EXPERIMENTAL INVESTIGATION AND STRENGTH ASPECTS OF SELF COMPACTING CONCRETE

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Abstract
Concrete that self-compacts has a higher ability to flow and settle without the use of mechanical vibration. This study's primary objective is to investigate the mechanical characteristics of reinforced self-compacting concrete (SCC) using ground granulated blast furnace slag (GGBS) and ultrafine Natural Steatite powder as mineral admixtures. The laboratory flexural strength destructive test on the beam reinforced with 4mm bars was carried out in the current study using cubes cast to find compressive test and cylinders for split tensile test. The purpose of the experiment was to look at how the fresh and solidified properties of SCC were affected by the replacement of the GGBS, UFNSP, and pond ash. To achieve self-compacting concrete properties and predict flow behavior, replacement of cement in various percentages, such as 20%, 40%, 60%, 80% GGBS & UFNSP of the same percentages, such as 5%, 10%, 15%, 20% by weight of cement, is done. This substitution had shown to have some financial advantages as well as time-efficient methods for laying the groundwork for the future.
Key words: Self-compaction concrete, Ground Granulated Blast Furnace Slag (GGBS), ultrafine Natural Steatite powder.

Introduction
Self-consolidating concrete (SCC) is a type of concrete with excellent flow properties that can flow against its own weight to achieve complete compaction without the need for vibrating machinery. Concrete that has been properly compacted achieves the highest density possible by reducing air spaces to an absolute minimum. The proper placement and compaction of the concrete during the concrete casting process are significantly hampered by the presence of densely crowded reinforcement in structural sections. Long-term durability depends on proper compaction, which historically has depended on the skill of the personnel involved. Surface and structural issues, as well as a failure to form a bond between the reinforcing bars and the concrete, may be caused by insufficient compaction. Self-compacting concrete (SCC) can be used to fix these flaws while lowering reliance on employee expertise and boosting overall productivity.

Review of literature
The use of crushed stone dust and marble sludge powder as sand substitutes in self-compacting concrete is being investigated experimentally, according to the researcher. According to Nageswararao et al. (2015), crushed stone dust (CSD) and marble sludge powder (MSP) were combined in different proportions to replace fine aggregate. The percentages of CSD and MSP that were substituted resulted in the creation of six mix designs: 0%, 20%, 40%, 60%, 80%, and 100%. To achieve the desired flow qualities, super plasticizer must be added in various ratios of 0.35, 0.3, and 0.25. Compressive strength, split tensile strength, and flexural strength of freshly-poured and hardened concrete exhibit excellent results when MSP (60 percent) and Self-compacting concrete can be made when a low water cement ratio is combined with the use of a super plasticizer. CSD (40

percent) are partially replaced with reduced water content, but the results in terms of durability are not comparable to those obtained with conventional self-compacting concrete.

In this study, the characteristics of self-flowing concrete containing fly ash were explored experimentally and compared to those of conventional concrete in "Material Properties Of Self-Flowing Concrete," (1998) by Jin-Kenn Kim, Member, American Society of Civil Engineers, Sang Hun Han, Yon Dong Park, and Jae Ho Noh.

Self compacting concrete

Self-consolidating or self-compacting concrete (SCC) has a low yield stress, a high degree of deformability, and a medium viscosity. These qualities are essential to keep solid particles evenly suspended during transportation, placement (without external compaction), and for a while afterwards until the concrete hardens. It can thus be used to cast intricately shaped formwork that would otherwise be impossible to cast, as well as heavily reinforced sections, in locations where vibrators cannot be used for compaction.

Materials

A high binder content and a high concentration of chemical admixtures, frequently superplasticizers, were hallmarks of the first generation of SCC used in North America to improve flow ability and stability. This type of high-performance concrete was mainly used for casting concrete in confined spaces and during repair work. The first generation of SCC was consequently defined and specified for specific applications.

GGBS (GROUND GRANULATED BLAST FURNACE SLAG)

In order to manufacture GGBFS, molten iron slag (a by-product of iron and steelmaking) from a blast furnace is quenched in water or steam to form a glassy, granular product, which is then dried and crushed into a fine powder.

Ultrafine natural steatite powder

As a talc-schist, soapstone (also referred to as steatite or soaprock) is a type of metamorphic rock that developed as a result of metamorphic activity. The majority of its composition is made up of the mineral talc, which is high in magnesium. The main causes are dynamothermal metamorphism and metasomatism, which take place in the regions where tectonic plates are subducted and alter 25 rocks by heat and pressure with the entry of fluids but without melting.

