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EXPERIMENTAL STUDY ON STEEL FIBRE REINFORCED CONCRETE BY PARTIALLY REPLACEMENT OF CEMENT WITH GGBS AND METAKAOLIN

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Abstract In this cutting edge situation, assumptions from concrete have expanded dramatically. Different actual boundaries of substantial like strength, solidness, workableness and expected assistance life needs improvement. This paper manages the investigation of the strength boundaries of cement by halfway substitution of concrete by ground granulated impact heater slag (GGBS). The tests were directed according to Bureau of Indian guidelines (BIS) to assess the reasonableness of GGBS as a halfway substitution of concrete. The steel fiber was utilized to build the durability of the substantial. Various strength parameters such as compressive strength, split tensile strength of concrete for a grade of M40 was tested and recorded. The to some extent supplanted concrete showed an expansion in strength when contrasted with traditional cement. Various mix combinations with a partial replacement of 0%, 10%, 20%, 30% by the weight of cement by GGBS and Metakaolin 0%, 5%, 10%, 15% was taken and 0.5%, 1% and 1.5% steel fiber of aspect ratio 50- 60 were used. The experimental outcomes show that the fractional substitution of concrete by both GGBS and steel fiber has an expansion in the strength of cement.. Considering all the strength parameters into account it was found that a 30% and 15% replacement of GGBS and Metakaolin with 1% steel fiber is optimum for M40 mix.

Keywords – METAKAOLIN and GGBS, STEEL FIBRE, fine aggregate, coarse aggregate, compressive strength, split tensile strength, flexural strength.

1.Introduction

Concrete is one of the most widely used construction material. Portland cement production is a major contributor to carbon dioxide emissions. The global warming is caused by the emission of greenhouse gases, such as carbon dioxide, to the atmosphere by human activities. Among the greenhouse gases, carbon dioxide contributes about 65% of global warming. Many efforts are being made in order to reduce the use of Portland cement in concrete. These efforts include the utilization of supplementary cementing materials such as fly ash, silica fume, granulated blast furnace slag, rice-husk ash and metakaolin, and finding alternative binders to Portland cement. In terms of reducing the global warming, the geopolymer technology could reduce the carbon- dioxide emission to the atmosphere caused by Cement about 80% [1]. In this paper, the effort was made to study the strength parameters of geopolymer concrete with GGBS and Metakaoline on Steel Fibre Reinforced Concrete [2-3].

There are two main constituents of geo polymers, namely the source materials and the alkaline liquids. The source materials for geopolymers based on alumina-silicate should be rich in silicon (Si) and aluminium (Al). These could be natural minerals such as kaolinite, clays, etc. Alternatively, by-product materials such as fly ash, GGBS, etc could be used as source materials. The choice of the source materials for making geopolymers depends on factors such as availability, cost, type of application, and specific demand of the end users. The alkaline liquids are from soluble alkali metals

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Vol-12 Issue-09 No.01 September 2022

that are usually sodium or potassium based. The most common alkaline liquid used in geo polymerization is a combination of sodium hydroxide (NaOH) and sodium silicate.

Concrete is good in compression and weak in tension. Steel fiber in the concrete improves its mechanical characteristics. The modern development of steel fiber reinforced concrete (FRC) started in the early sixties. The steel fibers are the mostly used fiber, in fiber reinforced concrete. Many studies show that addition of steel fiber to the concrete lowers the workability of concrete. Therefore to solve this problem super-plasticizer is added, without affecting other properties of concrete. FRC has been successfully used in construction due to its excellent flexural-tensile strength. Steel fiber in concrete improves malleability and its load carrying capability. The mechanical properties of steel fiber reinforced concrete are much improved by the use of straight fibers. Due to the addition of 1 percent steel fiber the flexural strength was increased and splitting tensile strength also increased.

