An investigational Study on Strength Characteristics of Concrete in Rigid Pavements by Partial Replacement of Cement with GGBS

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Abstract

Roads transportation is definitely the life saver of the field and its improvement is a key test. The bituminous asphalts and their needs for long life upkeep and recovery operations are extremely impartment toward the degree for bond solid asphalts. There are many preferences of bond solid asphalts inspect to bituminous asphalts. This wander accentuates on somewhat supplanting bond by method for floor granulated blast furnace slag (ggbs) in rigid (concrete) pavements, because of the reality GGBS supplanted in concrete has a decent risen as a fundamental option texture to traditional cement and has rapidly drawn the solid business. It is keep's the bond, vitality and cost, natural and socio-monetary favorable circumstances. Thus, in this venture is in a matter of seconds energized by utilization of waste material of GGBS having establishing properties, when which can be presented in bond concrete as fractional option of concrete, and without trading off on its quality and toughness. As an approach to be impact in cut of bond substance material and mechanically decrease in discharging the green house gasses to natural as an aftereffect of compound responses in cement. In the meantime completely utilized waste substances. The GGBS is a waste item from the iron assembling undertaking, which could likewise be utilized as fractional substitute of bond in cement and GGBS has solidifying properties. This venture assesses the quality of solidified cement, by method for incompletely changing bond through GGBS at a considerable amount of rates for M20 review of cement at unique quite a while. For this endeavor get ready solid blocks, barrels and shafts are created of five fractional GGBS substitution proportions (0%, 10%, 20%, 30%, and 40%). The blocks, chambers and bars have been tried on the age of 7, 14 and 28 days with unfaltering water curing circumstance.

Keywords*: GGBS, Workability, Compressive quality, Split Tensile quality, Flexural quality*

I. INTRODUCTION

In a setting up country reminiscent of India, roads systems frame the veins of the country. Asphalt is the layered structure on which vehicles travel. It used to two things these are to outfit a casual and solid floor for vehicles, and to diminish weights on basic soils. Enormous areas like India overall bituminous asphalts are for the most part utilized. Locally on bond cement is a superior contrasting option to bitumen which is the through item in refining of imported petroleum unrefined. Petroleum and its by method for stock are damning day by day. At whatever point we think about of as a roads development in India it is taken as a correct that it may be bituminous asphalt and there are extremely occasional shots for contemplating of an option like solid asphalts. Inside a few decades bituminous asphalt can be a chronicled past and appropriately the requirement for an option might be extremely fundamental. As well as can be expected be Rigid Pavements, as it fulfills two of the greatly requested necessities of asphalt texture in India, economy and brought down contamination. It likewise has two or three distinct points of interest like longer ways of life, low upkeep value, fuel successfully, great driving top notch, enhanced load conveying limit and in penetrability to water over adaptable asphalts.

In the unbending asphalts locally accessible solid materials are utilized however now a day's an element of concrete likewise diminished every day, so it is an ideal opportunity to utilize elective materials in bond supplanted. Since everyday utilization of bond is high consequently the cost of concrete likewise high and when utilization of concrete solid some of an Earth-wide temperature boost gasses additionally discharged. To maintain a strategic distance from these sorts of things to include some of option materials or waste materials in bond cement to give a similar quality and it is best decision to utilize ecological poisons operators. There are number of non-recyclable substance on the planet. In that some of non-recyclable substances are

utilized as a part of solid blend fractional supplanted. Ground Granulated Blast heater Slag (GGBS) is a repercussion from the impact heaters used to make press. At the point when made iron at 1500 degrees centigrade and are bolstered with a mindfully controlled blend of iron mineral, coke and limestone. The iron metal is lessened to press and the rest of from a slag that buoys on high of the iron. This slag is intermittently tapped off as a liquid fluid and in the event that it is for use for the produce of GGBS it must be quickly extinguished in enormous volumes of water. In the nation like India, where the advancement of the frameworks projects, for example, substantial water system, roads and building activities are either being developed or in culmination of their arranging and configuration stage, Such makes utilization of waste material in bond cement is not going to handiest lower the outflow of greenhouse gasses yet also would be the feasible method for organization of waste. The supplanting of Portland concrete with GGBS will prompt to a monster decrease of carbon dioxide gas emanation. GGBS is thus an ecologically benevolent advancement material. It might be utilized to trade as to such an extent as 70% of the Portland bond when used in cement. GGBS concrete has higher water in penetrability attributes and in addition enhanced imperviousness to consumption and sulfate assault. Consequently, the administration life of a structure is more prominent and the remodel rate lessened. High volume of GGBS in substitution of bond in cement is on one of the eco-accommodating substitution slag and uses the modern squanders to spares huge normal assets and vitality.