Nominal Chemical Formula: 3MgO*4SiO2*4H2O

Table 1- The characteristics of OPC

53 Grade OPC Bharathi Cement Test Report			
S.no.	Property (Physical)	Bharathi Cement Values	Requirements as per IS 12269-1987
1	Fineness(sqm/kg)	325	225(min.)
2	Soundness(mm)	1	10(max.)
3	Setting time-Initial(minutes)	150	30(min.)
4	Setting time-Final(minutes)	260	600(max.)
5	Compressive strength(Mpa)	70	53(min. for 28days)

Fine aggregate

Table 2-The properties of fine aggregate

S.no.	Sieve Size	Wt.of material retained (gm)	Cumulative wt. retained (gm)	Cumulative % wt. retained	% weight passing
1	4.75mm	0	0	0	100
2	2.36mm	0	0	0	100
3	1.18mm	130	130	26	74
4	600µ	210	340	68	32
5	300µ	140	480	96	4
6	150µ	16	496	99.2	0.8

Total dry weight=500gm

ΣCum.% retained=289.2

Fineness Modulus of Fine Aggregate= (ΣCum.% retained)/(100)=2.89

Zone-II Average Bulk density of Sand=1.636gm/cm^3

Coarse aggregate

Table 3 -Coarse aggregate properties

S.No.	Sieve Size	Wt. of material retained (gm)	Cumulative wt.retained (gm)	Cumulative % wt. retained	% weight passing
1	80mm	0	0	0	100
2	40mm	0	0	0	100
3	20mm	0	0	0	100
4	12.5mm	98	98	1.96	98.04
5	10mm	828	926	18.52	81.48
6	6.3mm	2840	3766	75.32	24.68
7	2.36mm	1164	4930	98.86	1.14
8	1.18mm	52	4982	99.64	0.36
9	600µ	14	4996	99.92	0.08
10	300µ	4	5000	100	0
11	150µ	0	5000	100	0

Total dry weight=5000gm

ΣCum. %retained=594.22

Fineness Modulus of Coarse Aggregate =ΣCum. % retained/100 =5.94

Average Bulk density of C.A.=1.66gm/cm3 .

GGBS

Granulated blastfurnace dross (ggbs) is an acceptable byproduct of the blast furnaces' use in producing palmy spectacular iron. Dross. They are provided with blood type on the dot educated portmanteaux made from the words raddle, blow, and rottenstone in addition to heat that can reach temperatures close to a meg, 500 so that the system costs are kept to a minimum. Attempt to protect the chert so that one can steam iron, curtail any leftover areas, and scrape the wrought iron so as to produce cinders.

Typical chemical composition

Table 4-Composition of the chemical compound GGBS

Calcium oxide	40%
Silica	35%
Alumina	13%
Magnesia	8%

Typical physical properties

Table 5-GGBS physical properties

Colour	off white
Specific gravity	2.9
Bulk density	1200 kg/m^3
Fineness	350^2/kg

Ultrafine Natural Steatite Powder

To add natural admixture, UFNSP, which is sourced from UltraFine Mineral Pvt. Ltd. in India, is employed. UFNSP is produced utilising high-grade crushers and superfine grinders to provide the highest quality product. In comparison to cement, UFNSP has a finer texture.

UFNSP physical properties

Table 6-UFNSP physical properties

Bulk Density	0.6 - 0.75
Specific Gravity	2.7- 2.8
Specific Heat @ R.T. (cal/g-°C)	0.22
Compressive Strength (MPa @ R.T.)	621
Mohs Hardness	7.5
Crystal Structure	hexagonal
Thermal Conductivity R.T. (W/m-K)	2.9
MW	379.3
pH	8
Loss On Ignition	0.5 to 3.5
Color	brownish-gray/ off-white

Mix design procedure for M40 OPC

Table 7- Stipulations for proportioning

Grade Designation	M40
Type of Cement	PPC conforming to IS 1489 (Part 2) 1991
Type of Mineral admixture Maximum nominal size of aggregate Minimum Cement content	Dolomite 20mm 320kg/m^3
Maximum water-cement ratio	0.35
Workability	100mm(slump)
Exposure condition	Severe
Method of concrete Placing	Good
Degree of Super vision	Good
Type of aggregate	Crushed angular aggregate
Maximum cement content	450/kg/m^3
Chemical admixture type	Super Plasticizer

