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AN EXPERIMENTAL STUDY ON USE OF QUARRY DUST AND RECYCLED AGGREGATE AS PARTIAL REPLACEMENT OF FINE AND COARSE AGGREGATE IN CEMENT CONCRETE

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Abstract: During the extraction and mining process of rocks and demolition of structures Quarry Dust and Recycled Aggregate are obtained which are basically waste materials. Due to increase in use of fine and coarse aggregates in construction industry it has become essential to find out an economic substitute for these materials which can be used in concrete. So in our study we are using Quarry Dust and Recycled Aggregate as an economic substitute for fine and coarse aggregates and checking their characteristics by comparing it with conventional concrete. Quarry dust obtained from Budera Quarry Mines near Raipur district and recycled aggregate is obtained from demolished old building in Raipur district. Here M20 mix of concrete of ratio 1:1.5:3 (Cement: Fine aggregate +Quarry dust: Coarse Aggregate +Recycled aggregate) and water cement ratio of 0.40 is used for preparing test samples by replacing fine and coarse aggregate with quarry dust and recycled aggregate in percentages varying from 0%, 10%, 20%, 30%, 40% and 50% by weight organized as A1, A2, A3, A4, A5, A6 respectively. The test results obtained from fresh and hardened concrete tests shows clearly that more than 40% replacement causes decrease in strength and workability of concrete hence the percentage of mix shall be kept upto 40%.

Index Terms **- Recycled Aggregates (RA), Quarry Dust (QA), Strength, Workability**

1. INTRODUCTION

Concrete is a composite man made material and is most widely used building material in the construction industry. Rather than existing as an self-governing material, concrete is a mix of numerous materials. These materials include cement, sand, water and crushed stones or gravel. Sand and gravel or crushed stones are classified under fine aggregate and coarse aggregate, respectively. Due to the hike in cost of these materials most of the countries in world are experiencing numerous challenges to replace fine aggregate and coarse aggregate partially or fully without reducing the strength and workability properties of concrete. Some emerging countries are facing a deficiency in the supply of natural sand because of river erosion and other environmental issues have led to scarcity of natural river sand. So to diminish the use of natural river sand and cost of concrete production it is necessary to find an alternative material to replace natural sand so as to avoid the soil erosion. Likewise coarse aggregate acquired from mining activities has also given rise to numerous environmental issues along with rise in the cost of it, so in order to overcome all these problems two such alternate materials have been used in our study i.e. Quarry Dust and other is Recycled Aggregate.

1.1 QUARRY DUST

Quarry dust is a byproduct obtained from quarrying process of rocks. After the extraction of aggregates of definite sizes the dust particles is generated which is basically grey in color and is considered as a waste material and these waste materials are now being used as a construction material. For our study Quarry dust is obtained from Budera mines of village Budera in Raipur district.

Figure 1- Quarry Dust

1.2 RECYCLED AGGREGATE

The recycled aggregate is a waste material obtained by crushing the demolished concrete structures. In other context recycled aggregate refers to material that has been previously used in construction activities. For our study recycled aggregate is obtained from old concrete demolished building located in Raipur District in Chhattisgarh State.

Figure 2- Recycled Aggregate

2. MATERIAL AND ITS PROPERTIES

Various materials used in our study are cement, sand, water, aggregate, quarry dust and recycled aggregate. Properties of these materials are determined by different lab tests which are tabulated below -

2.1 CEMENT

Cement for our study is purchased from local shop in Raipur district. It is Ordinary Portland Cement of Ultratech brand with compressive strength of 53 N/mm^2. Test for soundness, consistency, initial and final setting time and specific gravity are performed in lab. Test results are as follows –

Table 1- Physical properties of Cement

Parameter	Value
Normal consistency (%)	29
Specific gravity, G_C	3.15
Initial /Final setting time (minutes)	43/365
Soundness by Le-Chatelier expansion (mm)	3

Table 2- Chemical composition of Cement

CaO	SiO_2	AlO_3	Fe_2O_3	Mg O	K_2O	SO_3	P_2O_5	LOI	LSF
64.26	21.07	5.54	5.16	0.86	0.37	0.72	0.33	1.54	0.925

2.2 SAND

Sand for our study is obtained from Samoda River near Arang block, Raipur district, Chhattisgarh. Test for specific gravity and fineness modulus are performed in lab for sand. Test results are as follows –

