

EXPERIMENTAL STUDY ON PARTIAL REPLACEMENT OF FINE AGGREGATE WITH CONSTRUCTION DEBRIS

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Abstract

The construction industry has gained very fast growth in recent decades due to the increase in population, increase in industrialization and also introduction of new infrastructure projects. These resulted in the growth of construction industry drastically, which leads to a huge demand for construction materials and also in generation of huge amount of construction waste. The present work aims at finding the optimum concrete mixture encompassing of cement mortar and brick bat debris as a substitute for fine aggregate. Also the basic properties of cement mortar debris and brick bat debris as fine aggregate was studied and it is compared with the traditional fine aggregate. The effect of cement mortar debris and brickbat debris as fine aggregate in concrete for different proportions on strength was recorded at the curing age of 7, 14 and 28 days. All the data are tabulated and compared. It was observed that particular proportions of cement mortar debris and brickbat debris displayed enhancing effect on the compressive strength.

Keywords: Construction Waste, Debris, Compressive Strength

1. INTRODUCTION

Building materials accounts for about half of all materials used and about half the solid waste generated worldwide. Due to the increase in the economic growth after development and redevelopment projects in the country and subsequent increase in the urbanization in the cities has made construction sector to grow drastically on one side and on other side construction and demolition waste poses a great environmental impact due to increase in urban solid waste management. Construction and demolition waste is generated upto 25% annually in India. Out of it waste generation during construction alone is upto 60 kg per m²[1].

The major constituent of conventional concrete is sand which has become scarce and highly expensive. Hence the need for an alternative for the river sand has become a major concern for all. Moreover the surplus excavation of sand from river bed creates a major threat to the environment. The water head in the river bed decreases which results in lower ground water level due to digging of river sand. It also erodes the nearby land due to excess sand excavation and as well as it destroys the flora and fauna in nearby areas [2].

The present study aims at developing an optimum concrete mixture with cement mortar debris and brick bat debris as substitute to fine aggregate that can be used for building construction.

2. PROJECT DEVELOPMENT

Figure 1, illustrates the development of the project. In this study, the researcher collected pieces of uncontaminated cement mortar debris and brick bat debris from construction site.

These pieces of debris were crushed manually using hammer and graded as per the IS code 383 for fine aggregate, which is 100% passing in sieve 4.75mm. Using the sieved aggregate, various test and experiments such as specific gravity, water absorption, sieve analysis as per IS 2386(PART I) were conducted.

The graded crushed cement mortar debris, brick bat debris and river sand were mixed with water and cement with 1:1.5:3 ratios of cement to crushed cement mortar debris, brick bat debris and river sand to coarse aggregate.

The river sand is replaced about 50% with different proportions of cement mortar debris and brick bat debris. For each proportion 100mm cube specimens for 7th, 14th and 28th day of curing were tested for compression test. A conventional concrete was also tested in the same manner.

The results were evaluated to examine which proportion of cement mortar debris and brick bat debris can be used [3][4].

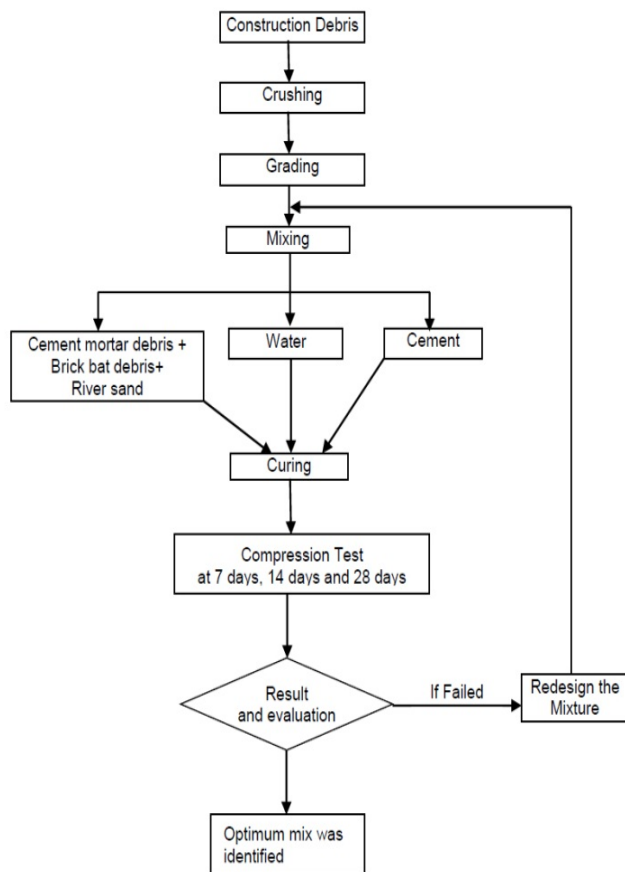


Fig.1 Project development flow chart

3. MATERIALS AND METHODOLOGY

Materials:

The following materials were used for the experiment:

Fine aggregate:

Crushed Cement mortar debris, brick bat debris collected from the construction site and river sand[5].