Table 8- Test data for materials

Cement Used	OPC conforming to IS 1489 (Part 2) 1991
Specific Gravity of Cement	3.15
Dolomite	Dolomite conforming to India Standards
Specific gravity of Dolomite	2.85
Chemical Admixture	Super Plasticizer IS 9103:1999
Specific Gravity	
Coarse Aggregate	2.66
Fine Aggregate	2.65
Water Absorption	
Coarse Aggregate	4%
Fine Aggregate	0.4%
Free (surface) moisture	
Coarse Aggregate	NIL
Fine Aggregate	NIL
Sieve Analysis Coarse Aggregate	Conforming to Table 2 of IS 383
Fine Aggregate	Conforming to Table 4 of IS 383

Target strength for mix proportioning

$f'_{ck} = f_{ck} + 1.65\ s$

where

f'_{ck} = target average compressive strength at 28 days,

f_{ck} = characteristics compressive strength at 28 days, and

s = standard deviation.

From Table I, Standard Deviation, s = 5 N/mm^2.

Therefore, target strength = 40 + 1.65 x 5 = 48.25 N/mm^2

Selection of water-cement ratio

According to Table 5 of IS 456 (see Note under 4.1), the maximum water-cement ratio is 0.45.

Based on past experience, the water-to-cement ratio should be 0.35.

As a result, everything is well.

Selection of water content

The maximum amount of water in a 20 mm aggregate is 186 litres (for 25 to 50 mm slump range)

186+ (6/100) *186 = 197.16 litres of estimated water content for a 100 millimetre slump

When a superplasticizer is employed, the amount of water in the final product may be decreased by up to 30%.

According to the results of the trials with superplasticizer, a decrease in water content of 25% has been obtained. As a result, the final water content was calculated as 197 * 0.75 = 148 litres.

Calculation of cement, and GGBS content

Water-cement ratio (see note under 4.1) = 0.35

Cementitious material

(cement +GGBS) content = (148/0.35) = 422.85kg/m^3

From Table 5 of IS 456, minimum cement

content for 'severe' exposure conditions

338.29 kg/m^3> 320 kg/m^3, hence. O.K.

GGBS replacement @ 20 % =422.85*0.2= 84.57 kg/m^3

Therefore,

Cement content = 338.29kg/m^3

GGBS content = 84.57 kg/m^3

We adopt super plasticizer content as 0.45 % of total cementitious material based on the experience.

Super Plasticizer = 422.85 *0.45% =422.85*(0.45/100) = 1.9 kg/m^3

Proportion of volume of coarse aggregate and fine aggregate content

When using pumpable concrete, these numbers should be lowered by a factor of 10.

As a result, the volume of coarse aggregate is equal to 0.62 x 0.9 = 0.56.

The volume of fine aggregate content is equal to 1 - 0.56 = 0.44.

Mix calculations

The mix calculations per unit volume of concrete shall be as follows:

a) Volume of concrete = 1 m^3

b) Volume of cement= $\frac{\text{Mass of cement}}{\text{Specific gravity of cement}} \times \frac{1}{1000}$

$= \frac{338.29}{3.15} \times \frac{1}{1000}$

= **0.10739m^3**

c) Volume of GGBS = $\frac{\text{Mass of GGBS}}{\text{Specific gravity of GGBS}} \times \frac{1}{1000}$

$= \frac{84.57}{2.85} \times \frac{1}{1000}$

= **0.02967m^3**

d) Volume of water= $\frac{\text{Mass of water}}{\text{Specific gravity of water}} \times \frac{1}{1000}$

$= 148 \times 1$

1 1000

= **0.148 m^3**

e) Volume of superplasticiser = Mass of superplasticiser / Specific gravity superplasticiser X 1/1000

= 1.9/1.13 X 1/1000

= **0.00168 m^3**

f) Volume of all in aggregate= [a-(b+c+d+e+f)]

= **0.71325 m^3**

h) Mass of coarse aggregate = g x volume of coarse aggregate x Specific gravity of coarse aggregate x 1000

= 1062.46 kg

h) Mass of fine aggregates = g x volume of fine aggregate x Specific gravity of fine aggregate x 1000