Table 3- Sieve Analysis of Fine Aggregate

I.S. Sieve size	Percentage passing		Remark
	As per test	IS requirement for Zone III	
10mm	100	100	Falling in zone III
4.75mm	98.57	100-90	
2.36mm	83.46	85-100	
1.18mm	74.56	75-100	
600µ	68.23	60-79	
300µ	34.38	12-40	
150µ	8.19	0-10	
75µ	0.80%	Max 15	

Table 4- Physical Properties of Fine Aggregate

Physical properties of fine aggregate	Results
Specific gravity	2.65
Fineness modulus	2.81

2.3 AGGREGATE

Aggregate for our study is obtained from Budera Mines near Budera Village, Raipur district, Chhattisgarh. Test for specific gravity and fineness modulus are performed in lab for sand. Test results are as follows –

Table 5- Properties of Coarse Aggregate

Physical properties of coarse aggregate	Results
Specific gravity	2.77
Fineness modulus	6.72
Shape	Angular
Size	20 mm

2.4 QUARRY DUST

Quarry Dust for our study is obtained from Budera Mines near Budera Village, Raipur district, Chhattisgarh. Test for specific gravity and fineness modulus are performed in lab for sand. Test results are as follows –

Table 6- Physical Characteristics of Quarry Dust

Physical properties of quarry dust	Results
Specific gravity	2.5
Fineness modulus	2.9

2.5 RECYCLED AGGREGATE

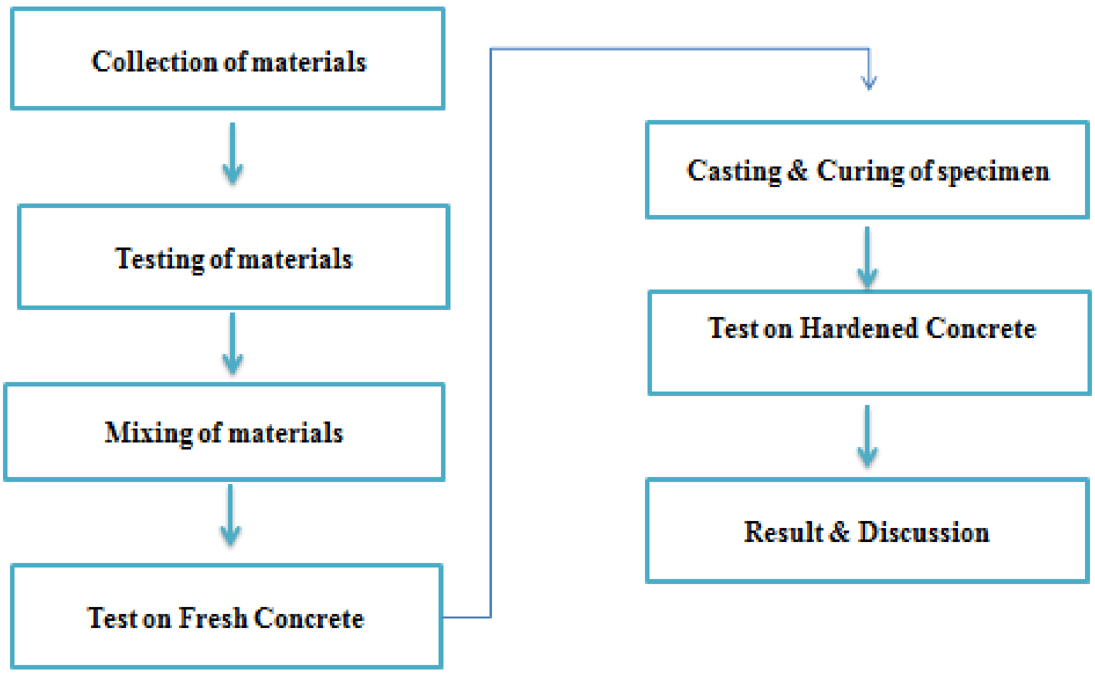
Recycled Aggregate for our study is obtained from demolished building from Raipur district Chhattisgarh. Test for specific gravity and fineness modulus are performed in lab for sand. Test results are as follows –

