Partial Replacement of Fine Aggregate in Rigid Pavement with Brick Dust and GGBS

[1]Pesingi Chaitanya Kumar, [2]G Mohana Rao, [3]PMS Satish Kumar, [4]M Udaya Sri

[1]PG Student, [2,4]Assistant Professor, [3]Head of the Department
Civil Engineering Department
Sanketika Institute of Technology and Management, Visakhapatnam, India

Abstract: **Now a day's world is facing a lack of excellence construction materials for transportation development. On the other side disposal of waste materials generated in the growth development is also a main concern. Transportation acting a key responsibility in the progress of a country. If there is high-quality transportation then improvement of that country wills growth at a rapid phase. Roads play a major role in the transportation development. Now the cost of construction is getting improved in regulate to obtain good excellence construction materials. The world is facing a lack of fine worth construction materials as they are depleting day by day.**

Now a day's fine aggregate(sand) is very expensive; so that by adding admixtures like Brick Dust and Ground Granulated Blast furnace Slag (GGBS) as partial replacement in fine aggregate would give better saving and environment free. This project consists of a partial replacement of fine aggregate with brick dust and GGBS in cement concrete for rigid pavement. In this project I have partially replaced two types of admixtures named as brick dust and GGBS in cement concrete mix. Here brick dust and GGBS is added in cement concrete mix with a percentage variation of 10%, 20%, 30%, 40% and 50%. By adding brick dust and GGBS there was a variation in test results of compressive strength, Split tensile strength and flexural strength.

Index Terms: Transportation, Brick Dust and Ground Granulated Blast furnace Slag (GGBS)

I. INTRODUCTION

Now a day the purpose of fine aggregate is very rapidly used in civil engineering constructions like apartments, water tanks, different types of roads etc. Fine aggregate was found from lakes, rivers, oceans etc. Will affect to the environment because it will be excavated and transported the fine aggregate with tones of load therefore there was a disturbance in below the layers of earth crest problem identified to the environment. So that if we partially replaced **Brick dust** and **Ground Granulated Blast furnace Slag (GGBS)** (equal proportions) in fine aggregate there was a reduced quantity of fine aggregate and the total quantity of fine aggregate will also be reduced in rigid pavement construction and this material environmentally better to use. The waste material do not poured into the dumping yard, so that this material was helpful for partial replacement in fine aggregate but also it environmentally free.

In a rigid pavement there was a three components namely sub-grade, base, surface course when compared to flexible pavement there was four components so that the cost of rigid pavement is high when compared to the flexible pavement. The rigid pavement will be constructed at rural areas but flexible pavement not suitable. Therefore finally it is very economical to use in rigid pavement construction.

Common Advantages Of Brick Dust And Ground Granulated Blast furnace Slag (GGBS):

1. Brick dust is the potential workable material to be used as fine aggregate to produce durable concrete.
2. Its use as fine aggregate in concrete will help in alleviating the potential problem of dwindling natural resources.
3. Its use will also help in protecting the environment surroundings.
4. Brick dust as waste product from brick kilns and tile factories available in Bangladesh could be used as mineral admixtures in concrete. Its use in concrete could save as much as 20 percent of cement as binding material, while providing the same strength.
5. Brick dust concrete could be produced with satisfactory slump and setting times with nearly the same water cementing material ratio as in normal concrete without mineral.
6. Under certain conditions, replacement of cement by brick dust appears to increase the strength of concrete.
7. In mass concrete, use of brick dust as mineral admixture would reduce the heat of hydration, which could help to control the development of secondary stresses in the structures.
8. The brick dust mineral admixture has a reddish color, which could be aesthetically more pleasant.
9. By mixing of GGBS and brick dust the voids in the cement concrete are filled and densified. Therefore increase compressive strength with optimum dosage.
10. By using the combination of brick dust and GGBS fulfill the requirement to reduced fine aggregate (sand) quantity .hence the economical cost of sand is decreased.

II. MATERIALS USED

Materials that are used in this study are Brick Dust, Ground Granulated Blast Furnace Slag (GGBS), Cement, Fine Aggregate, and Coarse Aggregate. The properties and the source of the materials are described below.

BRICK DUST

Brick Dust used in this study is purchased from Brick Kilns in Rajahmundry .Specific gravity of brick dust is 2.6.

Fig.1

Table.1 Gradation properties of Brick Dust are

S.no	Size of sieve(mm)	Weight retained(gm)	Cumulative weight retained	Cumulative weight retained (%)	% of finer	Standard% weight passing for zone-III
1.	4.75	34	34	6.8	93.2	90-100
2.	2.36	35	69	13.8	86.2	85-100
3.	1.18	51	120	23.8	76.2	75-100
4.	0.6	73	193	38.5	61.5	60-79
5.	0.3	127	320	63.8	36.2	12-40
6.	0.18	50	370	74	26.0	-
7.	0.13	10	380	76	24.0	-
8.	0.075	104	484	96.8	3.2	-
9.	Pan	16	500	100	0	-
			Total=466.5			

Ground Granulated Blast Furnace Slag (GGBS)

Ground Granulated Blast Furnace Slag (GGBS) is a by-product from a blast furnaces used for making Iron. Here in this study GGBS is purchased from the company Duracem GGBS which is located at Auto Nagar, Visakhapatnam

Fig.2

Table.2 Physical properties of GGBS (AS PER SUPPLIER)