A. Ground-Granulated Blast-Furnace Slag (GGBS)

Ground-granulated impact heater slag (GGBS or GGBFS) is gotten with the guide of extinguishing liquid iron slag (a by method for made of iron and metal-production) from an impact heater in water or steam, to supply a shiny, granular item that is then dried and floor directly into an incredible powder. To get a brilliant slag reactivity or hydaulricity, the slag diminish yearnings to be rapidly cooled or extinguished beneath 800 °C to have the capacity to block the crystallization of merwinite and melilite. To cool and section the slag a granulation approach can likewise be connected in which liquid slag is subjected to fly floods of water or air underneath strain. On the other hand, in the pillarization procedure the fluid slag is to a limited extent cooled with water and in this manner anticipated into the air through a turning drum.

II. PROPOSED METHOD

The review entitled "A test think about on quality on attributes of cement in inflexible asphalts by fractional supplanting of bond with GGBS" - An examination of constrain attributes of cement is done by method for taking after the procedure given underneath.

- ✓ M 20 traditional control blend is set up with consolidate extents as 1:1.52:3.02.
- ✓ Within the following stage zero% of bond is changed with GGBS and every single set shape, barrels and shafts.
- ✓ Similarly the bond is supplanted with GGBS with rates as much as 40% at an interim of 10%.
- ✓ All these threw solid shapes, chambers and bars are cured for 7, 14 and 28 days and are tried to discover the compressive quality, spilt rigidity and flexural quality for these individual days.

The Overall Work In A Glance Is Provided Below: In accomplishing the target of the work, the following procedural strides are taken after.

- ✓ Mix Design
- ✓ Batching
- ✓ Mixing
- ✓ Casting of molds
- ✓ Compaction
- ✓ Curing
- ✓ Testing

A. M20 Concrete Mix Design:

Configuration jogged on BIS empowered instructional materials for blend plan according to SP: 23-1982-BIS Publications.

1) Design Mix Test Data As Per (Is: 10262-1982)

a) Design Stipulations

- Characteristic compressive quality @ 28 days: 20 Mpa
- Max size of total : 20 mm (rakish)
- Degree of workability: 0.906 (compaction figure)
- Degree of value control : Good
- 5) Type of introduction : Mild

Test information for materials

- Particular gravity of concrete : 2.99
- 2. Particular gravity of fine aggregate : 2.56
- 3. Particular gravity of coarse aggregate : 2.67

b) Target Mean Strength of Concrete:

The objective mean compressive quality for the predefined trademark 3D shape quality = 20+ (1.65*4) =26.6Mpa.

c) Selection of Water – Cement Proportion:

From connection between free water-bond proportion and solid quality for stand-out concrete qualities, the Water/Cement proportion required for the objective infer constrain of 26.6Mpa is = 0.50. This is lower than greatest estimation of 0.55prescribed for "mellow" presentation in light of workability.

In this way, W/C = 0.50 <0.55 thus alright

For 20 mm Max Size of total, air content = 2 % (from IS: 10262-1982).

d) D. Selection of Water and Sand Content:

For M20 Grade concrete, for 20 mm Max. Measurement of blend and sand adjusting to evaluating Zone-1, water content material per cubic meter of cement = 186 kg and sand content as % of finish blend through supreme amount = 35%. For exchange in cost in water-bond proportion compacting segment and for sand having a place with Zone-1, the following conformities are required.

Table 2.1.1.A: Selection of Water and Sand Content

Change in condition	Adjustments Required	
	Water content (%)	% Sand in total Aggregate
For decreasing water cement ratio of (0.55-0.5)=0.05	0	-2.0
For increase in compacting factor (0.906)	+3.0	0
For sand conforming to zone 1 of table 4, IS 383-1970	0	+1.5%
Total	+3%	-0.5%

The required sand content as % of aggregate total by total volume = (35-0.5) =34.5% required water content = [185+3% of (185)] = 186+5.58 = 191.6 lit/m3 .

e) Determination of Concrete Substance:

Embracing water – bond proportion = 0.50, Water = 191.6litters

Concrete =191.6/0.50 = 383 kg/m3< 550 kg/m3 (Max. bond content)

Embracing bond content = 383 kg/m3

f) F. Determination of Coarse and Fine Total Substance:

The Specified Maximum Size of Aggregate of 20 mm, the measure of captured air in the wet cement is 2 % considering and applying conditions,

V = [W+C/S_c +1/P F_a/S_fa]X 1/1000 0.98= [191.6+ (383/3.15) + {(1/0.345) *(fa/2.56)}] (1/1000)

Fa= 584.55 kg/m3 say 585 kg/m3

Ca = {(1-0.345)/0.345}*585*(2.67/2.56) = 1158.37 kg/m3 say 1158 kg/m3

The Mix Proportion then gets to be

Table 2.1.1.B Details of Mix Design

Description	Water	Cement	Fine aggregate	Coarse aggregate
Weight	191.6	383	585	1158
Mix proportion	0.50	1	1.52	3.02

Actual qualities required for the Mix per cubic meter of concrete

- ✓ Cement = 383 kg
- ✓ Sand = 585 kg
- ✓ Coarse Aggregate = 1158 kg
- ✓ Water = 191.6 lit

B. Batching

There are two sorts clustering is there. Be that as it may, in present venture we are utilized weight clumping as it were.