Table 7- Physical Characteristics of Recycled aggregates

Physical properties of recycled aggregate	Results
Specific gravity	2.45
Shape	Angular
Fineness modulus	6.72
Size	20 mm

3. METHODOLOGY

The methodology adopted has been represented by flowchart:



3.1 MIXING OF MATERIALS

Concrete mixing is done using hand mix. First cement, sand and aggregate are taken in proportion 1:1.5:3 and mixed with quarry dust and recycled aggregates in different percentages i.e. 0%, 10%, 20%, 30%, 40%, 50% by replacing sand and aggregate each respectively. By which different mixes were formed named as A1, A2, A3, A4, A5 and A6 and then cement is mixed in required proportion by shovels. After this water is added to the different mixes to form concrete of required consistency by keeping water cement ratio of 0.40.

3.2 TESTS ON FRESH CONCRETE

For testing fresh concrete properties tests like slump test and compaction factor test are performed. These tests determine the workability and compaction factor of concrete.

3.3 CASTING AND CURING OF SPECIMEN

36 Cubes of size (150×150×150) mm and 36 Cylinders of size (150×300) mm were casted and tests were conducted to study the strength characteristics of hardened concrete of different test samples A1, A2, A3, A4, A5, and A6. Curing is the process of keeping the concrete moist enough, so that the hydration of cement can be completed until the desired properties are developed. The specimens are taken out of the mould after 24hrs and are then submerged into the water tank for curing period of 7 and 28 days.

3.4 TESTS ON HARDENED CONCRETE

Since the strength of concrete is related to the structure of hardened cement paste the following tests that have been performed on hardened concrete for assessing the strength of concrete. These tests are Compressive strength test and Split tensile strength test.

3.4.1 COMPRESSIVE STRENGTH TEST

As per IS Code for each mix 3 cubes should be casted for checking the compressive strength of concrete so after the desired curing period, the compressive strength of the specimen is determined. So in total thirty six cubes each of size 15cm X 15cm X 15cm were tested by compressive testing machine out of which 18 cubes were tested after 7 days and 18 cubes were tested after 28-days.

Compressive strength= Load/Cross sectional area

Figure 3- Compressive Strength Test

3.4.2 SPLIT TENSILE STRENGTH TEST

As per IS Code for each mix 3 numbers of cylindrical specimens of size (15cmX30cm) were casted and after the desired curing period, the split tensile strength of the cylinder is determined. So in total thirty six cylinders were tested out of which 18 cylinders were tested after 7 days and 18 cylinders were tested after 28-days.

Split tensile strength = 2P / πDL,

Where P = Applied load, L = Length of the specimen,

D = diameter of the specimen.

Figure 4- Split Tensile Strength Test

4. TEST RESULTS

This chapter is concerned with the presentation of results of the experiments carried out towards the objective of the project. It includes results from Slump test, Compaction factor test, Compressive Strength Test and Split TensileStrength.

4.1 SLUMP TEST RESULTS

Table 8- Slump Test values

Mix	Percentage of quarry dust and recycled aggregates	Slump value(mm)
A1	0%QD+0%RA	91
A2	10%QD+10%RA	85
A3	20%QD+20%RA	86
A4	30%QD+30%RA	83
A5	40%QD+40%RA	83
A6	50%QD+50%RA	81