Figure 1: Ground Granulated Blast Furnace Slag

Figure 2: Metakaolin

Figure 3: Steel Fibre

Ground granulated blast furnace slag is used for a long time in due to its economy in production of cement. Addition of slag in cement increases the durability properties of concrete and it also reduces the porosity of concrete. A 55-59% substitution of concrete by GGBS was found to deliver an ideal strength of cement. The consumption obstruction (for the most part because of chlorine), sturdiness and restricting force of cement is improved by utilizing GGBS. It changes the pore construction of cement and results in a more solidified concrete and furthermore scraped spot obstruction. The penetrability and entrance of chloride particles in concrete is diminished. It can likewise impact the electrochemical pore arrangement in concrete framework by the expansion of GGBS to concrete. The protection from sulfate assault on cement can likewise be diminished by the expansion of GGBS to concrete for both moderate and extreme climate.

Metakaolin is a dehydroxylated type of the earth mineral kaolinite. Metakaolin is ordinarily utilized in the development of earthenware production, but on the other hand is utilized as concrete substitution in concrete. Metakaolin has a more modest molecule size (~1-2 μm) and higher surface region contrasted and portland concrete, however a bigger molecule size than SF. At the point when utilized in concrete, metakaolin goes through a pozzolanic response and refines the microstructure of the hydrated concrete glue. Because of the little molecule size and high surface region, metakaolin responds rapidly and diminishes the dissemination coefficient contrasted and plain portland concrete. Research recommends that SF and metakaolin have comparative effects on the chloride entrance obstruction of cement. Run of the mill substitution levels for metakaolin range from 5% to 10%.

Steel fiber reinforced concrete (SFRC) is concrete made of pressure driven concretes containing fine or fine and coarse total and intermittent discrete steel filaments. In pressure, SFRC flops solely after the steel fiber breaks or pulled out of the concrete framework shows a run of the mill cracked surface of SFRC. Properties of SFRC in both the newly blended and solidified state, including sturdiness, are an outcome of its composite nature. The mechanics of how the fiber support reinforces cement or mortar, stretching out from the versatile precrack state to the to some degree plastic post-broke state, is a proceeding with research subject.

2.Objective of Current Study

The primary objectives of this study are to improve the strength properties of concrete by partial replacement of cement with GGBS and Metakaolin. Additionally steel fibre also added, so as to make it suitable for construction of any civil engineering structures.

- To study the workability of concrete using cement with GGBS and Metakaolin, additionally steel fibers.
- To study the compressive strength of concrete using cement with GGBS as 10%, 20% and 30% replacements and Metakaolin as 5%, 10% and 15%. Additionally 0.5%, 1% and 1.5 % of steel fibres in total volume of concrete.
- To study the Split tensile strength of concrete using cement with GGBS as 10%, 20% and 30% replacements and Metakaolin as 5%, 10% and 15%. Additionally 0.5%, 1% and 1.5 % of steel fibres in total volume of concrete.

ISSN: 2278-4632
Vol-12 Issue-09 No.01 September 2022

- To study the Flexural strength of concrete using cement with GGBS as 10%, 20% and 30% replacements and Metakaolin as 5%, 10% and 15%. Additionally 0.5%, 1% and 1.5 % of steel fibres in total volume of concrete.

3.SCOPE OF WORK

To accomplish the defined objectives for this research work the following scope of work was defined:

- Distinguishing and gathering the samples of materials that are appropriate for the substantial blend
- Materials used in the study were Metakaolin and GGBS and fibres used were Flat crimped steel fibres. Percentage of fibres adopted for these works vary from 0.5 to 1.5% volume of concrete.
- Detailed laboratory investigations for determination of mechanical properties of concrete like compressive strength, flexural strength, split tensile strength test and slump test were performed with different proportions and combinations of admixtures and fibres.
- To asses and analyze the laboratory results of mechanical properties and durability properties obtained at 7, 14 and 28 days.