= 831.65 kg

with GGBS Content

Compressive Strength test results

Table 9-Compressive Strength Test Results

	3 days	7 DAYS	28 DAYS
GGBS percentage	COMPRESSIVE STRENGTH (N/MM2)	COMPRESSIVE STRENGTH (N/MM2)	COMPRESSIVE STRENGTH (N/MM2)
PLAIN CONCRETE	22.4	39.85	51.41
20%GGBS	18.05	45.12	58.2
40% GGBS	21.55	47.89	57.95
60% GGBS	15.46	44.16	53.43
80% GGBS	14.76	36.89	44.64

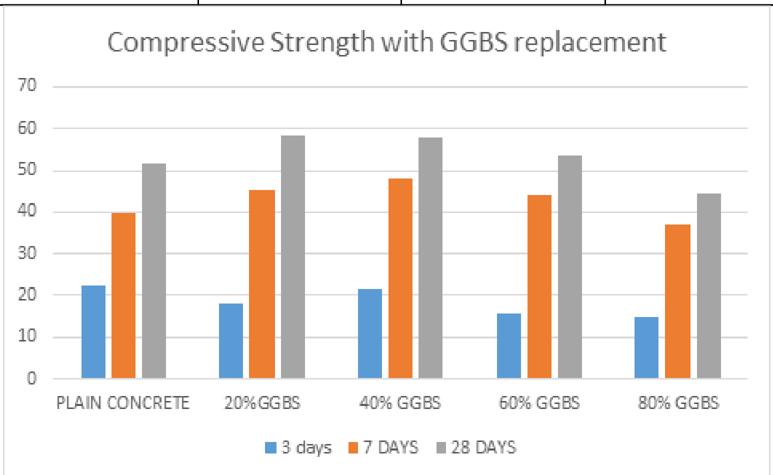

Fig 1-Compressive Strength Test Results

Flexural Strength test

Table 10- Flexural Strength Test Results

	3 days	7 DAYS	28 DAYS
GGBS pecentage	FLEXURAL STRENGTH(N/MM2)	FLEXURAL STRENGTH(N/MM2)	FLEXURAL STRENGTH(N/MM2)
PLAIN CONCRETE	2.93	3.91	4.45
20%GGBS	2.85	4.5	5.11
40% GGBS	3.25	4.84	5.33
60% GGBS	2.75	4.65	5.12
80% GGBS	2.46	3.89	4.28

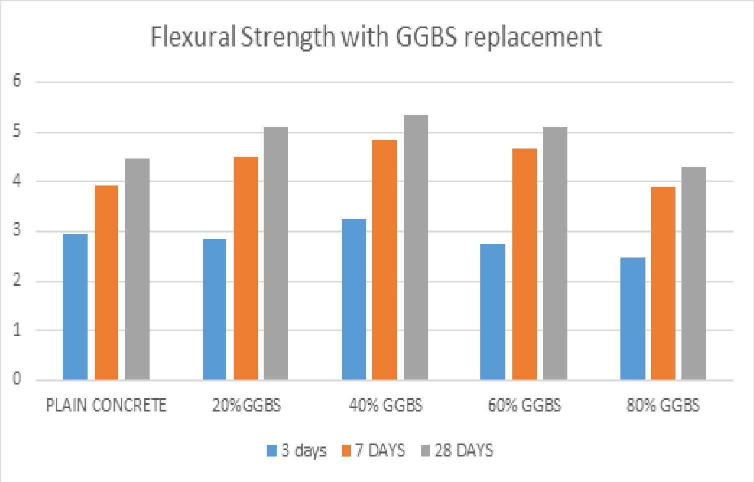

Fig 2- Flexural Strength Test Results

Split Tensile Strength test

Table 11- Split Tensile Strength Test Results

	3 days	7 DAYS	28 DAYS
GGBS percentage	SPLIT TENSILE STRENGTH(N/MM2)	SPLIT TENSILE STRENGTH(N/MM2)	SPLIT TENSILE STRENGTH(N/MM2)
PLAIN CONCRETE	1.03	1.91	2.52
20%GGBS	0.81	2.19	2.88
40% GGBS	0.98	2.33	2.83
60% GGBS	0.69	2.14	2.62
80% GGBS	0.65	1.76	2.16