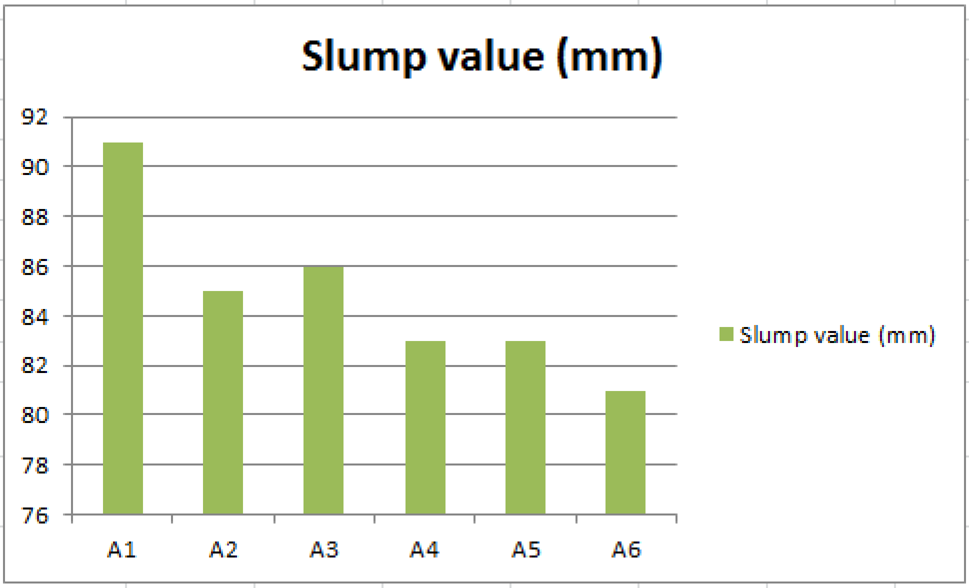


Figure 5 – Graph of Slump value (mm).

4.2 COMPACTION FACTOR TEST RESULTS

Table 9- Compaction Test values

Mix	Percentage of quarry dust and recycled aggregates	Partially Compacted Concrete (W_1)Kg	Fully Compacted Concrete (W_2)Kg	Empty Cylinder (W)Kg	Compaction Factor(W_1-W) / (W_2-W)
A1	0%QD+0%RA	16.9	17.6	4.6	0.94
A2	10%QD+10%RA	16.2	17.1	4.6	0.92
A3	20%QD+20%RA	16	17.3	4.6	0.89
A4	30%QD+30%RA	16.1	17.2	4.6	0.91
A5	40%QD+40%RA	15.45	16.7	4.6	0.89
A6	50%QD+50%RA	14.5	16.2	4.6	0.85

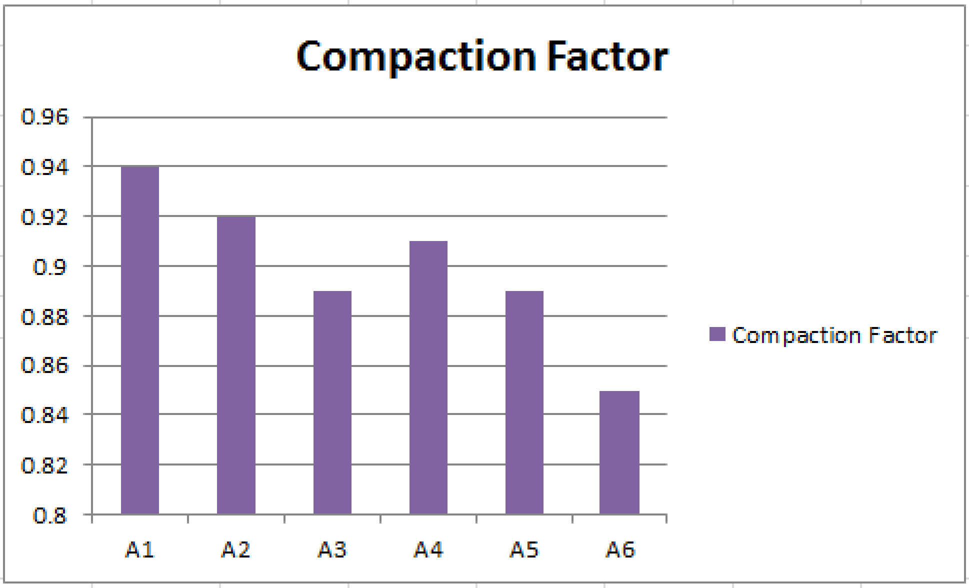


Figure 6 – Graph of Compaction factor test.

