CONCRETE MIX DESIGN USING BRICK DUST AND COCONUT SHELL.

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Abstract The demand of concrete in construction is increasing day by day. The materials used for the concrete are cement, coarse aggregate, fine aggregate, water, admixtures (if any). The use of cement causes the CO_2 emission in the environment. So to reduce the emission of CO_2, the cement should be replaced or substituted by other materials. In construction the use of bricks are necessary, the brick dust waste which is obtained by the transportation or in the making of the bricks has pozzolanic properties that enable it to play an important role in the strength and durability of concrete. The use of Coarse aggregate in concrete reduces the natural stone deposits. To overcome this problem, coconut shell is used as a partial replacement of the coarse aggregate. For the replacement of this material, different tests on the material were performed and mix design is prepared. Further, brick dust and coconut shells were partially replaced with cement and coarse aggregate respectively in different proportion and the compressive strength test on the concrete was performed. After the test, it is concluded that the concrete with Brick dust replacement of 10% and coconut shell replacement with 20% gave the strength which was nearly same as nominal concrete

Keywords:- Brick Dust, Coconut shell, Cement, Strength, Light Weight.

I. INTRODUCTION

Cement is a widely used construction material. In the production of cement, the CO_2 is emitted during the chemical process of the clinkers. One ton of cement is responsible for one ton of CO_2 emission. To overcome this problem the different materials should be used. One such alternative is brick dust which is available by production or transportation of the bricks. Brick dust has pozzolanic properties as same as cement. Therefore Brick dust can be used as a substitute of cement. The use of coarse aggregate in concrete increases the weight of concrete and decreases the natural stone deposits. So to overcome this problem, alternate material should be used. Coconut shell is the alternative material that can be used as a coarse aggregate. Coconut shell is agricultural waste. Coconut shell does not degrade for around 100 to 120 years. Thus coconut shells can be used as coarse aggregate in concrete.
A different test on this material including fine aggregate and coarse aggregate was performed in this study.

I. Plan of Work

The various tests of material have been carried out. The proportion by which the materials are replaced has been decided on a trial basis. Three cubes for each proportion, for one test were casted for finding the strength of concrete after 7, 14 and 28 days. After the period of 7, 14 and 28 days the different tests on the material have been carried out for compression test, flexure strength test. The test result for a different proportion of cubes has been compared and the proportion on which the maximum strength has obtained is taken as the final proportion. The maximum percentage by which the material can be replaced and after that proportion, the strength of concrete will be less and not acceptable is also described in this study.

II. EXPERIMENTAL STUDY:-

The freshly discarded shells were collected from the agriculture market. The coconut shells were crushed using concrete hammers to a size such that it passes through a 20mm sieve and retained on 4.75mm sieve. The surface texture of the shell was fairly smooth on concave and rough on convex faces. Coconut shell aggregates used were in saturated surface dry (SSD) condition.
Brick dust was obtained by crushing the bricks in the fine particles of 15 microns. The brick powder was sieved in a mechanical shaker to get the particle size of 15 microns.
Portland Pozzolana Cement (PPC) 53 Grade was used as a binder along with brick dust. Sand passing through 4.75mm sieve was used throughout the study as the fine aggregate. Crushed stone passing through 20 mm sieve and retained on 4.75 mm sieve was used as coarse aggregate along with coconut shells. Potable water was used for mixing and curing. Mix design for M30 grade of concrete was prepared according to IS 10262:2019 codal provision.
Nine different mixes were prepared with Cement replacement of 10%, 15% and 18% and coarse aggregate replacement of 12%, 20%, and 25%.

Fig.1 Coconut shell and crushed coconut shell

Fig.1 shows the sample of coconut shells to be used as a substitute of coarse aggregate. Before using coconut shells in the concrete it is kept in clean water for 24 hours so that the water absorption of coconut shells will be zero.

Fig.2 Brick dust

Fig.2 shows the sample of brick dust that is used as a substitute of cement in the concrete. The specific gravity of brick dust is obtained by the method of finding the specific gravity of cement.