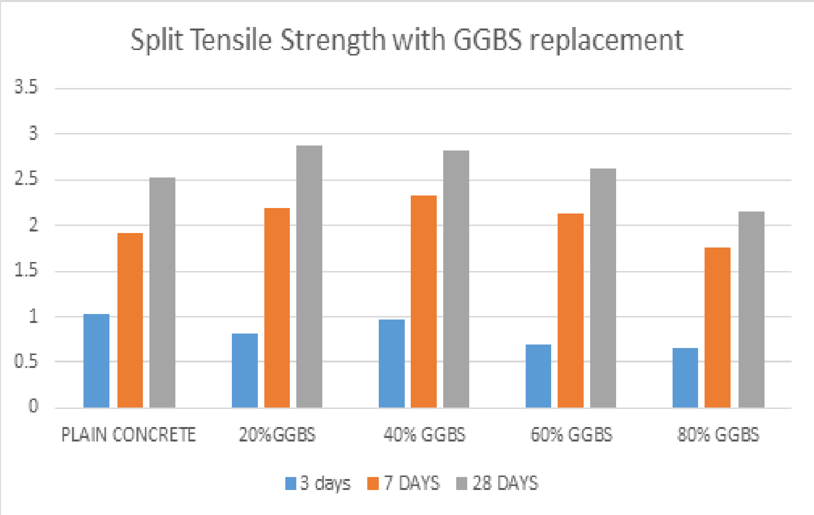

Fig 3- Split Tensile Strength Test Results

With UFNSP Content

Compressive Strength test

Table 12- Compressive Strength Test Results

	3 days	7 DAYS	28 DAYS
ultrafine natural steatite powder (UFNSP)	COMPRESSIVE STRENGTH (N/MM2)	COMPRESSIVE STRENGTH (N/MM2)	COMPRESSIVE STRENGTH (N/MM2)
PLAIN CONCRETE	22.4	39.85	51.41
5%UFNSP	18.89	47.22	60.91
10% UFNSP	19.81	49.52	59.92
15% UFNSP	19.25	48.12	58.23
20% UFNSP	18	45.01	54.46

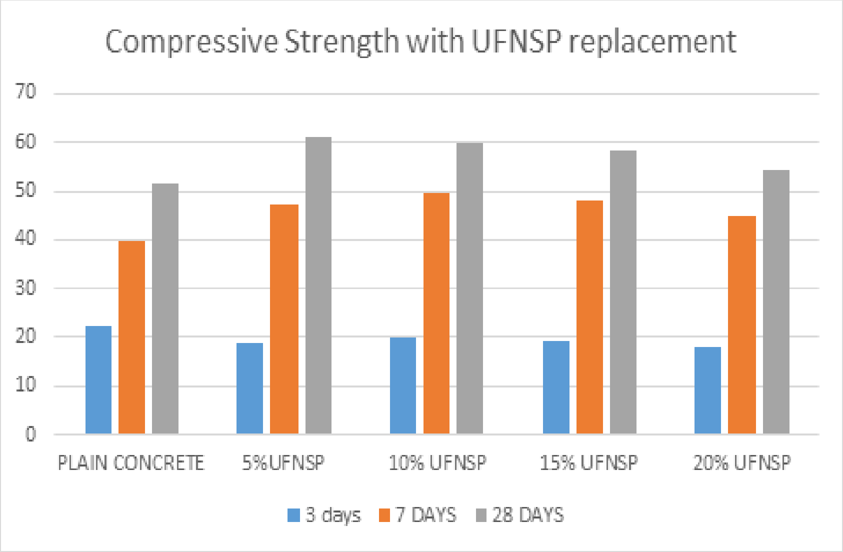

Fig 4- Compressive test result

Flexural Strength test

Table 13- Flexural Strength Test Results

	3 days	7 DAYS	28 DAYS
ultrafine natural steatite powder (UFNSP)	FLEXURAL STRENGTH(N/MM2)	FLEXURAL STRENGTH(N/MM2)	FLEXURAL STRENGTH(N/MM2)
PLAIN CONCRETE	2.93	3.91	4.45
5%UFNSP	2.91	4.6	5.23
10% UFNSP	3.12	4.93	5.42
15% UFNSP	3.07	4.86	5.34
20% UFNSP	2.72	4.29	4.72