1) Weigh Batching

Measure clumping is the correct methodology of measuring the substances on this venture. Usually for cement constantly weight clustering approach embraced. Utilization of weight process in grouping, permits exactness, adaptability and straightforwardness. Stand-out assortments of measure batchers are close by, the unmistakable assortment to be utilized, is needy upon the character of the occupation. Weigh clumping vegetation have programmed measuring hardware. The utilization of this programmed intend for bunching is viewed as one of modernity and requires confirmed and gifted designers. On this, further confusion will come to manage water substance to provide food for the dampness content material in the total. On colossal work sites, the measure can assortment of measuring types of gear is utilized. This encouraged from a colossal overhead stockpiling container and it releases with the guide of gravity, straight into the blender. The weighing is done through a lever-arm strategy and two interlinked shafts and move weights. The required scope of say, coarse blend is weighed, having best the psychologist shaft in operation. Subsequent to adjusting, with the guide of turning the littler lever, to one side of the pillar, the two bars are interlinked and the uncommon blend is brought until them for steadiness. The last dependability is shown by method for the pointer on the scale to the correct of the pillars. Release is through the swivel entryway at the base. Programmed clustering plants are accessible in little or huge limit. In this, the administrator has just to press maybe a couple catches to put into movement the weighing of all the distinctive materials, the stream of each being cut off when the right weight is come to. In their most progressive structures, programmed plants are electrically worked on a punched card framework. This sort of plant is especially reasonable for the

generation of prepared blended cement in which extremely visit changes in blend extent must be made to meet the fluctuating necessities of various clients.
Total measuring machines require standard consideration on the off chance that they are to keep up their precision. Research adjustments should persistently be made by method for including weights in the container equivalent to the full weight of the mix inside the cluster. The mistake watched is balanced once in a while.

In little occupations, concrete is frequently not measured; it is included sacks expecting the heaviness of the pack as 50 kg. In all actuality, however the concrete pack is made of 50 kg. At the manufacturing plant, because of transpiration, taking care of at various spots, it loses some concrete, especially, when jute sacks are utilized. Really, the weight of a concrete pack on the site online is generously a great deal less. Over and over, the absence of weight gets to be distinctly more noteworthy than 5 kg. This is likely one of the wellsprings of mistake in amount grouping and in like manner in weigh bunching, when the bond isn't genuinely weighed. In any case, in premier principal cementing employments, bond can be in actuality weighed and the particular extent as planned is kept up.
NOTE: In this endeavor I'm making utilization of weight clustering approach for the reason that of its low time take weight of GGBS that is the reason I'm going adopt weight bunching strategies.

Table 2.2.2 Quantities of Materials Used In Concrete

% of GGBS replacing in cement	Water (lit)	Cement (kg)	Sand (kg)	coarse aggregate (kg)	GGBS (kg)
0%	191.6	383	585	1158	0
10%	191.6	344.7	585	1158	38.3
20%	191.6	306.4	585	1158	76.6
30%	191.6	268.1	585	1158	114.9
40%	191.6	229.8	585	1158	153.2

C. Mixing

Blending must be refined over an impenetrable floor. Spread out the deliberate segments of coarse blend and best total in interchange layers. The solid might be mixed either by utilizing hand or as a part of an appropriate research center blender in clumps of one of these sizes as to leave around 10% overabundance in the wake of trim output example. The totals should be blended completely to get a high phenomenal cement.

1) Hand Mixing

The fixings are blend in a water –tight, spotless, moist metal dish with a trowel or a scoop.
The accompanying strategy might be embraced,

- ✓ Combine the bond and fine total together in a dry state with the exception of they are entirely mixed.
- ✓ Add the coarse total and blending the entire clump unless the coarse total is consistently appropriate through the bunch.
- ✓ Add the water and keep blending until plastic cement is of uniform shading and of favored consistency.

D. Casting of Cubes, Cylinders and Beams

The solid 3D shapes and chambers had been good to go to test the compressive quality and split rigidity of cement. For the arrangement of 3D squares and barrels, metal molds steel or cast iron is utilized. These molds must be of abundant thick to confine contortion. These molds are made in such a technique to encourage the expulsion of formed example without damage. Each form is furnished with a base plate having a plane surface. The base plate has radiant measurements to help the buildup for the time of the filling without spillage and it is in a perfect world associated with the form with the guide of screws. The inside floor of the shape is meagerly fixed with oil to block attachment of cement. At last these arrangements, then the solid is situated inside the form.

E. Compaction:

Ensure that the adequate compaction is finished by method for packing the solid with the packing pole. Deficient compaction can prompt to the low workable cement and this makes the solid unforgiving. Because of misleading compaction voids could likewise be unnecessary fundamental to the peculation of water and affect the strength of solid so the correct compaction ought to be refined by means of making utilization of hand compaction and mechanical compaction. Mechanical compaction may likewise be accomplished through utilizing work area vibrator. Sufficiently after compaction, discard the surplus cement through utilizing travel. Check the solid 3D shapes for reference. At that point allow these 3D squares for an interim of 24hrs without dampness misfortune. At that point keep up these 3D squares in water for curing plan.