4.3 COMPRESSIVE STRENGTH TEST RESULTS

Table 10- Compressive Strength Test values

Mix	Percentage of quarry dust and recycled aggregates	w/c	7 days f_{ck}	28 days f_{ck}
A1-1	0%QD+0%RA	0.4	13.2	22.5
A1-2	0%QD+0%RA	0.4	13.8	23.1
A1-3	0%QD+0%RA	0.4	13.5	23.4
A2-1	10%QD+10%RA	0.4	13.2	21.6
A2-2	10%QD+10%RA	0.4	12.8	21.65
A2-3	10%QD+10%RA	0.4	12.6	21.7
A3-1	20%QD+20%RA	0.4	13.1	20.8
A3-2	20%QD+20%RA	0.4	12.5	21.6
A3-3	20%QD+20%RA	0.4	12.8	21.4
A4-1	30%QD+30%RA	0.4	12.4	20.8
A4-2	30%QD+30%RA	0.4	12.9	21.6
A4-3	30%QD+30%RA	0.4	12.1	21.3
A5-1	40%QD+40%RA	0.4	12.2	20.25
A5-2	40%QD+40%RA	0.4	11.95	20.5
A5-3	40%QD+40%RA	0.4	11.45	19.75
A6-1	50%QD+50%RA	0.4	11.1	19.5
A6-2	50%QD+50%RA	0.4	10.5	18.7
A6-3	50%QD+50%RA	0.4	10.8	18.9

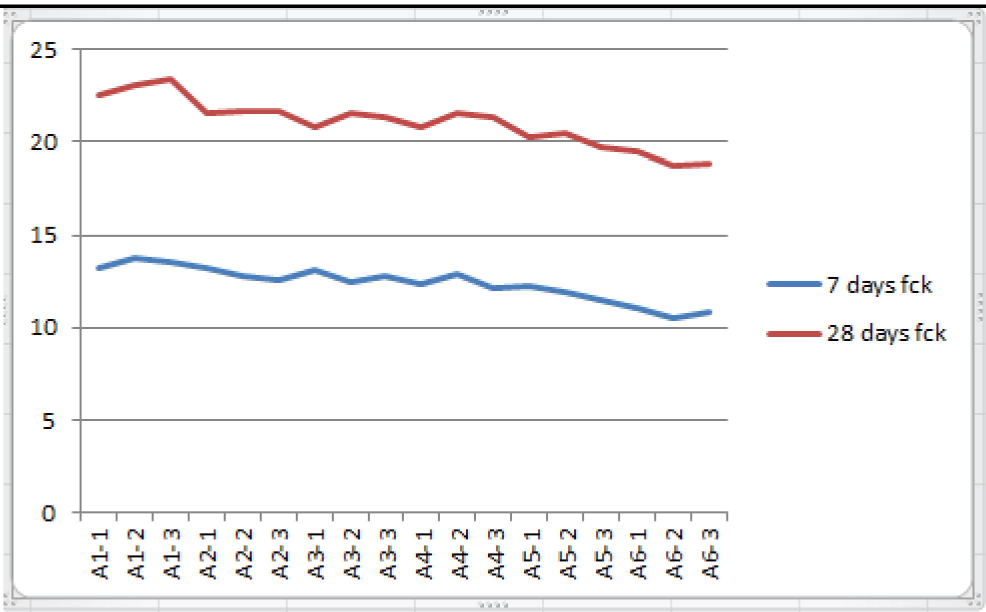


Figure 7 – Graph for compressive strength test.

4.4 SPLIT TENSILE STRENGTH TEST RESULTS

Table 11- Split Tensile Strength Test values

Mix	Percentage of quarry dust and recycled aggregates	w/c	7 days tensile strength	28 days tensile strength
A1-1	0%QD+0%RA	0.4	1.73	3.13
A1-2	0%QD+0%RA	0.4	1.69	3.15
A1-3	0%QD+0%RA	0.4	1.74	3.09
A2-1	10%QD+10%RA	0.4	1.72	3.12
A2-2	10%QD+10%RA	0.4	1.61	2.97
A2-3	10%QD+10%RA	0.4	1.59	2.98
A3-1	20%QD+20%RA	0.4	1.56	2.96
A3-2	20%QD+20%RA	0.4	1.59	2.97
A3-3	20%QD+20%RA	0.4	1.67	3.01
A4-1	30%QD+30%RA	0.4	1.61	3.07
A4-2	30%QD+30%RA	0.4	1.66	3.00
A4-3	30%QD+30%RA	0.4	1.65	3.03
A5-1	40%QD+40%RA	0.4	1.54	2.89
A5-2	40%QD+40%RA	0.4	1.6	2.93
A5-3	40%QD+40%RA	0.4	1.51	2.87
A6-1	50%QD+50%RA	0.4	1.55	2.9
A6-2	50%QD+50%RA	0.4	1.52	2.85
A6-3	50%QD+50%RA	0.4	1.45	2.82