III. TEST ON MATERIAL:-

For the preparation of mix design according to IS 10262:2019 Test of different material were carried out such as,

- **The specific gravity of fine aggregate**
- **The specific gravity of coarse aggregate**
- **The specific gravity of brick dust**
- **The specific gravity of coconut shell**
- **Slump test**
- **Water absorption of coarse aggregate**
- **Water absorption of fine aggregate**

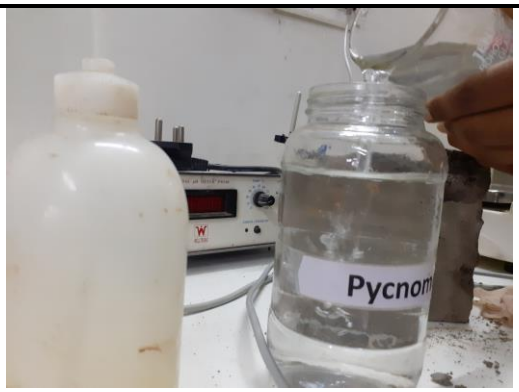

Fig.3 Specific gravity test by Pycnometer

A specific gravity test was performed using a pycnometer. Fig.3 shows some glimpse of the test performed.

Table.1 The test result of material

Specific gravity of cement	3.15
Specific gravity of Brick dust	2.26
Specific gravity of C.A	2.74
Specific gravity of F.A	2.69
Specific gravity of C.S	1.16
Zone of soil	Zone 3
Water absorption of C.A	0.2
Water absorption of F.A	0.6

Specific gravity test, water absorption and zone of soil (sand) for different materials were performed for this study. Table.1 shows the test results of the test performed.

IV. MIX DESIGN:-

After the tests on the material, the mix design was prepared according to IS 10262:2009 and IS 10262:20019.
After the mix design preparation, a concrete cube of 150x150x150mm was casted. Total 9x9=81 number of cubes was casted for testing after 7, 14 and 28 days according to IS 10262:2019. After preparing a mix design for brick dust and coconut shell concrete, a slump test was conducted on concrete for the workability test.

Table.2 Data for IS 10262:2009 and IS 10262:2019

Type of cement	OPC 53 Grade
Grade of Designation	M 30
Maximum Size of Aggregate	20 mm
Max Cement Content	320
Max w/c Ratio	0.45
Workability	100 mm slump
Exposure Condition	SEVERE
Sp. Gr. Of Cement	RCC
Sp. Gr. Of Brick dust	3.15
Sp. Gr. Of C.A	2.26
Sp. Gr. Of C.S	2.74
Sp. Gr. Of F.A	2.69
Water Absorption:- F.A C.A	 0.6 0.2
Standard Deviation S	5

Maximum water Content	186
Zone Of soil	Zone 3
Free surface moisture:- F.A C.A	 0 0
Chemical Admixture	None
Method of placing concrete	Normal

The basic data required for the preparation of mix design is shown in Table.2. Mix design as per IS 10262:2009 and IS: 10262:2019 was prepared by using the above data

Table.3 Comparison of Mix Design As per IS 10262:2009 and IS 10262:2019

Target Mean Strength		**Target Mean Strength**	
fck´=fck+1.65*S	38.25	1)fck´=fck+1.65*S	38.25
fck´ =	38.25	2)fck´=fck+X	36.5
Selection of w/c ratio		fck´	38.25 (Greater of 1 and 2)
From the experiments, it can be achieved at w/c ratio of	0.45	Approximate Air Content	1%
Adopt w/c ratio =	0.45		(FROM TABLE 3:(For normal concrete the approximate entrapped air is 1.0 percent for 20 mm nominal size of aggregate.))
Selection of water Content			
Estimated Water content for 100 mm slump	197 liters		
Calculation of Cement and Brick Dust Content		**Selection of w/c ratio**	
Cementitious Material (Cement + Brick Dust)	437.77	From the experiments, it can be achieved at w/c ratio of	0.45
	438 kg/m³	Adopt w/c ratio =	0.45
	O.K	**Selection of water Content**	
Increasing Cementitious material by	10%	Estimated Water content for 100 mm slump	197 liters
Cementitious material content	481.8	**Calculation of Cement and Brick Dust Content**	
	482kg/m³	Cementitious Material (Cement + Brick Dust)	437.77
Let us take a percentage of Brick dust as	12%		438 kg/m³
Brick Dust Content	57.84		O.K
	58 kg/m³	Increasing Cementitious material by	10%
Cement	424 kg/m³	Cementations' material content	481.8
w/c ratio	0.4087		482kg/m³
	0.409	Let us take a percentage of Brick dust as	12%
The proportion of the volume of C.A and F.A content		Brick Dust Content	57.84