S.No	Property	Values
1	Colour	White
2	Water Absorbtion	0.75%
3	Specific Gravity	2.77
4	Residue on 45 micron sieve	3.0%
5	Fineness	$395m^2/kg$

Table .3 Chemical properties of GGBS (AS PER SUPPLIER)

S.No	Property	Values
1	Calcium oxide (CaO)	0.40%
2	Silicon Dioxide (SiO_2)	0.35%
3	Aluminium Oxide (Al_2O_3)	0.13%
4	Magnesium Oxide (MgO)	8.2%
5	Insoluble residue	0.66%
6	Manganese oxide (MnO)	0.40%
7	Sulfide sulfur (S)	0.79%

8	$\frac{CaO + MgO + 1/3\, Al_2O_3}{SiO_2 + 2/3\, Al_2O_3}$	1.04
9	$\frac{CaO + MgO + Al_2O_3}{SiO_2}$	1.84

COARSE AGGREGATE

Locally available of crushed coarse aggregates of size 20mm were used in this work.

Fig.3

The following physical properties of coarse aggregates are

Average crushing value of aggregate sample = **26.15%.**

Average value of impact value of aggregate sample= **13.06**

FINE AGGREGATE

- The sources of fine aggregate for partial replacement are river sand or , artificial sand by crushed rocks. Locally available sand confirming to IS Zone-II and Specific gravity **2.71** was used as a fine aggraegate in the present study.

Fig.4

- Gradation details of fine aggregate were given in the table

Table.4 Gradation details

S.No	Sieve size	Weight retained (gm)	Cumulative weight retained(gm)	Cumulative %weight retained	% weight passing
1	10 mm	0	0	0	100
2	4.75 mm	22	22	2.2	97.8
3	2.36 mm	34	56	5.6	94.4
4	1.18 mm	131	187	18.7	81.3
5	600 μm	216	403	40.3	59.7
6	300 μm	384	787	78.7	21.3
7	150 μm	202	988	98.8	1.2
				Total = 244.3	

CEMENT

Ordinary Portland cement of **53 grade** was used in the investigation.

Fig.5

Table.5 Physical Properties of OPC

S.No	Property	Values
1	Specific Gravity	3.14
2	Fineness of Cement by sieving	3 %
3	Normal Consistency	29 %
4	Setting Time a) Initial Setting time b) Final setting time	121 min 245 min
5	Compressive Strength a) 3 days b) 7 days c) 28 days	24.4 N/mm^2 37.8 N/mm^2 51.6 N/mm^2

III. MIX PROPORTION

Table .6 Description of Concrete mix

Mix designation	Description of Mix
Conventional concrete	C.C+0% GGBS&BD
C1	C.C+10% GGBS &BD
C2	C.C+20% GGBS &BD
C3	C.C+30% GGBS &BD
C4	C.C+40% GGBS &BD
C5	C.C+50% GGBS &BD

IV. EXPERIMENTAL PROGRAM

Mix design:

Selection of Water Content

From table 5 of IS 456:2000, Max. Water cement ratio = 0.6
Based on experience, maximum water-cement ratio = 0.45 is adopted.
Maximum water content for 20 mm aggregate =186 litres (For 25 to 50 mm slump range).

Calculation of Cement Content

Water-cement ratio = 0.41
Cement content = 186/0.41 =453.65kg/m^3
From Table 5 of IS 456, minimum cement content for 'Mild' exposure condition = 320kg/m^3, max = 540kg/m^3
453.65 kg/m3 > 320 kg/m3, hence ok

Proportion of Volume of Coarse and Fine Aggregate

From Table 3 of IS 10262:2009, volume of coarse aggregate corresponding to 20 mm size aggregate and fine aggregate.
In the present case water-cement ratio is 0.41. Therefore, volume of coarse aggregate is required to be increased to decrease the fine aggregate content. As the water-cement ratio is lower by 0.10, the proportion of volume of coarse aggregate is increased by 0.02 (at the rate of -/+ 0.01 for every ± 0.05 change in water-cement ratio).
The mix calculations per unit volume of concrete shall be as follows:

a) Volume of concrete = 1 m^3
b) Volume of cement = (Mass of cement/Specific gravity of cement)×(1/1000)
= (453.65/3.07) × (1/1000)= 0.147 m^3
c) Volume of water = (Mass of water /Specific gravity of water)×(1/1000)
= (186/1) × (1/1000) =0.186 m^3
d) Volume of all materials = a-(b+c)
= 1-(0.147+0.186)
= 0.667 m^3
e) Mass of coarse aggregate = d×volume of coarse aggregate ×specific gravity×1000
= 0.667×0.65×2.87×1000
= 1244.28 kg
f) Mass of fine aggregate = d × volume of fine aggregate × specific gravity×1000
= 0.667×0.35×2.71×1000
= 630.31 kg

Mix Proportions

Cement	=	453.65 kg
Water	=	186 liters
Fine aggregate	=	630.31 kg
Coarse aggregate	=	1244.28 kg
Water-cement ratio	=	0.41

EXPERIMENTS

Following test procedures are conducted in this study are

- Compressive Strength
- Split Tensile Strength
- Flexural Strength

1. Compressive Strength Test

The compressive strength of a material is that value of uni-axial compressive stress reached when the material fails completely.