4.LITERATURE REVIEW

Concrete enjoys a few benefits as fundamental material for development in contrast with the other development materials. It is the most promptly accessible material all over the place and it has magnificent protection from water in contrast with wood and steel. In this manner, concrete has turned into a more sturdy material. What's more, the plastic consistency of new substantial makes it simpler to be framed into different shapes and sizes utilizing pre-assembled formwork. In talking about the significance of HPC.

B. Sarath Chandra Kuma (2017) Construction industry is dominated by new materials which are ecologically violable and feasible solution for ever growing architectural industry. Effort are in progress all over the world to develop environment friendly construction materials which minimizes the utility of natural resources and helps to decrease green house gas emissions in to the atmosphere. The green house gas releases in the atmosphere is increasing day by day due to ordinary Portland cement production. In this connection, Geopolymer is in need, where the binders used in the production of geopolymer concrete is inorganic polymers. Geopolymer concrete will be introduced as an alternative concrete which did not use any cement in its mixture and used Metakaoline and GGBS as alternative cement. NaOH and Na2SiO3 were used as activator solution. The fixed ratio of sodium silicate to sodium hydroxide is 2.5 and the concentration of sodium hydroxide is 8 Molar.

K. Ramesh (2018) The geopolymer concrete specimens are casted and tested in the laboratory for compressive strength, Split Tensile Strength and Flexural Strength for 3 Days, 7 Days and 28 days and cured at ambient temperature. This study helps in gaining knowledge about the morophological composition of geopolymer concrete which might result in path-breaking trends in research and construction industry. The limited observations from the present investigation on properties of fresh and hardened metakaolin and GGBS based concrete are: Workability of geopolymer concrete decreased as the metakaolin content increases with GGBS. But increase in GGBS does not affect the workability. Mechanical properties such as compressive strength, split tensile strength and flexural strength shows increasing trend with the decrease of metakaolin. Mix with 30% of metakaolin and 70% of GGBs and

seems to have good compressive, split and flexural strengths, this may be due to increase in alkaline reaction between GGBS particles and calcium in Metakaoline. Nearly 90% of total strength of GPC is achieved within the age of 7days.
Then increase in strength of GPC between 7days and 28days appeared to be high when compared with 3days and 7days.It shows that even after 7days geopolymer reaction is taking place but at a higher rate

Dhanya R , Arasan G.V (2019) In this modern scenario, expectations from concrete have increased exponentially. Various physical parameters of concrete like strength, durability, serviceability and expected service life needs improvement. This paper deals with the study of the strength parameters of concrete by partial replacement of cement by ground granulated blast furnace slag (GGBS). The tests were conducted as per Bureau of Indian standards (BIS) to evaluate the suitability of GGBS as a partial replacement of cement. The steel fiber was used to increase the toughness of the concrete. Various strength parameters such as compressive strength, split tensile strength of concrete for a grade of M25 was tested and recorded. The partially replaced concrete showed an increase in strength as compared to conventional concrete. Various mix combinations with a partial replacement of 10%, 20%, 30% and 40% by the weight of cement by GGBS was taken and 0.5%, 1% and 1.5% steel fiber of hooked end type of aspect ratio 50-60 were used. The test results show that the partial replacement of cement by both GGBS and steel fiber has an increase in the strength of concrete. Considering all the strength parameters into account it was found that a 30% replacement of GGBS with 1% steel fiber is optimum for M25 mix.

Ganapathy Ramasamy (2020) The experiment was used to find the optimum possible replacement of cement by GGBS and Steel fiber in concrete to produce a better concrete. The following conclusion are made for GGBS at 30% and 1% Steel fiber with respect to conventional concrete. 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
Arasan G.V (2020) The superplasticiser content in percent by weight of fastener content fluctuated from 0.4 to 0.8. From the review it was seen that the post-raised temperature compressive strength of MK20 blend persistently diminished with the increment of temperature. The misfortune in compressive strength of up to 9%, 22%, 37% and 72% was seen after openness level of 200°C, 400°C, 600°C and 800°C separately. The fly debris blend showed misfortune in post-raised temperature compressive strength as temperature expanded from 27°C to 800°C. The misfortune in compressive strength after openness of 200°C, 400°C, 600°C and 800°C ultimately depended on 10%, 15%, 41%, 72% separately though the FA20 blend showed gain in post-raised temperature compressive strength of 14% when cement was exposed to 200°C while after 400°C openness, a tiny decrease of 4% was noticed.