F. Curing

Curing can be portrayed as saving the solid clammy and worm sufficient so that the hydration of bond can proceed in the ideal temperature in cement amid the interim immediately taking after the position, seeing that to finish hydration of concrete with the exception of the wanted houses are created to an adequate degree to fulfill necessity of administration. Curing is being given an area of expanding significance in light of the fact that the interest for prime fine

cement is expanding. It has been perceived that the outstanding of cement proposes all round development with productive continuous curing. On the off chance that curing is ignored in early interim of hydration, the lovely of solid will mastery a sort of unsalvageable misfortune. A proficient curing in the early time of hydration will likewise be contrasted with a decent and empowering bolstering given to a fresh out of the box new conceived minimal one.

Table 2.6: Number of Specimens

Percentage	Age/Days	Compressive strength	Split tensile Strength	Flexural strength
		Cubes	Cylinders	Beams
0%	7	3	3	3
	14	3	3	3
	28	3	3	3
10%	7	3	3	3
	14	3	3	3
	28	3	3	3
20%	7	3	3	3
	14	3	3	3
	28	3	3	3
30%	7	3	3	3
	14	3	3	3
	28	3	3	3
40%	7	3	3	3
	14	3	3	3
	28	3	3	3
Total		45	45	45
Grand Total		135		

G. Testing of Concrete:

1) Compressive Strength

Compressive quality of cement is most remark test to lead on grouped cement. Because of the way that fantastic properties of cement and subjectively concerning its compressive quality.

The compressive quality is done on an example cubical or barrel shaped in frame. Crystal can be routinely utilized; be that as it may it isn't for quite some time built up in our nation. Regularly the compressive quality of cement is dictated by making utilization of constituents of a shaft built up in flexure. The end components of pillar are left in place after disappointment in flexure and in view that the shaft is for the most part of rectangular move area, this a some portion of bar would be utilized to find the compressive quality.

The shape example is of 15×15×15cm. In the event that the greatest ostensible size of the blend does now not surpass 20 mm estimation solid shapes can likewise be utilized as substitution.

Compressive quality = stack/zone n/mm2

2) Tensile Test:

Elasticity is a most vital property of solid when you consider that solid developments are high. Be that as it may, elasticity is lessening than compressive quality. In view of impediment in applying uniaxial nervousness to a solid example the rigidity of a solid relies on upon these two tests

- ✓ Split tractable test.
- ✓ Flexure test.

a) Split Tensile Test

It is the conventional analysis, to evaluate the rigidity of cement in a circuitous technique this test would be completed by: 5816-1970.

An ordinary investigation chamber of solid example (300mmX150mm measurement) is put on a level plane between the stacking surfaces of pressure testing machine. The pressure load is used oppositely and consistently along the extent of barrel until the disappointment of the chamber along the vertical distance across. Solid chambers separate into two parts close by this vertical plane as a result of slanted tractable anxiety created through Poisson's impact.

Because of this compressive stacking, a component lying close by the vertical width of the barrel is subjected to a vertical compressive anxiety and a level anxiety the stacking stipulations delivers a high compressive anxiety right away underneath the stacking aspects. It's assessed that the compressive anxiety is performing for around 1/6 profundity and the rest of the 5/6 profundity is subjected to strain due to Poisson's impact.

Uniform parallel malleable anxiety is Ft then it can be ascertained from

$Ft=2P/\pi DL$ n/mm2

P = Compressive load at disappointment, L = Length of barrel, D = Diameter of Cylinder

The above test outcomes speaks to "split elasticity" of solid that more than a couple between 1/8 and 1/12 of the 3D square compressive quality.

b) Flexure Test

After the Splitting tractable analysis one other unique examination performed for determination of rigidity is flexure quality. The test would be performed in view of according to BS 1881: stage 118:1983. A basic certain solid bar is stacked at one – third traverse features. Basic typical measurement of example is 150X150X750mm. Measure up to hundreds are connected at the separation of 1/3 from each of the pillar bolsters. It instigates approach reaction same in light of the fact that the stacking at each of makes a difference. From the above stacking arrangement obviously the center one-1/3 partition, in the middle of two loadings, bar is subjected to immaculate bowing. No shear drive is incited inside this bit. It is this segment of bar where greatest immaculate bowing

snapshot of Pd/2 is provoked joined by utilizing zero shear drive.
Flexural quality is Fbt then
Fbt = Pl/(b*d*d)n/mm2
P = Load at disappointment,
L = Beam traverse between backings,
d = Depth of bar,
b = Width of bar,
fbt = Modulus of break.