The cubes are then tested between the loading surfaces of the compressive testing machine of capacity 2000KN in such a way that the smooth surface directly receives the load and it is applies until the failure of the load. The compressive strength is determined by the ratio of failure load to the cross sectional area of the specimen.

$$\text{fck} = \frac{\text{failure load}}{\text{Cross sectional area}} \qquad (4.1)$$

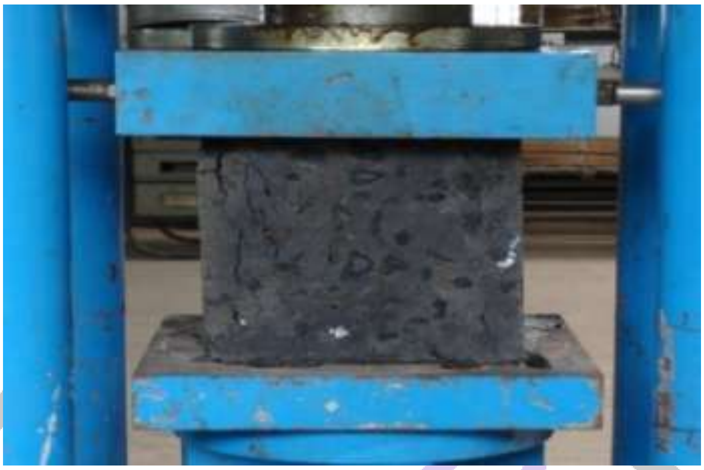

Fig.6, **Testing of Cube Specimens**

2.Split Tensile Strength Test

The resistance of a material to a force tending to tear it apart, measured as the maximum tension the material can withstand without tearing. Tested by keeping the cylindrical specimen in the compressive testing machine and is continued until failure of the specimen occurs.

Splitting Tensile Strength shall be calculated by using the formula:

$$\text{fct} = \frac{2p}{\pi \text{lD}} \qquad (4.2)$$

P = maximum load in Newton’s applied to the specimen,
L = length of the specimen in mm,
D = cross sectional dimension of the specimen in mm.

Fig.7, **Testing of Cylindrical Specimens**

3. FLEXURAL STRENGTH TEST

The flexural strength may be expressed as the modulus of rupture f_b, which, if “a” equals the distance between the line of fracture and the nearer support, measured on the centre line of tensile side of the specimen, shall be calculated to the nearest 0.5kg/sq.cm as follows:

$$f_b = \frac{pl}{bd^2} \qquad (4.3)$$

When “a” is greater than 20.0 cm for 15 cm specimen or greater than 13.3 cm for a 10.0 cm specimen

$$f_b = \frac{3p \times a}{bd^2} \qquad (4.4)$$

When a is less than 20.0 cm but greater than 17.0cm for a 15.0 cm specimen, or less than 13.3 cm but greater than 11.0cm
Where

b = measured width in cm of the specimen
d = measured depth in cm of the specimen.
l = length in cm of the span in which the specimen was supported and
p = maximum load in kg applied to the specimen.

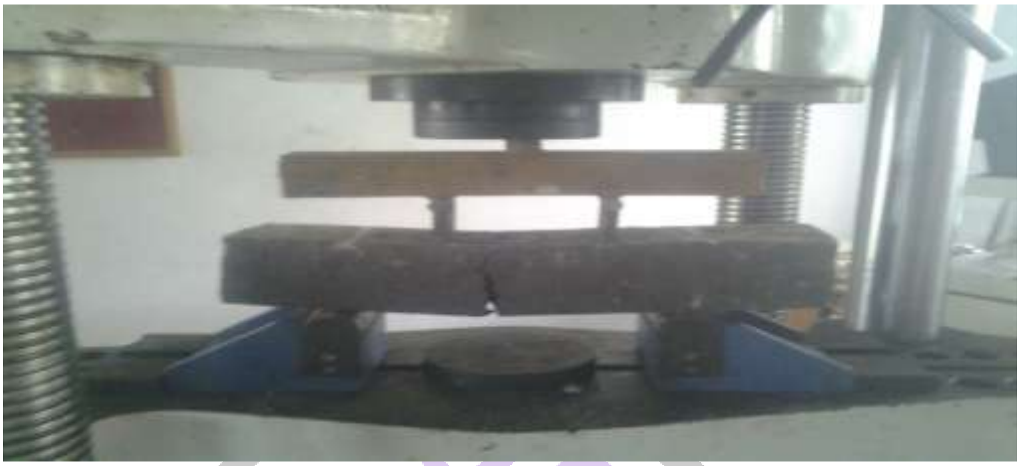

Fig.8, **Testing of Prism Specimens**

V. RESULTS AND DISCUSSIONS

5.1 Compressive Strength Of BD & GGBS in Cube Specimens

Table .7 Compressive strength of BD & GGBS in cube specimens

Mix	7 days(MPa)	28 days(MPa)
C.C	17.29	24.00
BD&GGBS (10%)	19.31	25.37
BD&GGBS (20%)	20.31	28.50
BD&GGBS (30%)	22.01	30.05
BD&GGDS (40%)	24.12	32.30
BD&GGBS (50%)	22.03	31.27