5.MATERIALS AND METHODOLOGY

In this experiments Portland cement of grade 53 was used, Natural river sand was used as a fine aggregate of size not more than 4.75 mm, coarse aggregate of size varying from 12 mm to a maximum of 20 mm was used and GGBS and Metakaolin was used as a partial replacement of cement for various

ISSN: 2278-4632
Vol-12 Issue-09 No.01 September 2022

volume ratio. The properties of these materials were determined by conducting test as per IS code. The test results are presented in Table 1.

Table 1. Physical Properties of Materials

Constituents	Test	Results	Limitations from IS code
Cement	Specific gravity	3.18	3 to 3.25
	Standard consistency in %	31	26 to 33%
	Initial setting time in minutes	45	Not less than 30 minutes
Coarse aggregate	Fineness modulus	7.41	6.50 to 8
	Specific gravity	2.76	2.5 to 3
	Bulk density Kg/m^3	1716	1600 to 1800
Fine aggregate	Fineness modulus	3.335	2 to 4
	Specific gravity	2.68	2.5 to 3
	Bulk density Kg/m^3	1650	1520 to 1680
GGBS	Specific gravity	2.95	2.5 to 3.5
	Bulk density	1275	1200 to 1400
	Physical form	Powder form	Powder
Metakaolin	Specific gravity	2.5	2.4 to 2.6
	Bulk density Kg/m^3	1862	1750 to 1900
	Physical form	Powder form	Powder

Table 2: Properties of fibre

Properties	Steel
Length	10mm
Construction	Crimped
Acid Resistance	-
Alkali Resistance	-
Aspect ratio	45

ISSN: 2278-4632
Vol-12 Issue-09 No.01 September 2022

Tensile strength	600MPa
Tenacity	-

Table 3. Mix Porportion of M-40 Grade

	Mix	Cement	Fine Aggregate	Coarse Aggregate	W/C
Ratio	**M40**	1	1.65	2.92	0.4

6.TEST METHODS

Tests on new concrete and solidified concrete were finished in the current review. Every one of the tests were completed according to the suggestion of significant guidelines laid by IS: 1199-1959 and IS: 516-1959. Tests on new cement are fundamentally intended to evaluate the functionality of cement. Functionality might be characterized as the property of substantial which decides how much valuable interior work important to deliver full compaction. The strength of cement of a given blend extent influences intensely by the level of compaction, the consistency of the blend genuinely should be to such an extent that the substantial can be shipped, set and completed adequately effortlessly and without isolation

COMPRESSIVE STRENGTH TEST

Compressive strength test is the most widely recognized test directed on solidified concrete, part of the way as a result of its effortlessness to perform and part of the way in light of the fact that the vast majority of the beneficial trademark properties of cement are subjectively connected with its compressive strength. Generally solid shapes and chamber examples are utilized to decide the compressive strength. The test examples were exposed to pressure test following 28 days of relieving and wanted level of warming. The pressure testing was completed according to IS: 516-1959 rules.

SPLIT TENSILE TEST

Part tractable test is completed utilizing chamber example. Chamber parting pressure test is additionally called as "Brazilian Test" The split malleable test is a roundabout technique for deciding the elasticity of cement. The parting test is easy to perform and gives more uniform outcomes than other pressure tests. The fundamental benefit of this technique is that a similar sort of example and a similar testing machine can be utilized which is utilized for pressure test.