III. RESULT AND DISCUSSION

Headquartered on the experimental investigations, the results of cubes are awarded beneath

A. Tests on Concrete Cubes for Compressive Strength

The outcomes of cubes are provided below:

Table 3.1.1:- 0% of GGBS Replaced With Cement in Concrete Cubes for Compressive Strength

No. of days	cube numbers	load in KN	compressive strength in N/mm²	Avg. compressive strength in N/mm²
7	1	430	19.11	18.81
	2	410	18.22	
	3	430	19.11	
14	1	460	20.44	20.29
	2	440	19.55	
	3	470	20.88	
28	1	590	26.22	26.96
	2	610	27.11	
	3	620	27.55	

The average compressive strength for 7 days ,14 days and 28 days = 18.81 N/mm2,20.29 N/mm2 and 26.96 N/mm2

Table 3.1.2:-10% of GGBS Replaced With Cement in Concrete Cubes for Compressive Strength

No. of days	cube numbers	load in KN	compressive strength in N/mm²	Avg. compressive strength in N/mm²
7	1	420	18.66	18.96
	2	430	19.11	
	3	430	19.11	
14	1	480	21.33	21.33
	2	490	21.77	
	3	470	20.88	
28	1	620	27.55	28.29
	2	640	28.44	
	3	650	28.88	

The average compressive strength for 7 days ,14 days and 28 days = 18.96 N/mm2,21.33 N/mm2 and 28.29 N/mm2

Table 3.1.3:- 20% of GGBS Replaced With Cement in Concrete Cubes for Compressive Strength

No. of days	cube numbers	load in KN	compressive strength in N/mm²	Avg. compressive strength in N/mm²
7	1	440	19.55	19.70
	2	440	19.55	
	3	450	20.00	
14	1	500	22.22	22.36
	2	510	26.66	
	3	500	22.22	
28	1	680	30.22	30.81
	2	700	31.11	
	3	700	31.11	

The average compressive strength for 7 days =19.70 N/mm2
The average compressive strength for 14 days = 22.36 N/mm2
The average compressive strength for 28 days = 30.8 N/mm2

Table 3.1.4:- 30% of GGBS Replaced With Cement in Concrete Cubes for Compressive Strength

No. of days	cube numbers	load in KN	compressive strength in N/mm²	Avg. compressive strength in N/mm²
7	1	460	20.44	20.29
	2	450	20.00	
	3	460	20.44	
14	1	510	22.66	22.96
	2	520	23.11	
	3	520	23.11	
28	1	720	32.00	32.15
	2	730	32.44	
	3	720	32.00	

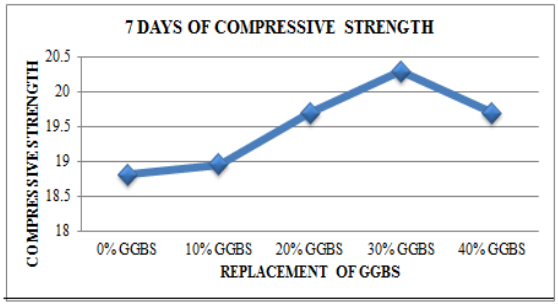
The average compressive strength for 7 days ,14 days and 28 days = 20.29 N/mm2,22.96 N/mm2 and 32.15 N/mm2

Table 3.1.5:- 40% of GGBS Replaced With Cement in Concrete Cubes for Compressive Strength

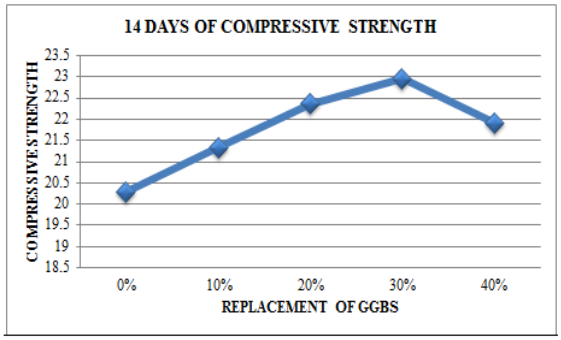
No. of days	cube numbers	load in KN	compressive strength in N/mm²	Avg. compressive strength in N/mm²
7	1	450	20.00	19.70
	2	440	19.55	
	3	440	19.55	
14	1	480	21.33	21.72
	2	510	22.66	
	3	490	21.77	
28	1	690	30.66	31.11
	2	700	31.11	
	3	710	31.55	

The average compressive strength for 7 days ,14 days and 28 days = 19.70 N/mm2,21.72 N/mm2 and 31.11 N/mm2

Graph 3.1.1: Compressive Strength at the Age of 7 Days



Graph 3.1.2: Compressive Strength at the Age of 14 Days



Graph 3.1.3: Compressive Strength at the age of 28 Days

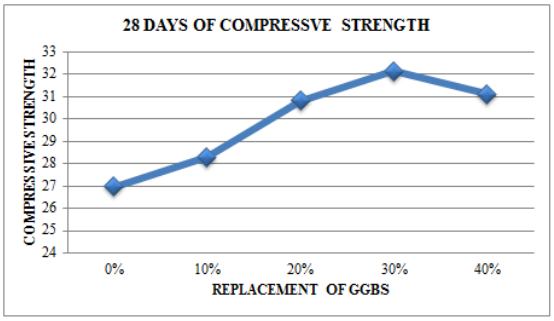
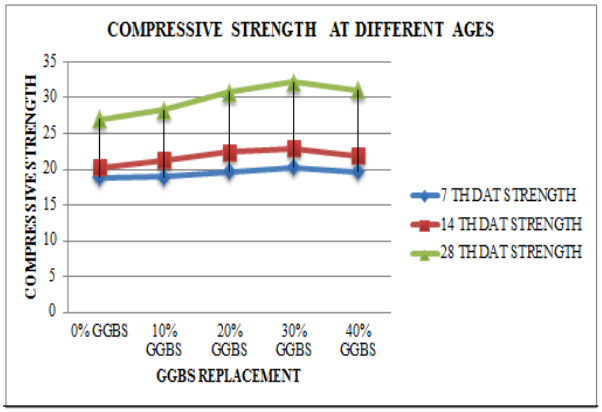