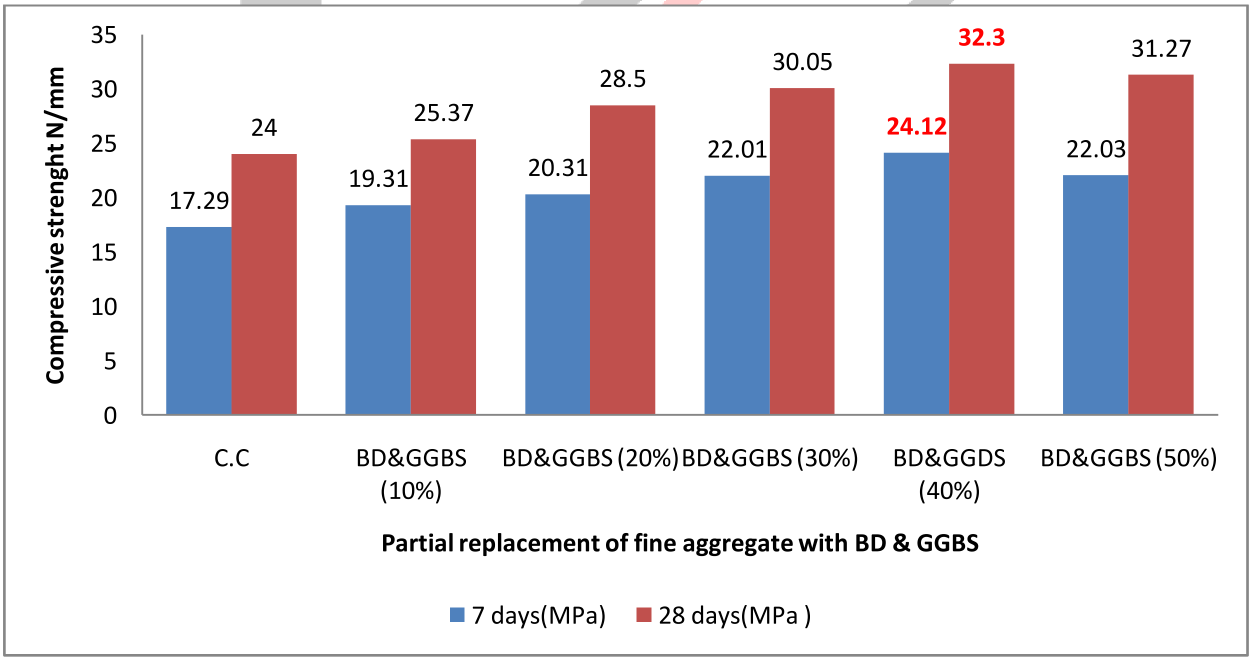

Fig.9

Compressive strength values of C.C and BD & GGBS at 7 and 28 days

Description of Results:

1. From the figure 5.1 it is observed that compressive strength of the concrete increases to 0.54%,1.54%,3.24% and 5.35% when % of BD & GGBS mixture increases from 10%, 20%,30% and 40% when it is compared with conventional concrete at 7days.
2. From the figure 5.1 it is observed that compressive strength of the concrete increases to 3.37%, 6.5%, 8.05 and 9% when % of BD & GGBS mixture increases from 10%, 20%,30% and 40% when it is compared with conventional concrete at 28 days.
3. From the figure 5.1 it is observed that compressive strength values decreased as the percentage of BD&GGBS mixture increases beyond 40%.

5.2 Split Tensile Strength of BD & GGBS in Cylinder Specimens

Table 8. Split Tensile Strength of BD & GGBS

ix Designation	7 days(MPa)	28 days(MPa)
C.C	2.47	2.94
BD&GGBS (10%)	2.94	3.33
BD&GGBS (20%)	3.61	3.91
BD&GGBS (30%)	4.08	4.57
BD&GGDS (40%)	4.67	5.08
BD&GGBS (50%)	4.59	4.84

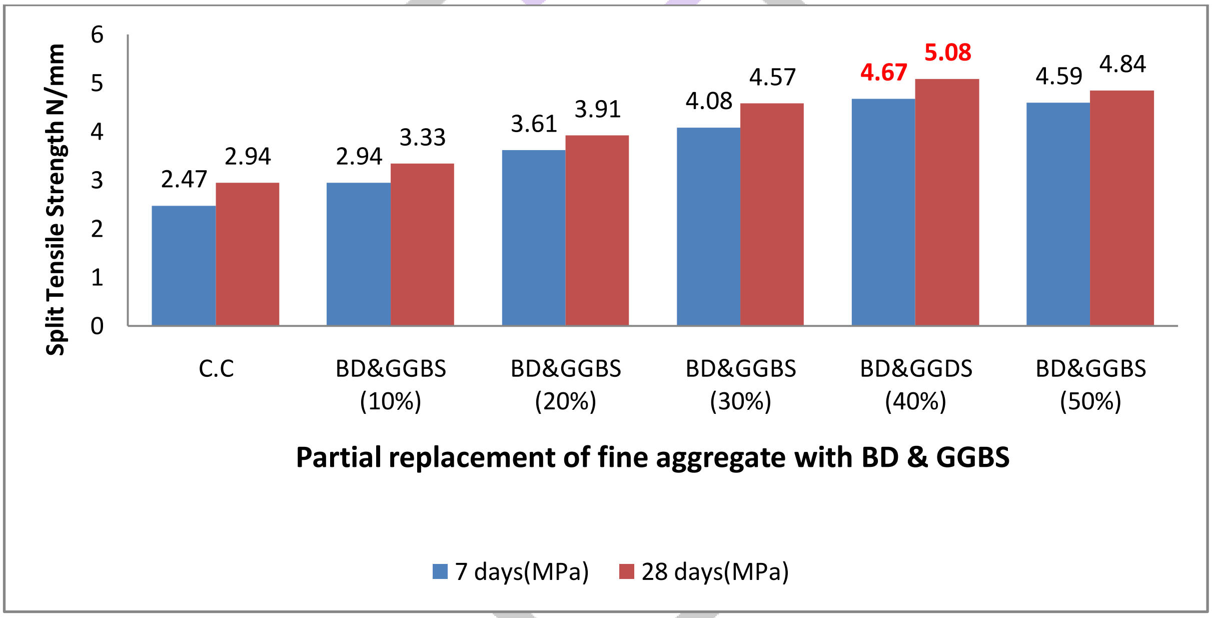

Fig.10

Split tensile strength values of C.C and BD & GGBS at 7 and 28 Days

Description Of Results:

1. From the figure 5.2 it is observed that tensile strength of the concrete increases to 0.5%, 0.7%,1.5% and 2.01% when % of BD&GGBS mixture increases from 10%, 20%,30% and 40% when it is compared with conventional concrete at 7days.