MODULUS OF RUPTURE TEST

In this review, modulus of crack or flexural trial of pillars were completed of size 150 mm × 150 mm × 700 mm. The flexural testing was completed according to IS: 516-1959 rules. The examples removed from relieving tank ought to be surface dry and clean and examples warmed ought to be cooled to room temperature.

ISSN: 2278-4632
Vol-12 Issue-09 No.01 September 2022

Table 6: Compressive Strength Results

Mix	Specification	Mix ratio	Compressive strength (N/mm^2)		
			7th day	14th day	28th day
M1	0% GGBS + 0% Metakaolin	1 : 1.65 : 2.92	30.4	38.4	52.2
M2	10% GGBS + 5% Metakaolin	1 : 1.65 : 2.92	31.4	39.4	52.5
M3	20% GGBS + 10% Metakaolin	1 : 1.65 : 2.92	32.1	40.4	53.3
M4	30% GGBS + 15% Metakaolin	1 : 1.65 : 2.92	33.8	41.5	54.8
M5	0.5% Steel fiber	1 : 1.65 : 2.92	33.2	40.4	53.5
M6	1% Steel fiber	1 : 1.65 : 2.92	37.1	44	58.8
M7	1.5% Steel fiber	1 : 1.65 : 2.92	35.5	41.5	55.6
M8	30% GGBS + 15% Metakaolin & 1% Steel fiber	1 : 1.65 : 2.92	37.26	44.5	59.8

The compressive strength of Metakaolin and GGBS based geopolymer concrete at the age of 7 days 14 days and 28 days are presented in the Table

Replacing cement with GGBS and Metakaolin

Compressive strength test on cubes is the most common test conducted on hardened concrete because it is an easy test to perform and most of the desirable properties of concrete are comparatively related to its compressive strength. The compression test was carried out on cubical specimen of size 150mm in a compression testing machine of capacity 2000 kN. The strength is determined at 7, 14 and 28 days of casting. The variation of compressive strength at the age of 7th and 28th days with optimum percentage of GGBS and Metakaolin were given below in Table 6 From the test results, it was observed that the maximum compressive strength was obtained for mix M8 it is observed that the percentage increase in strength from 7 days to 28 days is more in mix M8 i. e. 30% GGBS and 15% Metakaoline with 1% Steel fiber.