Table 3.1.6: Compressive Strength at Different Ages

% of GGBS replaced	7 of average compressive strength in N/mm²	14 of average compressive strength in N/mm²	28 of average compressive strength in N/mm²
0%	18.81	20.29	26.96
10%	18.96	21.33	28.29
20%	19.70	22.36	30.81
30%	20.29	22.96	32.15
40%	19.70	21.72	31.11

Graph 3.1.4: Compressive Strength at Different Ages



B. Tests on Concrete Cylinders for Split Tensile Strength

The results of cylinders are provided under:

Table 3.2.1: 0% of GGBS Replaced With Cement in Concrete Cylinders for Split Tensile Strength

No. of days	cylinders numbers	load in KN	split tensile strength in N/mm²	Avg. split tensile strength in N/mm²
7	1	140	1.98	1.96
	2	135	1.91	
	3	140	1.98	
14	1	165	2.33	2.40
	2	175	2.48	
	3	170	2.40	
28	1	190	2.69	2.71
	2	195	2.62	
	3	200	2.83	

The average compressive strength for 7 days ,14 days and 28 days = 1.96 N/mm2,2.40 N/mm2and 2.71 N/mm2

Table 3.2.2:- 10% of GGBS Replaced With Cement in Concrete Cylinders for Split Tensile Strength

No. of days	cylinders numbers	load in KN	split tensile strength in N/mm²	Avg. split tensile strength in N/mm²
7	1	155	2.19	2.17
	2	145	2.05	
	3	160	2.26	
14	1	175	2.48	2.48
	2	180	2.55	
	3	170	2.40	
28	1	200	2.83	2.88
	2	205	2.90	
	3	205	2.90	

The average compressive strength for 7 days ,14 days and 28 days = 2.17 N/mm2,2.48 N/mm2and 2.88 N/mm2

Table 3.2.3:- 20% of GGBS Replaced With Cement in Concrete Cylinders for Split Tensile Strength

No. of days	cylinders numbers	load in KN	split tensile strength in N/mm²	Avg. split tensile strength in N/mm²
7	1	175	2.48	2.40
	2	165	2.33	
	3	170	2.40	
14	1	190	2.69	2.66
	2	190	2.69	
	3	185	2.62	
28	1	215	3.04	3.02
	2	210	2.97	
	3	215	3.04	

The average compressive strength for 7 days ,14 days and 28 days = 2.40 N/mm2,2.66 N/mm2 and 3.02 N/mm2

Table 3.2.4- 30% of GGBS Replaced With Cement in Concrete Cylinders for Split Tensile Strength

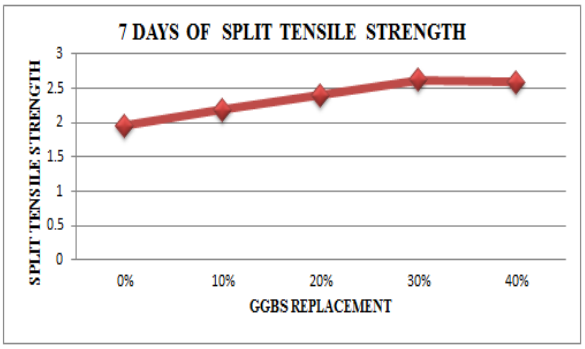
No. of days	cylinders numbers	load in KN	split tensile strength in N/mm²	Avg. split tensile strength in N/mm²
7	1	190	2.69	2.62
	2	180	2.55	
	3	185	2.62	
14	1	195	2.76	2.73
	2	195	2.79	
	3	190	2.69	
28	1	230	3.25	3.21
	2	220	3.11	
	3	230	3.25	

The average compressive strength for 7 days ,14 days and 28 days = 2.62 N/mm2,2.74 N/mm2 and 3.21 N/mm2

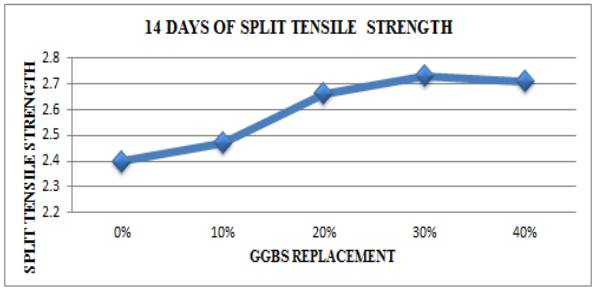
Table 3.2.5:- 40% of GGBS Replaced With Cement in Concrete Cylinders for Split Tensile Strength