2. From the figure 5.2 it is observed that tensile strength of the concrete increases to 0.45%, 0.66%, 1.53% and 2.3% when % of BD&GGBS mixture increases from 10%, 20%,30% and 40% when it is compared with conventional concrete at 28days.

3. From the figure 5.2 it is observed that tensile strength values decreased as the percentage of BD&GGBS mixture increases beyond 40%.

5.3 Flexural Strength of BD & GGBS in Beam Specimens

Table .9 ,Flexural strengths of BD & GGBS in beam specimens

Mix	7 days(MPa)	28 days(MPa)
C.C	2.84	4.2
SDBD(10%)	3.21	4.51
SDBD(20%)	3.87	4.92
SDBD(30%)	4.33	5.48
SDBD(40%)	4.82	5.90
SDBD(50%)	4.76	5.79

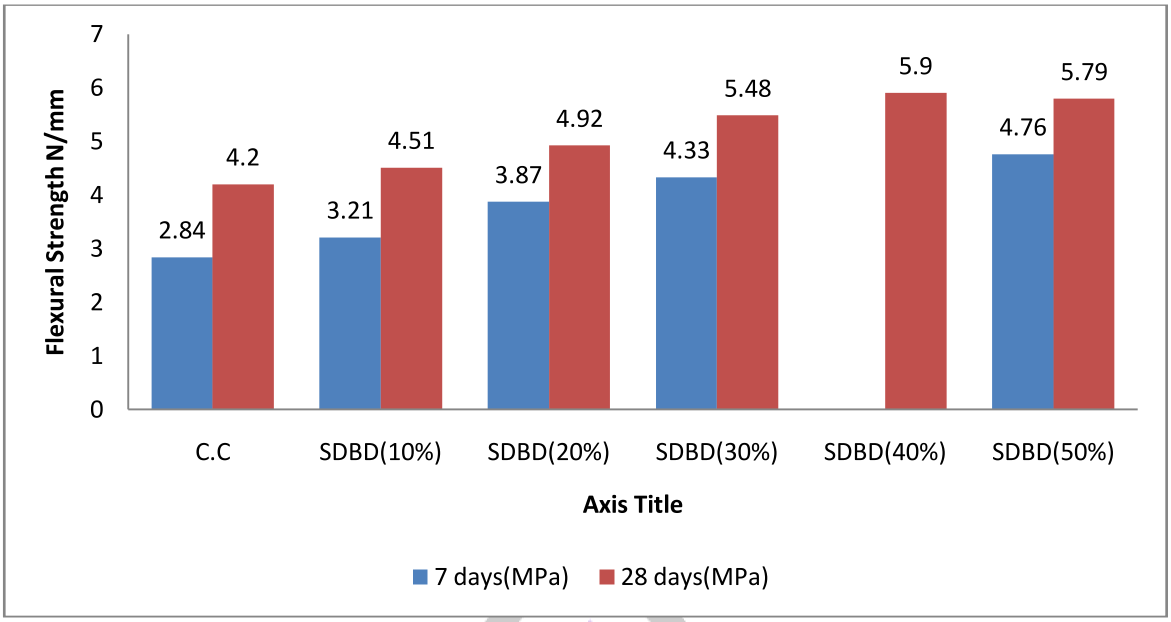

Fig.11

Flexural strength values of C.C and SD&BD at 7 and 28 Days

Description Of Results:

1. From the figure 5.3 it is observed that flexural strength of the concrete increases to 0.2%,0.6%,1.0% and1.6% when % of BD&GGBS mixture increases from 10%, 20%,30% and 40% when it is compared with conventional concrete at 7days.
2. From the figure 5.3 it is observed that flexural strength of the concrete increases to 0.5%, 0.8%,1.1% and 2% when % of BD&GGBS mixture increases from 10%, 20%,30% and 40% when it is compared with conventional concrete at 28days.
3. From the figure 5.3 it is observed that flexural strength values decreased as the percentage of BD&GGBS mixture increases beyond 40%.

DESIGN OF SLAB THICKNESSS

Pavement slab is designed as per IRC 58:2002. The flexural strength is directly taken from the beam flexural test. The axial load spectrum is taken from IRC: 58-2002 and other data used in this design are given below.

A cement concrete pavement is to be designed for a two lane two-way National Highway. The total two-way traffic is 3000 commercial vehicles per day at the end of the construction period. The design parameters are:

VI. Designs

6.1 Design Of Slab Thickness For Conventional Concrete

Flexural strength of cement concrete	=	32.3 kg/cm^2
Effective modulus of subgrade reaction of the DLC sub-base	=	8 kg/cm^3
Elastic modulus of concrete	=	2.23×10^5 kg/ cm^2
Poisson's ratio	=	0.15
Coefficient of thermal expansion of concrete	=	$10\times10^{-6}/^0$C
Tyre pressure	=	8 kg/cm^2
Rate of traffic increase	=	0.075
Spacing of contrction joints	=	4.5 m
Width of slab	=	3.5 m
Design life	=	20 years
Present traffic	=	3000 cvpd.