ISSN: 2278-4632
Vol-12 Issue-09 No.01 September 2022

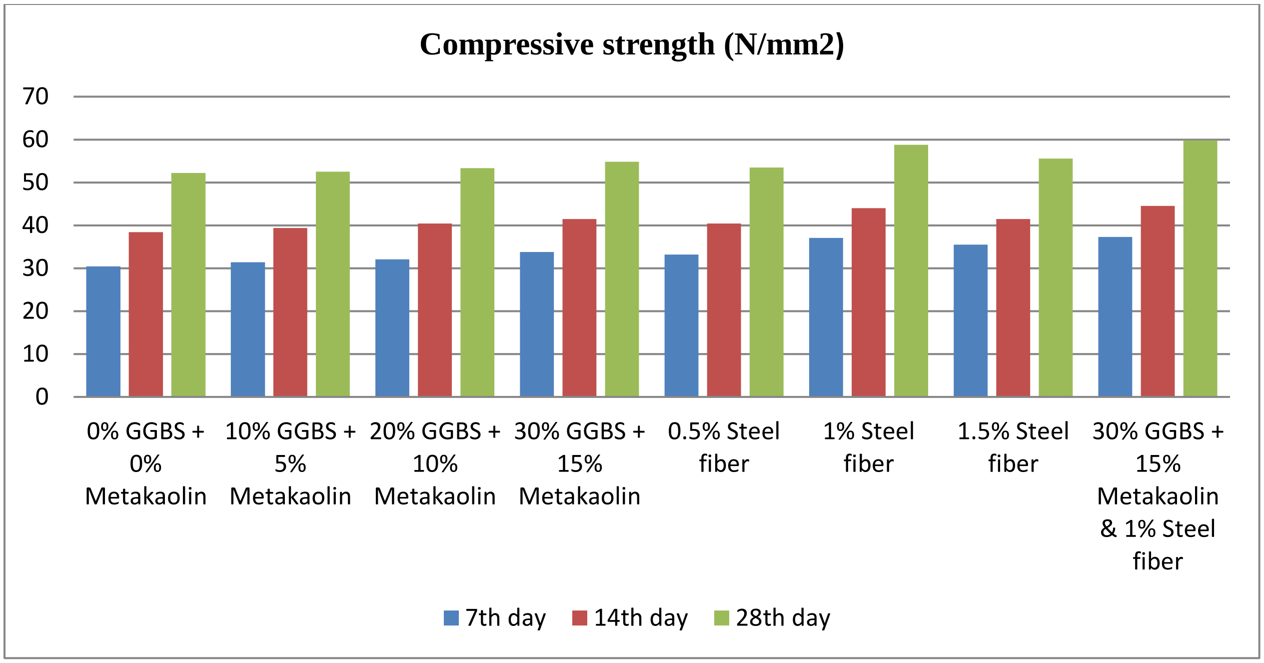


Table 7: Split Tensile Strength Results

Split Tensile Strength of concrete cylinders 150mm diameter and 300mm long were tested as per the procedure explained in IS 5816.

Replacing cement with GGBS and Metakaolin

Mix	Specification	Mix ratio	Split Tensile Strength (N/mm^2)		
			7th day	14th day	28th day
M1	0% GGBS + 0% Metakaolin	1 : 1.65 : 2.92	3.18	3.56	4.41
M2	10% GGBS + 5% Metakaolin	1 : 1.65 : 2.92	3.30	3.68	4.49
M3	20% GGBS + 10% Metakaolin	1 : 1.65 : 2.92	3.41	3.74	4.57
M4	30% GGBS + 15% Metakaolin	1 : 1.65 : 2.92	3.48	3.82	4.69
M5	0.5% Steel fiber	1 : 1.65 : 2.92	3.28	3.63	4.50
M6	1% Steel fiber	1 : 1.65 : 2.92	3.53	3.92	4.7
M7	1.5% Steel fiber	1 : 1.65 : 2.92	3.19	3.45	4.34

ISSN: 2278-4632
Vol-12 Issue-09 No.01 September 2022

M8	30% GGBS + 15% Metakaolin & 1% Steel fiber	1 : 1.65 : 2.92	3.74	4.21	5.02

The values of split tensile strength of cylindrical specimens subjected to ambient curing conditions. The variation of split tensile strength at the age of 28th days with optimum percentage of GGBS and metakaolin were given in Table 7. It was observed that the maximum split tensile strength was obtained for mix M8. Also, the split tensile strength decreases with increase of 1.5% Steel fiber