The volume of C.A for 20 mm MSA and F.A falling on zone 3 and w/c of 0.5 = 0.64			58 kg/m³
The volume of coarse aggregate is increased by	0.01	Cement	424 kg/m³
The volume of C.A for the w/c ratio of 0.45 will be	0.65	w/c ratio	0.4087
let us take a percentage of C.S	12%		0.409
The volume of C.S	0.078	**The proportion of volume of C.A and F.A content**	
The volume of C.A	0.57	Volume of C.A for 20 mm MSA and F.A falling on zone 3 and w/c of 0.5 = 0.64	
The volume of F.A	0.35	The volume of coarse aggregate is increased by	0.01
Mix Calculation		The volume of C.A for the w/c ratio of 0.45 will be	0.65
The volume of concrete	1m³	take a percentage of C.S	12%
		The volume of C.S	0.078
Absolute volume of cement	0.135m³	The volume of C.A	0.57
Absolute volume of Brick Dust	0.026m³	The volume of F.A	0.35
The volume of Water	0.197m³	**Mix Calculation**	
Total Volume of all in aggregate	0.643m³	The volume of concrete	1m³
Weight of coarse aggregate	1007 kg/m³	The volume of entrapped air in wet concrete	0.01m³
Weight of C.S	58 kg/m³	Absolute volume of cement	0.135m³
Weight of F.A	508 kg/m³	Absolute volume of Brick Dust	0.026m³
Field correction		Volume of Water	0.197m³
Absorption of C.A	2.01 kg/m³	Total Volume of all in aggregate	0.633m³
Absorption of F.A	3.05 kg/m³	Weight of coarse aggregate	992 kg/m³
Quantity of Surface moisture of F.A	0	Weight of C.S	57 kg/m³
Quantity of Surface moisture of C.A	0	Weight of F.A	500 kg/m³
weight of C.A in Field	1005.33 kg/m³	**Field correction**	
weight of F.A in Field	505.35 kg/m³	Absorption of C.A	1.98 kg/m³
As -5.07 kg of extra water is absorbed and is added in total water content		Absorption of F.A	3.0 kg/m³
water content = 202 kg/m³		Quantity of Surface moisture of F.A	0
Mix proportion :-		Quantity of Surface moisture of C.A	0
Cement	424 kg/m³	weight of C.A in Field	989.69 kg/m³
Brick dust	58 kg/m³	weight of F.A in Field	497.49 kg/m³
Water	202 kg/m³	As -5.07 kg of extra water is absorbed and is added in total water content	
F.A	505 kg/m³	water content = 202 kg/m³	

C.A	1005 kg/m³	**Mix proportion :-**	
C.S	58 kg/m³	Cement	424 kg/m³
Wet density	2253 kg/m³	Brick dust	58 kg/m³
Mix proportion for 0.15*0.15*0.15 cubes = 0.003375		Water	202 kg/m³
Cement	1.431kg/m³	F.A	497 kg/m³
F.A	1.705561 kg/m³	C.A	990 kg/m³
C.A	3.392982 kg/m³	C.S	57kg/m³
Water cement ratio	0.45 kg/m³	Wet density	2228 kg/m³
C.S	0.196271 kg/m³	**Mix proportion for 0.15*0.15*0.15 cubes = 0.003375**	
Brick dust	0.19575 kg/m³	Cement	1.431kg/m³
Mix Proportions for slump volume 0.0055 m³		F.A	1.679025 kg/m³
Cement	2.332 kg/m³	C.A	3.340192kg/m³
F.A	2.78 kg/m³	Water cement ratio	0.45 kg/m³
C.A	5.53 kg/m³	C.S	0.193218 kg/m³
Water Cement ratio	0.45	Brick dust	0.19575 kg/m³
C.S	0.32 kg/m³	**Mix Proportions for slump volume 0.0055 m³**	
Brick dust	0.319 kg/m³	Cement	2.332 kg/m³
		F.A	2.74 kg/m³
		C.A	5.44 kg/m³
		Water Cement ratio	0.45
		C.S	0.31 kg/m³
		Brick dust	0.319 kg/m³