Design

Present traffic = 3000 cvpd, Design life = 20 yrs, r = 0.075

Cumulative repetition in 20 yrs. = $3000 \times 365\left[\frac{(1.075)^{20}-1}{0.075}\right]$

= 47,418,626 commercial vehicles

Design traffic = 25 percent of the total repetitions of commercial vehicles

= 11,854,657

Front axles of the commercial vehicles carry much lower loads and cause small flexural stress in the concrete pavements and they need not to be considered in pavement design. Only the rear axles, both single and tandem, should be considered for the design. In the example, the total number of rear axles is 11,854,657. Assuming that midpoint of the axle load class represents the group, the total repetitions of the single axle and tandem axle loads are as follows

Table .10, Expected repetitions for single and tandem axle loads

Single Axles		Tandem Axles	
Load in tones	**Expected repetitions**	**Load in tones**	**Expected repetitions**
20	60000	36	40000
18	120000	32	50000
16	300000	28	73000
14	128030	24	199000
12	250000	20	150000
10	26022000	16	70000
Less than 10	3569000	Less than 16	170000

Trail thickness = 35cm, sub grade modulus = 8 kg/cm^3, design period = 20 yrs, modulus of rupture = 32.3kg/cm^2, load safety factor = 1.2.

Table .11, Calculation of fatigue life consumed for slab thickness of 35cm

Axle load (AL), Tones	A.L×1.2	Stress, Kg/cm^2 From charts	Stress ratio	Expected repetition, N	Fatigue life, N	Fatigue life consumed
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**Ratio (5)/(6)**
Single axle						
20	24.0	18	0.55	60000	1.24x10^5	0.48
18	21.6	17	0.52	120000	3.26x10^5	0.36
16	19.2	15.3	0.47	300000	5.2x10^6	0.05
14	16.8	13.5	0.41	128030	-	0
Tandem axle						
36	43.2	15.3	0.47	40000	5.2x10^6	0
32	38.4	13.5	0.41	50000	-	0

Cumulative fatigue life consumed = 0.89

The cumulative fatigue life consumed being less than 1; the design life is safe from fatigue conditions.

Check for temperature stress

Temperature stresses tends to produce two types of stresses in a concrete pavement.

These are

(i) Edge warping stress
(ii) Frictional stress

(i) Edge warping stresses

Edge warping stress = $\frac{CE\propto t}{2}$ (6.1)

L = 450 cm.

B = 300 cm.

$$l=\sqrt[4]{\frac{Eh^3}{12(1-\mu^2)k}} \quad (6.2)$$

E = 2.23×10^5 kg/cm^2

h = 35cm.

μ= 0.15.

K= 8 kg/cm^3

l =100.46 cm

$\frac{L}{l}$= 4.479

C = 0.50 (Figure 2 IRC-58:2002)

α = 10×10^{-6}/^{0}C

t= 21^0 (was taken for the Karnataka region)

Edge warping stress = 11.70 kg/cm^2

(ii) Frictional stresses

$$S_f = \frac{WLf}{2\times10^4} \quad (6.3)$$

$$= \frac{2400\times4.5\times1.5}{2\times10^4}$$

= 0.81 kg/ cm^2

Critical combination of stresses

During summer:

Critical combination of stresses = load stress + warping stress - frictional stress (at edge region).
= 18.00+11.70-0.81
= 28.89 kg/cm^2

During winter:

Critical combination of stresses = load stress + warping stress + frictional stress (at edge region).
= 18.00+11.70+0.81
= 30.51kg/cm^2

At corner region:

There is no frictional stress at the corner region
Critical combination of stresses = load stress + warping stress (at corner region)
= 18.00+11.70
= 29.70 kg/cm^2

This is less than the flexural strength of the concrete i.e., 32.3 kg/cm^2. So the pavement thickness of 35cm is safe under combined action of wheel load and temperature.

Check for corner stress

Corner stress can be calculated by following equation

$$\text{Corner stress} = \frac{3p}{h^2}\left[1-\left(\frac{a\sqrt{2}}{l}\right)^{1.2}\right] \qquad (6.4)$$

l = 100.46 cm
a= radius of area of contact of wheel.

Considering single axle duel wheel

$$a = \left[0.8521 \times \frac{p}{q\pi} + \frac{s}{\pi}\left(\frac{p}{0.5227\,q}\right)^{0.5}\right]^{0.5} \qquad (6.5)$$

p= load(8tones)
s= c/c distance between 2 tyres = 32cm.
q= tyre pressure(8kg/cm^2, a = 26.51cm
Corner stress = 17.17 kg/cm^2

The corner stress is less than the flexural strength of the concrete i.e., 32.3 kg/cm^2 and the pavement thickness of 35 cm assumed is safe.

6.2 Design Of Slab Thickness For BD&GGBS Reinforced Concrete

Trail thickness = 30 cm, sub grade modulus = 8 kg/cm^3, design period = 20 yrs, modulus of rupture = 42 kg/cm^2, load safety factor = 1.2.