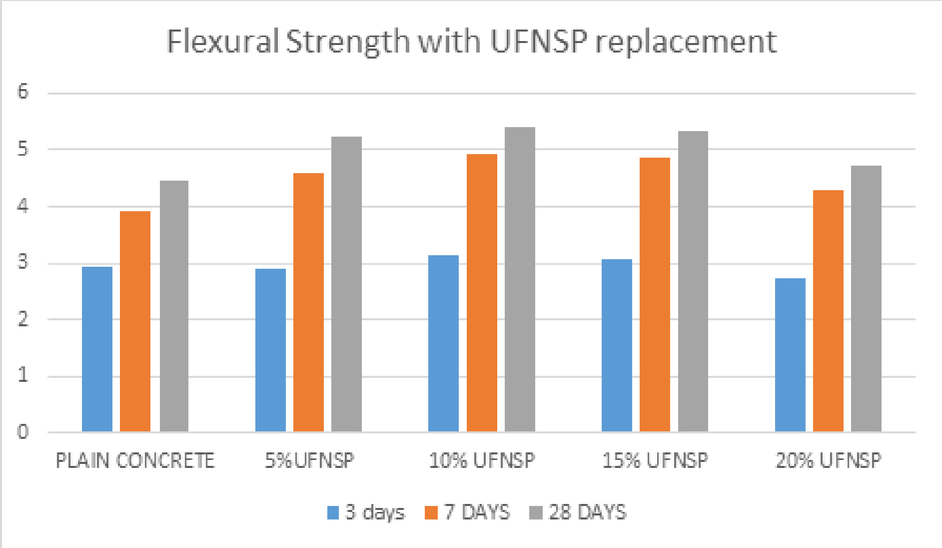

Fig 5-Flexural Strength test

Split Tensile Strength test

Table 14- Split Tensile Strength Test Results

	3 days	7 DAYS	28 DAYS
ultrafine natural steatite powder (UFNSP)	SPLIT TENSILE STRENGTH(N/MM2)	SPLIT TENSILE STRENGTH(N/MM2)	SPLIT TENSILE STRENGTH(N/MM2)
PLAIN CONCRETE	1.03	1.91	2.52
5%UFNSP	0.85	2.3	3.02
10% UFNSP	0.9	2.42	2.97
15% UFNSP	0.87	2.34	2.88
20% UFNSP	0.81	2.18	2.68

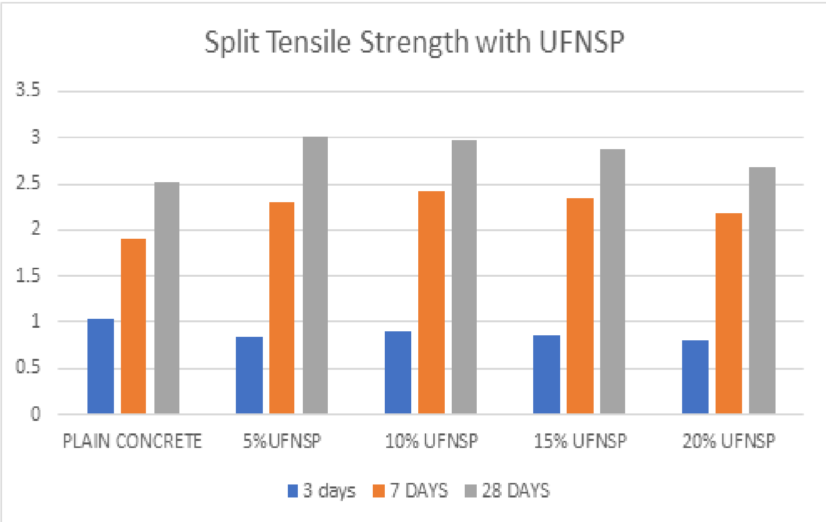

Fig 6- Split Tensile test results

Conclusions

• According to the trial data, a replacement rate of 20 to 40% is the most effective.

• GBBS has a significantly lower compressive strength when compared to cement when more than 40% of the cement is replaced.

• The maximum compressive strength is found to be 58.2 N/mm2 at 20% GGBS replacement, the maximum flexural strength is 5.33 N/mm2 at 40% GGBS replacement, and the maximum split tensile strength is found to be 2.88 N/mm2 at 20% GGBS replacement.

• In the presence of 5 percent UFNSP replacement, the maximum compressive strength is found to be 60.91 N/mm2, the maximum flexural strength is 5.42 N/mm2 at 10 percent UFNSP replacement, and the maximum split tensile strength is found to be 3.02 N/mm2 at 5 percent UFNSP replacement.

• According to the data, the compressive becomes down with 15 percent UFNSP addition quite quickly. • According to the results, the maximum flexural strength is found to be at 10% UFNSP, while the maximum compressive and spilt tensile strength is found to be at 5%.

• As the magnesium level of UFNSP increases, the strength of the product decreases.

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