Cement:

Ordinary Portland cement (OPC 43) locally available in Puducherry in 50 kg bag was used for the experiment[5].

Water:

Normal potable water used for concrete[5].

Coarse aggregate:

Crushed quarry rocks (gravel)[5]

Methods:

Specific Gravity of Fine Aggregates:

The Pycnometer test method (IS 2386-PART I) was used to obtain the specific gravity of the river sand, cement mortar debris and brick bat debris [5].

Table 1: Specific gravity of river sand, cement mortar debris and brick bat debris

Material	River sand	Cement mortar debris	Brick bat debris
Specific Gravity	2.64	2.26	2.57

Gradation Test:

Sieve analysis (IS 2386-PART I) was carried out on the river sand, cement mortar debris and brick bat debris[6][7].

Table 3: Gradation analysis of the sand

Sl. No	Sieve size (mm)	Weight of aggregate retained (kg)	Weight retained (%)	Cumulative percentage of aggregate retained	Percentage passing (%)
1	4.75	0	0	0	100
2	1.60	1.050	35	35	65
3	0.60	0.510	50	85	15
4	0.425	0.190	6	91	9
5	0.30	0.100	3	94	6
6	0.15	0.007	0.2	94.2	5.8
7	0.09	0.010	0.3	94.5	5.5
8	Pan	0	0	94.5	5.5

Table 4: Gradation analysis of the cement mortar debris

Sl. No	Sieve size (mm)	Weight of aggregate retained (kg)	Weight retained (%)	Cumulative percentage of aggregate retained	Percentage passing
1	4.75	0	0	0	100
2	1.60	0.230	46	46	54
3	0.60	0.145	29	75	25
4	0.425	0.050	10	85	15
5	0.30	0.025	5	90	10
6	0.15	0.020	4	94	6
7	0.09	0.015	3	97	3
8	Pan	0.015	2	100	0

Table 5: Gradation analysis of the brick bat debris

Sl. No	Sieve size (mm)	Weight of aggregate retained (kg)	Weight retained (%)	Cumulative percentage of aggregate retained	Percentage passing
1	4.75	0	0	0	0
2	1.60	0.130	26	26	74
3	0.60	0.075	15	41	59
4	0.425	0.040	8	49	51
5	0.30	0.065	13	62	38
6	0.15	0.150	30	92	8
7	0.09	0.025	5	97	3
8	Pan	0.015	3	100	0

4. MIX DESIGN FOR M20 GRADE

Mix design is done for M20 grade concrete as per IS 456(2000)[8]

a. Design Stipulations:

Characteristic compressive strength required in field at 28 days is 20 N/mm²; Maximum size of aggregate is 20mm(angular);

Degree of workability is 0.90C.F;

Degree of quality control is good;

Type of exposure is Mild

b. Test Data for Materials:

Specific gravity for cement is 3.15;

Specific gravity of coarse aggregate is 2.6 and Fine aggregate is 2.6;

Table 6: Selection of water and sand content

Change in Condition	Adjustment	
	% of Water	% of sand in total Aggregate
Zone II	0	-1.5
For decrease in W/C (0.6-0.5=0.1)	0	-2
For increase in Compaction factor (0.9-0.8=0.1)	+3	0
	+3	-3.5

Required sand content as % of total aggregate by absolute volume = 35 - 3.5 = 31.5%

Required water content = (186 + 3/100) + 186 = 191.6 kg/m³

Water absorption for coarse aggregate is 0.5% and for Fine aggregate is 2.0 %

c. Design

Target Mean Strength of Concrete,

Assumed standard deviation as per IS 456-2000 referring the table (6) is S=4

Target mean strength = fck + ts

= 20 + 1.65(4) = 26.6 N/mm²

d. Selection of Water Cement Ratio:

For Target mean strength = 26.6 N/mm²;

From figure W/C ratio = 0.5

e. Selection of Water and Sand Content:

For aggregate size 20mm, water content including surface water, per cubic meter of concrete is 186kg.

Sand content as percentage of total aggregate of absolute volume is 35%

f. Determination of Cement Content:

Water cement ratio = 0.5

Water = 191.6 lit

Cement = 383.16 kg/m³

g. Determination of Coarse and Fine Aggregate Content:

Fine Aggregate: $V = \{W + C / S_c + (1/P)(f_a / S_{fa})\} (1/1000)$

Fine aggregate = 546 kg/m³

Coarse Aggregate: $V = \{W + C / S_c + (1/1-P)(C_a / S_{ca})\} (1/1000)$

Coarse Aggregate = 1187 kg/m³

h. Mix Proportion:

Water:Cement:FA: CA [9][10]