For a better understanding of the difference between two IS codes i.e.; IS 10262:2009 and IS 10260:2019, mix design was prepared using both IS 10262:2009 and IS 10262:2019 and the comparison was done as shown in Table.3

Abbreviation

C.A	Coarse Aggregate
C.S	Coconut Shell
F.A	Fine Aggregate
w/c ratio	Water/Cement Ratio
fck´	target mean compressive strength at 28 days, in N/mm²
Fck	characteristic compressive strength at 28 days, in N/mm²
X	factor based on the grade of concrete
S	standard deviation, in N/mm²

Fig.4 Slump test

Fig.4 shows the slump tests performed for the workability of the concrete using the brick dust and coconut shell.

V. DETERMINATION OF STRENGTH OF CONCRETE:-

According to IS 516:1959, a compressive strength test was performed using the Compression Testing Machine (CTM). The description of specimen and test result are shown in the following Table.4

Table.4 Description of specimen

Sr no.	Replacement %		Number of cubes	Total number of cubes
	Brick Dust	Coconut shell		
1	10	12	9	81
2	15	20	9	
3	18	25	9	
4	10	20	9	
5	10	25	9	
6	15	12	9	
7	15	25	9	
8	18	12	9	
9	18	20	9	

Table 4 shows the number of cubes casted for the experimental study.

VI. COMPRESSION STRENGTH OF CONCRETE

After performing all the tests and preparing the mix design for M-30 Grade of cement for brick dust and coconut shell, cubes were casted for 7 days, 14 days and 28 days. For each day test, three cubes were casted for every proportion.

Fig.5 150mm*150mm*150mm cube

Fig.5 shows the Concrete cube casted using 12 % Brick dust and 12% coconut shell For getting some idea about the strength of concrete using the substitute's material,

After the cubes were casted for each proportion for 7, 14 and 28 days, cubes were tested for compression strength using a compression testing machine.

Fig.6 Concrete cubes (150mm*150mm*150mm) in Compression test machine (CTM)

Compressive strength of cubes tested in the compression testing machine is shown in Fig.6

VII. RESULT OF COMPRESSION TEST

The compression of the cube cast was performed in the laboratory. Cubes were placed in the compression testing machine and the load was applied till the cubes were cracked. Analysis of the result from the compression test was done to obtain the optimum percentage of brick dust and coconut shell at which the concrete gives strength as near as the nominal concrete. Results of the tests performed are mentions below:-

Table.5 Result of tests.

Sr.no	Percentage of material		Compression strength		
	Brick dust	Coconut shell	7 days	14 days	28 days
1	10	12	18.7 N/mm²	25.98 N/mm²	29.15 N/mm²
2	15	20	16.18 N/mm²	22.99 N/mm²	24.21 N/mm²
3	18	25	15.37 N/mm²	19.20 N/mm²	21.05 N/mm²
4	10	20	18.5 N/mm²	25.74 N/mm²	28.98 N/mm²
5	15	12	17.2 N/mm²	23.45 N/mm²	26.12 N/mm²
6	18	12	16.02 N/mm²	21.32 N/mm²	24.16 N/mm²
7	10	25	17.48 N/mm²	24.33 N/mm²	27.19 N/mm²
8	15	25	15.7 N/mm²	20.1 N/mm²	22.63 N/mm²
9	18	20	15.58 N/mm²	20.72 N/mm²	23.32 N/mm²
10	0	0	19 N/mm²	26.13 N/mm²	29.35 N/mm²

As stated before, cubes were cast for testing at 7 days, 14 days and 28 days. The test result for the compression test at 7 days, 14 days and 28 days is shown in Table.5.