Table .12, Calculation of fatigue life consumed for slab thickness of 30 cm

Axle load (AL), tones	A.L×1.2	Stress, Kg/cm^2 From charts	Stress ratio	Expected repetition(n)	Fatigue life, (N)	Fatigue life consumed
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**Ratio (5)/(6)**
Single axle						
20	24.0	23.00	0.56	60000	9.41x10^4	0.63
18	21.6	22.00	0.52	120000	3.26x10^5	0.36
16	19.2	19.00	0.45	300000	6.279x10^7	0
14	16.8	17.00	0.40	128030	-	0
Tandem axle						
36	43.2	18.00	0.433	40000	-	0

Cumulative fatigue life consumed = 0.99
The cumulative fatigue life consumed being less than1; the design life is safe from fatigue conditions.

Check for temperature stress

Temperature stresses tends to produce two types of stresses in a concrete pavement.
These are

(i) Edge warping stress
(ii) Frictional stress

(i) Edge warping stresses

Edge warping stress = $\frac{CE\propto t}{2}$

L = 450 cm.

B = 300 cm.

$l = \sqrt[4]{\frac{Eh^3}{12(1-\mu^2)k}}$

E = 2.93×10^5 kg/cm^2

h = 30cm

μ= 0.15

K= 8 kg/cm^3

l = 95.82cm.

$\frac{L}{l}$= 4.69

C = 0.6 (Figure 2 IRC-58:2002)

α = $10\times10^{-6}/^0$C

t= 21^0 (was taken for the Karnataka region)

Edge warping stress = 18.00 kg/cm^2

(ii) Frictional stresses

$s_f = \frac{WLf}{2\times10^4}$

$= \frac{2400\times4.5\times1.5}{2\times10^4}$

= 0.81 kg/ cm^2

Critical combination of stresses

During summer:

Critical combination of stresses = load stress + warping stress - frictional stress (at edge region).

= 23+18-0.81

= 40.19 kg/cm^2

During winter:

Critical combination of stresses = load stress + warping stress + frictional stress (at edge region).

= 23.0+18.0+0.81

= 41.81 kg/cm^2

At corner region:

There is no frictional stress at the corner region

Critical combination of stresses = load stress + warping stress (at corner region)

= 23+18

= 41kg/cm^2

This is less than the flexural strength of the concrete i.e., 42 kg/cm^2. So the pavement thickness of 31cm is safe under combined action of wheel load and temperature.

Check for corner stress

Corner stress can be calculated by following equation

Corner stress = $\frac{3p}{h^2}\left[1-\left(\frac{a\sqrt{2}}{l}\right)^{1.2}\right]$

l = 95.82 cm

a= radius of area of contact of wheel.

Considering single axle duel wheel

a = $\left[0.8521 \times \frac{p}{q\pi} + \frac{s}{\pi}\left(\frac{p}{0.5227\,q}\right)^{0.5}\right]^{0.5}$

p= load

s= c/c distance between 2 tyres = 32cm.

q= Tyre pressure

a = 26.51 cm

Corner stress = 18.01kg/cm^2

The corner stress is less than the flexural strength of the concrete i.e., 42 kg/cm^2 and the pavement thickness of 30 cm assumed is safe.

VII. COST COMPARISION

A cement concrete pavement is to be laid with following dimensions. Quantity and cost of each material for that stretch is calculated and compared for conventional concrete and brick dust and GGBS concrete in this section.

7.1 cost For Conventional Concrete

Length of the pavement = 1m.

Width of the pavement = 3.75m.

Thickness of the pavement = 35cm.

Total volume of concrete required to fill the surface course = L×b×h.

= 1m×3.75m×0.35m.

=1.312m^3

Table .13, Estimation of materials for conventional concrete

S.no.	Material	Quantity (kg)	Rate per kg in Rs.	Cost in Rs.
1	Cement	595.18	6.6	3928.18
2	Fine aggregate	826	1.87	1544.62
3	Coarse aggregate (20mm)	1632	1.00	1632.8

Total cost in Rupees for 1.16m^3 of concrete for a stretch of 1m×3.75m×0.35m = 7105.8 /-

7.2 Costs For GGBS&BD concrete

Length of the pavement = 1m.

Width of the pavement = 3.75m.

Thickness of the pavement = 30cm

* Total volume of concrete required to fill the surface course = L×b×h.

= 1m×3.75m×0.30m.

=1.125m^3

Table .14, Estimation of materials for SD&BD

S.no.	Material	Quantity (kg)	Rate per kg in Rs.	Cost in Rs.
1	Cement	510.35	66	3368
2	Fine aggregate(60%)	425.45	1.87	795.59
3	Coarse aggregate (20mm)	1399.81	1.00	1399.81
4	GGBS(20%)	141.82	0.75	106.36
5	Brick dust(20%)	141.82	0.25	35.45

Total cost in Rupees for 0.937 m^3 of concrete for a stretch of 1m×3.75m×0.30m = 5705.52/-

From the above calculation we can save 1400.28/- Rs per 1m length by using GGBS and brick dust mixture. Thus the construction cost of the pavement is reduced by 19.7% by using GGBS and brick dust mixture.

VIII. CONCLUSIONS

This chapter describes about brick dust and stone dust mixture used for casting samples and they are tested for compressive, flexural and split tensile with varying percentages. From the tests conducted on various samples and results obtained as follows.

1. From the figure 5.1 it is observed that compressive strength of the concrete increases to 11.68%,17.46%,27.29% and 39.50% when % of BD & GGBS mixture increases from 10%, 20%,30% and 40% when it is compared with conventional concrete at 7days.