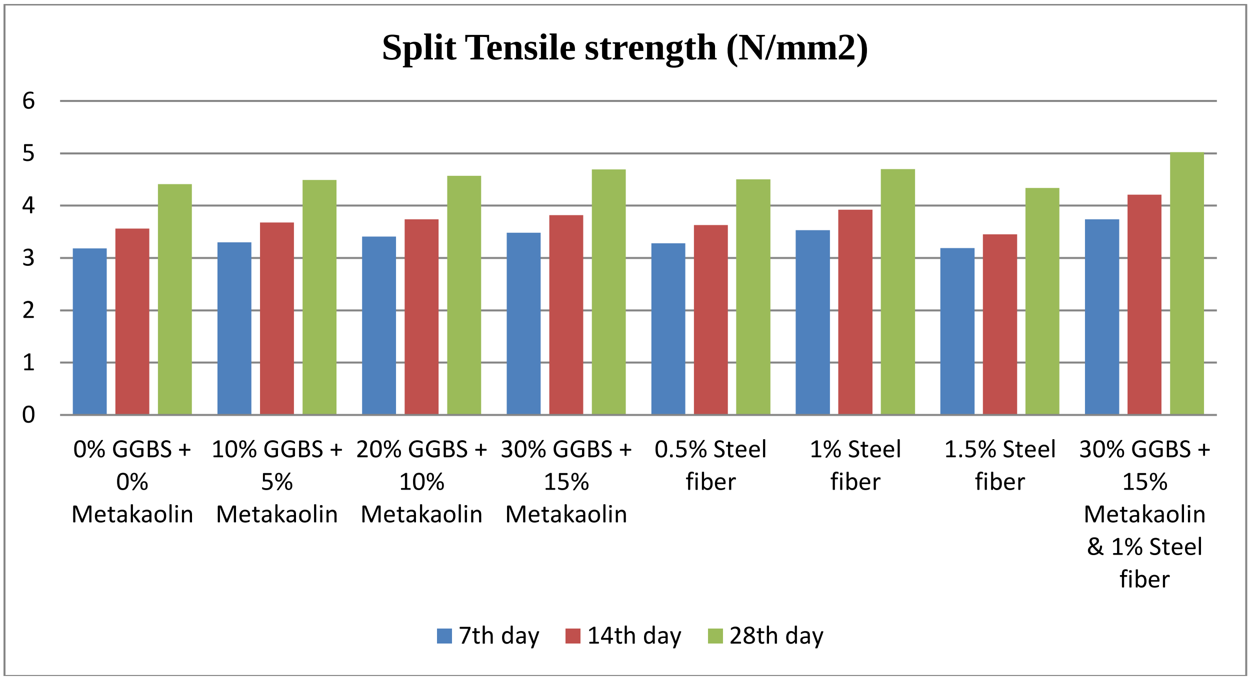


Table 8: Flexural Strength Results

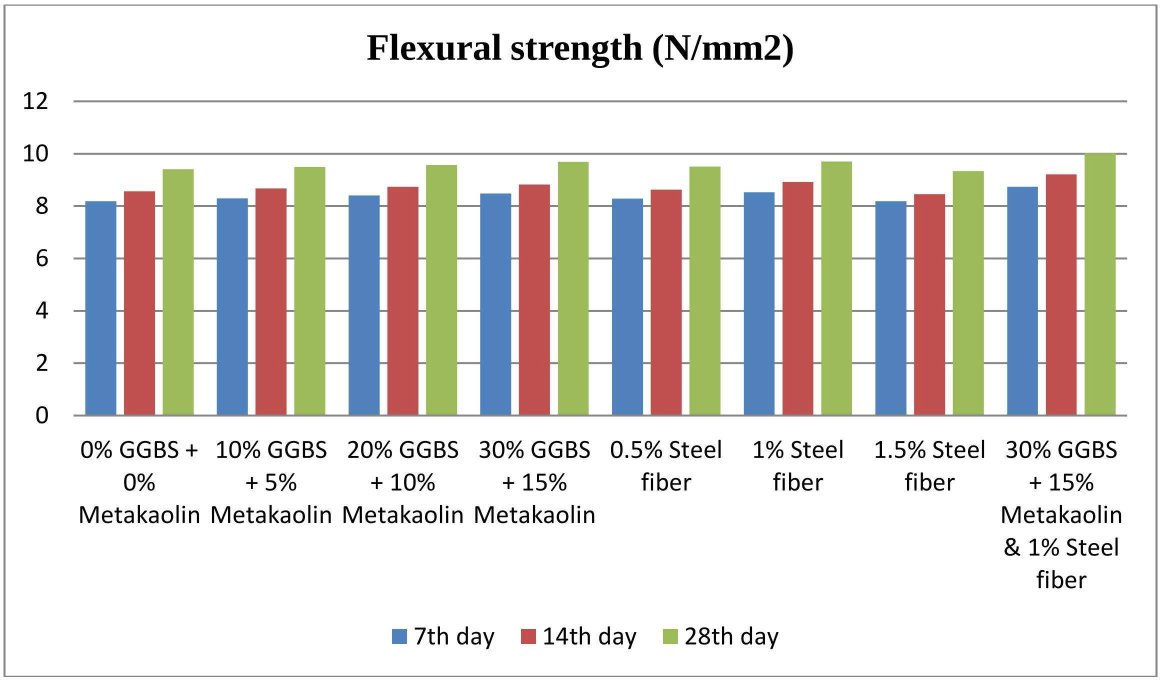
Replacing cement with GGBS and Metakaolin