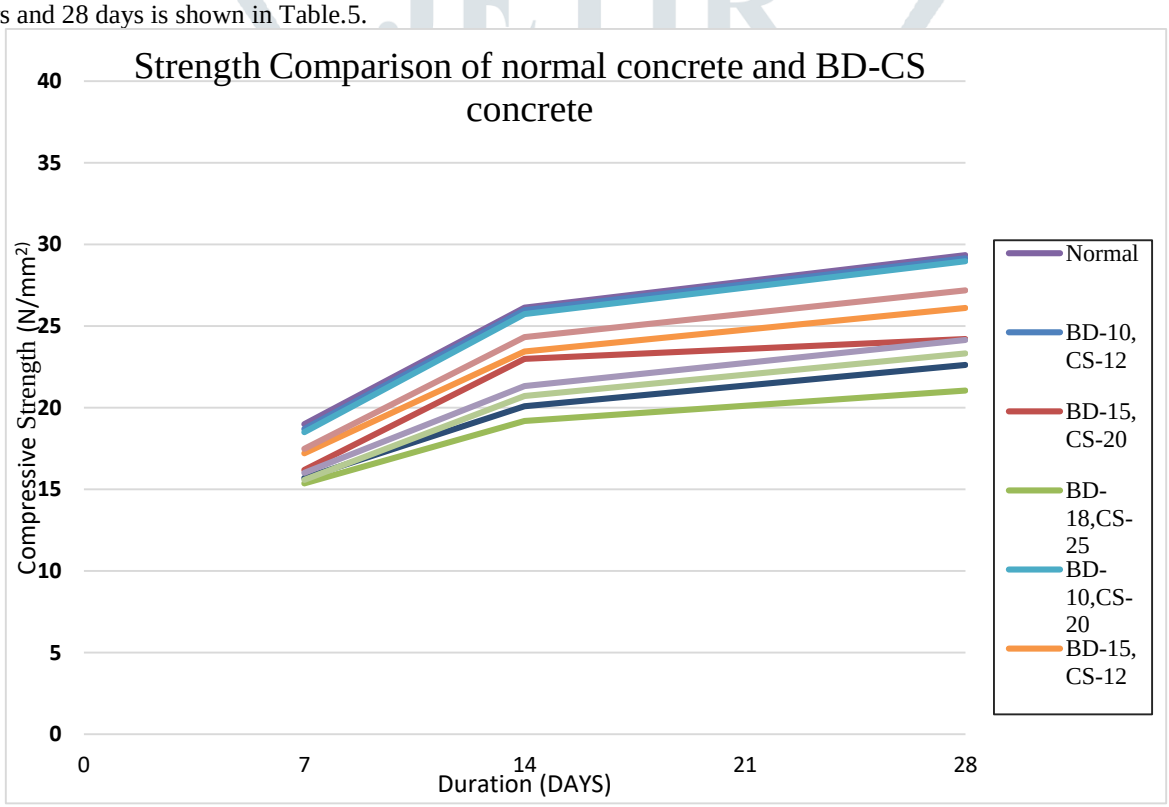

Fig.7 Comparison of Brick dust-coconut shell concrete and nominal concrete

For the better understanding of the test result of compression test, results was compared with nominal concrete. A graph was plotted to get the optimum percentage of coconut shell and brick dust that can be replaced with coarse aggregate and coconut shell respectively. Fig.7 shows the graph comparing Brick dust and coconut shell concrete with Nominal concrete.

II. Conclusion

So from the results, it is concluded that brick dust and coconut shells in concrete can be used to reduce the weight of the concrete.

- As the material used for replacement is a coconut shell, which is degradable but it takes more than 100 years to degrade, this material can be used as coarse aggregate.
- From the test performed on concrete, it is observed that as the percentage of Brick dust and coconut shell increase in the concrete the compressive strength of concrete decreases.
- It is also seen that as the percentage of Brick dust and coconut shell increases in concrete, the weight of concrete decreases.
- The cost of the concrete is reduced by using the substitute's material.

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