191.6	383.16	546	1187
0.5	1	1.5	3

5. MIX PROPORTION

Mix	Cement(%)	River sand(%)	Coarse aggregate(%)	Cement mortar debris(%)	Brick bat debris (%)	Cement(kg)	River sand(kg)	Coarse aggregate(kg)	Cement mortar debris(kg)	Brick bat debris(kg)
C1	100	50	100	25	25	1	0.750	3	0.375	0.375
C2	100	50	100	30	20	1	0.750	3	0.450	0.300
C3	100	50	100	40	10	1	0.750	3	0.600	0.150
C4	100	50	100	10	40	1	0.750	3	0.150	0.600
C5	100	50	100	20	30	1	0.750	3	0.300	0.450
C6	100	100	100	0	0	1	1.500	3	0	0

6. TESTING ON CONCRETE

Compressive Strength Test

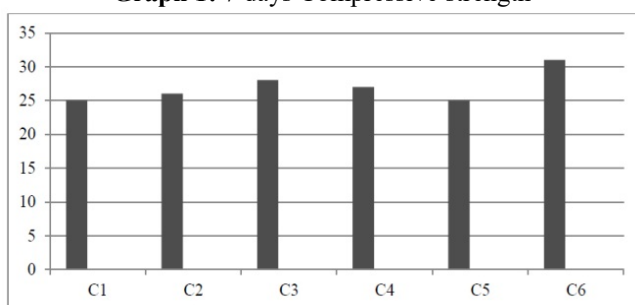
Metal moulds measuring 100mmX100mmX100mm were used to cast the concrete cubes. A total of 54 cubes were prepared for the mix ratios of 1:1.5:3 by weight and proportions of (River Sand: Cement mortar debris: brick bat debris) 50:25:25, 50:30:20, 50:40:10, 50:10:40, 50:20:30, 100:0:0 [11].

For each proportion 9 cubes were casted. The samples were left to cure for 7, 14 and 28 days. The weight of each cube of concrete for the compressive strength test was 2.5kg [12]. The concrete cubes were loaded to failure using compression machine in the laboratory. Compressive strength for different proportions on 7, 14 and 28 days was plotted on the graph A, graph B and graph C respectively[8].

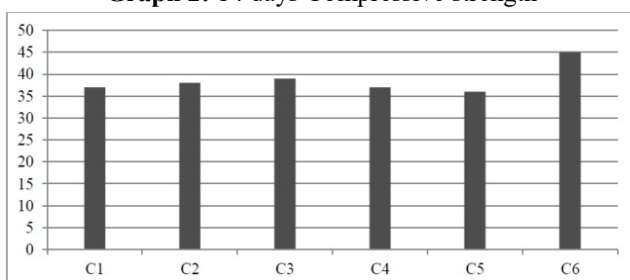
7. RESULTS AND DISCUSSION:

RESULTS

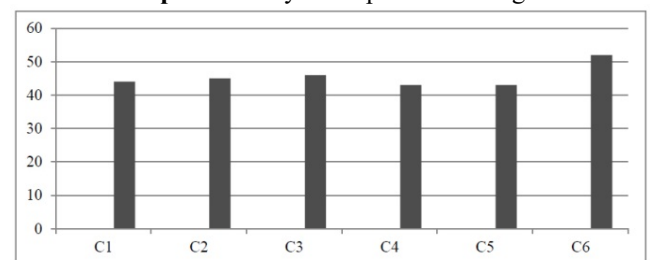
Graph 1: 7 days Compressive strength



Graph 2: 14 days Compressive strength



Graph 3: 28 days Compressive strength



DISCUSSION

Compressive strength for different concrete mix on 7, 14 and 28 days are plotted on the graph A, graph B and graph C respectively.

Mix C6 which is conventional concrete compressive strength on 28th day is 52kN/mm² is more than others.

All the other mixes C1 which has 25% of cement mortar debris and 25% of brick bat debris, C2 which has 30% of cement mortar debris and 20% of brick bat debris, C3 which has 40% of cement mortar debris and 10% of brick bat debris, C4 which has 10% of cement mortar debris and 40% of brick bat debris, and C5 which has 20% of cement mortar debris and 30% of brick bat debris have attained compressive strength about 80-90% of conventional concrete.

Mix C3 which has 40% of cement mortar debris and 10% of brick bat debris is relatively good and its compressive strength on 28th day is 46 kN/mm² [13][14][15].

8. CONCLUSION

The major constituent of conventional concrete is sand which has become scarce and highly expensive not just from economic point of view but also from environmental perspective too. Sand quarrying is done to extract sand for construction purposes. It affects the environment to a great extent. There is an urgent need to seek an alternative. Construction waste disposal in the environment disturbs the eco-system. From the results of experimental investigations conducted it is concluded that the construction debris such as concrete debris and brickbat

debris can be used as a replacement for fine aggregate. Hence, this concrete from construction waste can be used in construction buildings. Thus construction waste are disposed in an eco-friendly way and sand quarrying can be reduced. Thus a greener environment can be build. [16].

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