fiber.
16. The advantage of addition of GGBS in cement is that it sets faster than it is made with OPC, it also gain strength continuously with a longer curing period.
17. It also offers high resistance against corrosion attack and provides protection against sulphate attack hence can be used in effluent and sewage treatment plant (to avoid sulphate attack), in marine work and many more.

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