2. From the figure 5.1 it is observed that compressive strength of the concrete increases to 5.70%, 18.75%, 25.20% and 34.5% when % of BD & GGBS mixture increases from 10%, 20%,30% and 40% when it is compared with conventional concrete at 28 days.

3.From the figure 5.2 it is observed that tensile strength of the concrete increases to 19.02%,46.15,65.18% and 89.06% when % of BD&GGBS mixture increases from 10%, 20%,30% and 40% when it is compared with conventional concrete at 7days.

4. From the figure 5.2 it is observed that tensile strength of the concrete increases to13.26%, 32.99%,55.44% and 72.78% when % of BD&GGBS mixture increases from 10%,20%,30% and 40% when it is compared with conventional concrete at 28days

5. From the figure 5.3 it is observed that flexural strength of the concrete increases to 13.02%,36.26%,52.46% and69.71% when % of BD&GGBS mixture increases from 10%, 20%,30% and 40% when it is compared with conventional concrete at 7days.

6. From the figure 5.3 it is observed that flexural strength of the concrete increases to 7.38%, 17.14%,30.47% and 40.47% when % of BD&GGBS mixture increases from 10%, 20%,30% and 40% when it is compared with conventional concrete at 28days.

7. From the above calculation we can save 1400/- Rs per 1m length by using GGBS and brick dust mixture. Thus the construction cost of the pavement is reduced by 19.7% by using GGBS and brick dust mixture

FURTHER SCOPE :

1) A study can be taken up with other types of admixtures and comparison can be done among the admixtures for maximum strength property.

2) A study can be done by Concrete mix design for different types of mix like M40, M50, and M60 for stone dust and brick dust material.

3) A study can be done by using waste material are used as sub base material or base material for flexible pavement by conducting different laboratory tests on that materials.

REFERENCES

1. Celik, T. and Marar, K. 1996. Effects of crushed stone dust on some properties of concrete. Cement Concre.Res. 26(7): 1121-1130.

2. Eren, S., Khaled, K., Irassar, E.F. and Barai, S.V. 2007.Partial replacement using crusher stone dust. IE J-CV.87: 2006.

3. Hameed, M.S. and Sekar, A.S.S. 2009. Quarry dust as replacement of fine aggregate in concrete. ARPN J.Engg. Appl. Sci. 4(4): 83-89.

4. IS 1489:1991. Portland Pozzolana Cement Specification-Part 1: Fly Ash Based, Bureau of Indian standard institution, New Delhi.

5. IS: 10262:1982. Recommended guidelines for 1. Bonavetti, V., Donza, H., Rahhal, V. and Irassar, E.1993. Influence of initial curing on properties of concretecontaining limestone blended cement. Cement Concre.Res. 30: 703-708.
concrete mix design, Bureau of Indian standards, New Delhi.

6. IS: 2386-1963. Indian standards code of practice for methods of test for Aggregate for concrete, Bureau of Indian standard Institution, New Delhi.

7. IS: 383-1970. Specification for Coarse and Fine Aggregates from natural sources for concrete" (Secondrevision).

8. IS: 516-1959. Method of test for strength of concrete Bureau of Indian standards. New Delhi, India.

9. Jain, M.E.M., Safiuddin, M. and Yousuf, K.M. 1999.A study on the properties of freshly mixed high performance concrete. Cement Concre. Res. 29(9):1427-1432.

10. Patel, A.N. and Pitroda, J. 2013. Stone waste: Effective replacement of cement for establishing green concrete.Int. J. Innov. Technol. Exploring Engg. 2(5): 1782-1785.

11. Sahu, A.K., Kumar, S and Sachan, A.K. 2009. Utilization of crushed stone waste in concrete. NCACM Method and Management (AC3M-09) 21-22 January, 2009 Hyderabad, India.

12. Edward Allen, Robert Hallon. Fundamental of residential construction (3rd edition), 672 pages. John Wiley & Sons, San Francisco, USA, 2011.

13. Roy chudley, Roger Greeno. Construction Technology (4thedition), 634 pages. Prentice Hill, New Jersey, USA,2000.

14. Jeorge J. Venta, P.Eng. "Life cycle analysis of brick and mortar products", the ATHENATM Sustainable MaterialInstitute, Canada, Ottawa, 1998.

15. Jeorge J. Venta, P.Eng. "Life cycle analysis of brick and mortar products", The ATHENATM Sustainable Material Institute, Canada, Ottawa, 1998.

16. Aeslina AK, Abbas M, Felicity R, John B. "Density, strength, thermal conductivity and leachate characteristics of light weight fired clay bricks incorporating cigarette butts", International Journal of Civil and Environmental Engineering, Vol. 2. Pp 179-184, 2010.

17. Hanifi B, Orhan A, Tahir S. "Investigation of fibre reinforced mud brick as a building material", Construction and building material, Vol. 19. Pp. 313-318, 2005.

18. Rahman MA. "Properties of clay-sand-rice husk ash mixed bricks", International Journal of Cement Composite Lightweight Concrete, Vol. 9. Pp. 105–108, 1987.

19. Demir I, Serhat M, Mehmet O. "Utilization of kraft pulp production residues in clay brick production", Building and Environment, Vol. 40. Pp. 1533–1537, 2005.

20. Demir I. "An investigation on the production of construction brick with processed waste tea", Building and Environment, Vol. 41. Pp. 1274–1278, 2006.