No. of days	cylinders numbers	load in KN	split tensile strength in N/mm²	Avg. split tensile strength in N/mm²
7	1	185	2.62	2.59
	2	185	2.62	
	3	180	2.55	
14	1	190	2.69	2.71
	2	195	2.76	
	3	190	2.69	
28	1	210	2.97	2.95
	2	205	2.90	
	3	210	2.97	

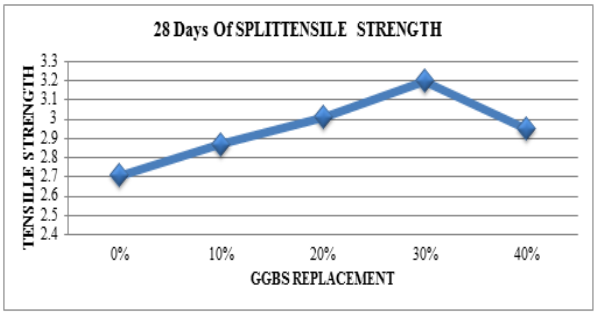
The average compressive strength for 7 days ,14 days and 28 days = 2.59 N/mm2,2.71 N/mm2and 2.95 N/mm2



Graph 3.2.1: Split Tensile Strength at the Age of 7 Days



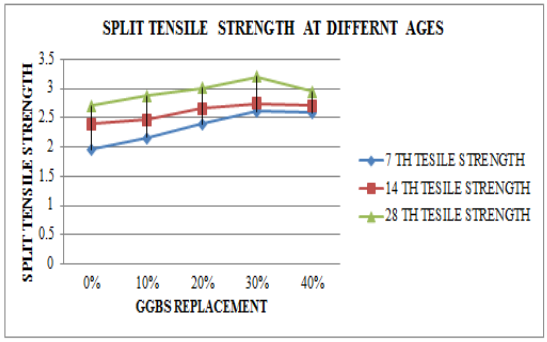
Graph 3.2.2: Split Tensile Strength at the Age of 14 Days



Graph 3.2.3: Split Tensile Strength at the Age of 28 Days

Table 3.2.6 Split Tensile Strength of Cylinders at Different Ages

% of GGBS replaced	7 of avg split tensile strength in N/mm²	14 of avg split tensile strength in N/mm²	28 of avg split tensile strength in N/mm²
0%	1.96	2.40	2.71
10%	2.17	2.48	2.88
20%	2.40	2.66	3.02
30%	2.62	2.73	3.21
40%	2.59	2.71	2.95



Graph 3.2.4: Split Tensile Strength of Cylinders at Different Ages

C. Tests on Concrete Beams ror Flexural Strength

The results of beams are presented under:

Table 3.3.1: 0% of GGBS Replaced With Cement in Concrete Beams for Flexural Strength

No. of days	beam numbers	load in KN	flexural strength in N/mm²	Avg. flexural strength in N/mm²
7	1	13.0	2.88	2.93
	2	13.2	2.93	
	3	13.5	3.00	
14	1	14.8	3.28	3.37
	2	15.3	3.40	
	3	15.5	3.44	
28	1	18.4	4.08	4.17
	2	19.1	4.24	
	3	18.9	4.20	

The average compressive strength for 7 days, 14 days and 28 days = 2.93 N/mm2, 4.17 N/mm2and 2.95 N/mm2

Table: 3.3.2: 10% of GGBS Replaced With Cement in Concrete Beam for Flexural Strength

No. of days	beam numbers	load in KN	flexural strength in N/mm²	Avg. flexural strength in N/mm²
7	1	16.4	3.64	3.55
	2	15.9	3.53	
	3	15.7	3.48	
14	1	17.3	3.84	3.81
	2	17.1	3.80	
	3	17.1	3.80	
28	1	19.8	4.40	4.47
	2	20.4	4.53	
	3	20.2	4.48	

The average flexural strength for 7 days,14 days and 28 days = 3.55 ,3.81 N/mm2 and 4.47 N/mm2

Table: 3.3.3: 20% of GGBS Replaced With Cement in Concrete Beam for Flexural Strength

No. of days	beam numbers	load in KN	flexural strength in N/mm²	Avg. flexural strength in N/mm²
7	1	17.7	3.93	3.93
	2	17.5	3.88	
	3	18.0	4.00	
14	1	18.9	4.20	4.27
	2	19.3	4.28	
	3	19.5	4.33	
28	1	22.5	5.00	5.00
	2	22.9	5.08	
	3	22.2	4.93	

The average flexural strength for 7 days,14 days and 28 days = 3.93 N/mm2,4.27 N/mm2 and 5.00 N/mm2

Table: 3.3.4: 30% of GGBS Replaced With Cement in Concrete Beam for Flexural Strength