Mix	Specification	Mix ratio	Flexural Strength (N/mm^2)		
			7th day	14th day	28th day
M1	0% GGBS + 0% Metakaolin	1 : 1.65 : 2.92	8.18	8.56	9.41
M2	10% GGBS + 5% Metakaolin	1 : 1.65 : 2.92	8.30	8.68	9.49
M3	20% GGBS + 10% Metakaolin	1 : 1.65 : 2.92	8.41	8.74	9.57
M4	30% GGBS + 15% Metakaolin	1 : 1.65 : 2.92	8.48	8.82	9.69
M5	0.5% Steel fiber	1 : 1.65 : 2.92	8.28	8.63	9.50
M6	1% Steel fiber	1 : 1.65 : 2.92	8.53	8.92	9.7
M7	1.5% Steel fiber	1 : 1.65 : 2.92	8.19	8.45	9.34

ISSN: 2278-4632
Vol-12 Issue-09 No.01 September 2022

M8	30% GGBS + 15% Metakaolin & 1% Steel fiber	1 : 1.65 : 2.92	8.74	9.21	10.02

The results of flexural strength of concrete at the age of 7, 14 and 28 days are presented in Table 8. The variations in flexural strength at the age of 28 days with different percentage of GGBS and metakaolin were plotted .From the test results, it was observed that when the percentage of GGBS increases, the flexural strength of concrete also increases. On the contrary, the strength decreases when the percentage of steel fiber increases.



7.RESULTS AND DICUSSION

The following tests were conducted on the concrete cubes, Cylinders & Prisms and are shown in Tabular representations of the results are also follows. Replacements of natural cement with with GGBS as 10%, 20% and 30% replacements and Metakaolin as 5%, 10% and 15% in same mix of concrete grade M-40. Additionally 1.5% to 2% of total weights of concrete as fibers are also added to improve its tensile strength.

8.CONCULSION

Replacing of natural cement with 5% 10%, 15% of Metakaolin and 10%, 20% and 30% of GGBS. Additionally 0.5%, 1% and 1.5 % of steel fibres in total volume of concrete. The experiment was used to find the optimum possible replacement of cement by GGBS, Metakaolin and steel fiber in concrete to produce a better concrete.

The following are the conclusions made from my experimental studies for M-40 Grade Concrete for GGBS 30% + 15% Metakaolin and 1% of steel fiber with respect to conventional concrete.

- Maximum Compressive strength of 59.8 N/mm2 is achieved at 15% replacement of Metakaolin and

30% replacement of GGBS with 1% of steel fibre in concrete.

- Maximum Split Tensile strength of 5.02 N/mm2 is achieved at 15% replacement of Metakaolin and 30% replacement of GGBS with 1% of steel fibre in concrete.
- Maximum Flexural strength of 10.02 N/mm2 is achieved at 15% replacement of Metakaolin and 30% replacement of GGBS with 1% of steel fibre in concrete.
- The compressive strength, Split tensile strength and Flexural Strength of concrete increased about 14.5% , 13.8% and 6.48% respectively.
- Considering all the test results it can be said that for M40 mix, 30% replacement of cement by GGBS, 15% replacement of cement by Metakaolin and 1% Steel fiber is considered as optimum.
- The partial replacement of cement by GGBS & Metakaolin not only provides the economy in construction but it also utilization of the GGBS which is generated in huge quantities.

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