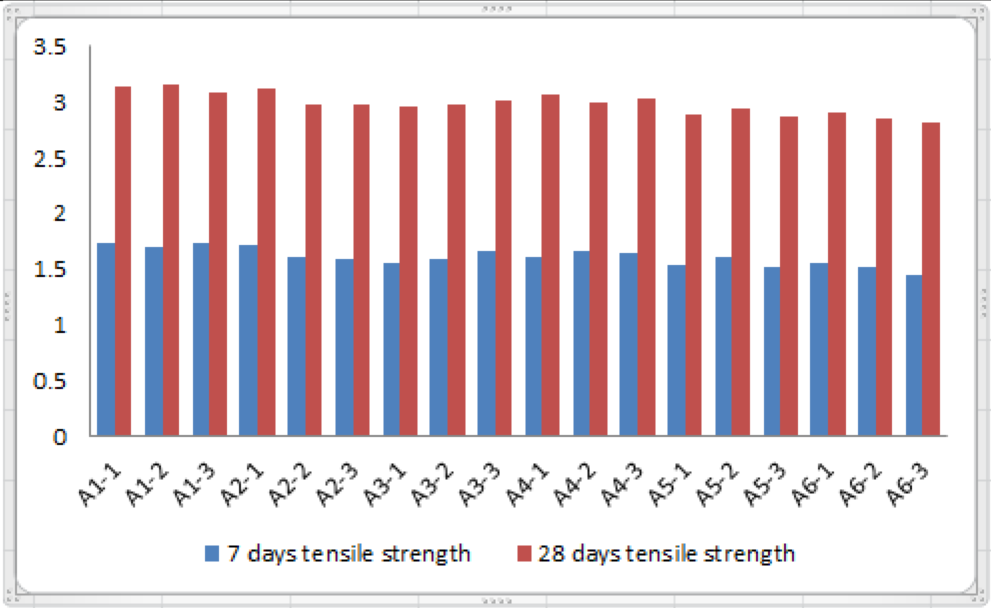


Figure 8– Graph for Split tensile strength test.

5. CONCLUSION

When the fine and coarse aggregate are replaced with quarry dust and recycled aggregate in different percentages varying from 0 to 50% then the following test results were determined :-

1. From table 8 & 9 it can be clearly depicted that by replacing Sand and Aggregate with Quarry dust and Recycled aggregate shows a minute change in workability of concrete, hence concrete can be easily used as it makes the concrete workable as per IS standards norms.

2. From table 10 it can be clearly depicted that the compressive strength of concrete at the end of 7days and 28days obtained from A5 mix is 11.86 N/mm^2 and 20.16 N/mm2 respectively, the strength of which is found to be identical to compressive strength of conventional concrete for M20 mix. So it can be concluded that by replacing 40% of fine and coarse aggregate with quarry dust and recycled aggregate, the desired strength of concrete can be achieved.

3. From table 11 it can be clearly depicted that the split tensile strength of concrete at the end of 7days and 28days obtained from A5 mix is1.55N/mm^2 and 2.89N/mm^2 respectively, the strength of which is found to be identical to split tensile strength of conventional concrete for M20 mix. So it can be concluded that by replacing 40% of fine and coarse aggregate with quarry dust and recycled aggregate, the desired strength of concrete can be achieved.

4. So it can be summarized from test results that replacement of 40% of fine and coarse aggregate with quarry dust and recycled aggregate the concrete properties are within the permissible limit as per IS Code.

5. So by replacing 40% of fine and coarse aggregate with quarry dust and recycled aggregate turns out to be economical by reducing the cost of construction upto 30%.

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