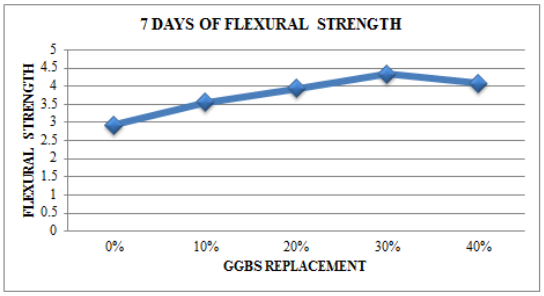
No. of days	beam numbers	load in KN	flexural strength in N/mm²	Avg. flexural strength in N/mm²
7	1	19.5	4.33	4.33
	2	19.8	4.40	
	3	19.3	4.28	
14	1	20.9	4.64	4.65
	2	20.7	4.60	
	3	21.3	4.73	
28	1	24.7	5.48	5.50
	2	25.2	5.60	
	3	24.5	5.44	

The average flexural strength for 7 days,14 days and 28 days = 4.33 N/mm2 ,4.65 N/mm2 and 5.50 N/mm2

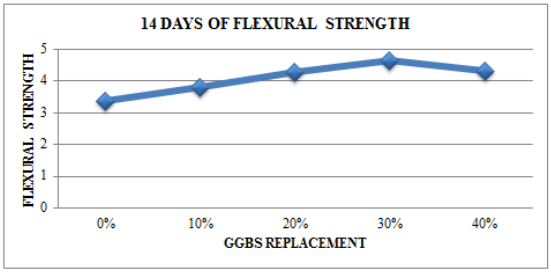
Table: 3.3.5: 40% of GGBS Replaced With Cement in Concrete Beam for Flexural Strength

No. of days	beam numbers	load in KN	flexural strength in N/mm²	Avg. flexural strength in N/mm²
7	1	18.4	4.08	4.08
	2	18.6	4.13	
	3	18.2	4.04	
14	1	19.8	4.40	4.32
	2	19.3	4.28	
	3	19.3	4.28	
28	1	22.5	5.00	5.02
	2	22.7	5.04	
	3	22.7	5.04	

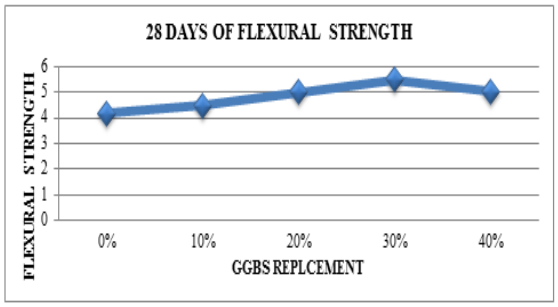
The average flexural strength for 7 days,14 days and 28 days = 4.15N/mm2,4.32N/mm2 and 5.02N/mm2



Graph 3.3.1: Flexural Strength of Concrete Beam at the Age of 7 Days



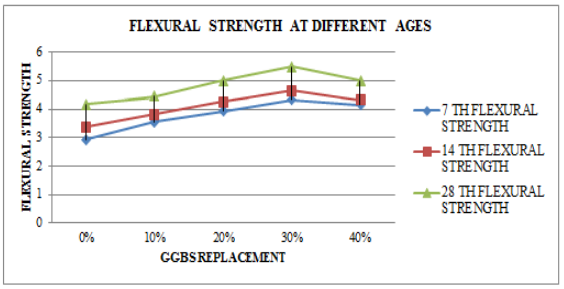
Graph 3.3.2: Flexural Strength of Concrete Beam at the Age of 14 Days



Graph 3.3.3: Flexural Strength of Concrete Beam at the Age of 28 Days

Table 3.3.6: Flexural Strength of Concrete Beam at Different Ages

% of GGBS replaced	7 of average flexural strength in N/mm²	14 of average flexural strength in N/mm²	28 of average flexural strength in N/mm²
0%	2.93	3.37	4.17
10%	3.55	3.81	4.47
20%	3.93	4.27	5.00
30%	4.33	4.65	5.50
40%	4.08	4.32	5.02



Graph 3.3.4: Flexural Strength of Concrete Beam at Different Ages

IV. CONCLUSION

Based on the analysis of experimental results and discussion, there upon the following conclusion With the increase in GGBS replacement level the degree of workability of concrete is increased. It's suitable for rigid pavements. The compressive strength of concrete multiplied when cement is changed through GGBS for M_{20} grade of concrete. At 30% substitute of cement by using GGBS the concrete attained highest compressive strength 32.15 N/mm^2 for M_{20} grade of concrete. The split tensile strength of concrete is accelerated when cement is replaced with GGBS for M_{20} grade of concrete. The break up tensile force is maximum carried out at 30% of replacement. The highest cut up tensile force at 30% of GGBS replacement is 3.20 N/mm^2 for M_{20} grade of concrete. The flexural strength of concrete is also accelerated when the cement is replaced through GGBS for M_{20} grade of concrete. At 30% replacement the flexural strength is maximum and the highest worth of flexural strength at 30% of GGBS substitute is 5.50 N/mm^2 for M_{20} grade of concrete.

From the above experimental outcome, it's proved that GGBS can be utilized rather fabric for cement, lowering cement consumption and decreasing the cost of construction in the rigid pavements. In step with experimental results, GGBS replaced cement in concrete and in addition utilized in rigid pavements for any sort of lading stipulations.

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