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Mechanical Properties of Coconut Shell Concrete with Quarry Dust

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Abstract

The main of this experimental study is to investigation mechanical properties of coconut shell concrete with quarry dust. Compressive, flexural, split tensile strengths and impact resistance were tested and compared with conventional concrete with river sand, conventional concrete with quarry dust, coconut shell concrete with river sand, coconut shell concrete with quarry dust. Coconut shell concrete with quarry dust compressive, flexural, split tensile strengths are increased by 7%, 2.15%, 5.6% and impact resistance is also increased more compared to coconut shell concrete with river sand.

Keywords:

Conventional concrete with river sand(CC),
Conventional concrete with quarry dust(CCQ),
Coconut shell concrete (CSC),
Coconut shell concrete with quarry dust (CSCQ).

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1. Introduction:

Conventional concrete is a mixture of cement and aggregates. Properties of aggregates affect the durability and performance of concrete, so coarse aggregate and fine aggregate is an essential component of concrete.The rapid growth of construction industry leads to more usage of coarse aggregate and fine aggregate it directly affects the presence of natural resources. In this situation researchers began to replace both coarse aggregate and fine aggregate. In this paper research is done if coarse aggregate is replaced with coconut shells and fine aggregate is replaced with quarry dust.

1.1. Coconut shell aggregate:

In view of the escalating environmental problems, the use of aggregates from by-products and/or solid waste materials from different industries is highly desirable. In recent years researchers have also paid more attention to some agriculture wastes for use as building material in construction. One such alternative is coconut shell (CS) , which is one of the most common agricultural solid wastes in many tropical countries. Eight of the ten large producers are in the Asia Pacific region. The three main producers, Indonesia, the Philippines and India account for 75% of world production. The vast amount of this discarded coconut shell resource is yet unutilized

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commercially; its use as a building material, especially in concrete, on the lines of other lightweight aggregates is an interesting topic for further studies.

1.2. Quarry dust:

The global consumption of natural sand is very high, due to the extensive use of concrete. In general, the demand of natural sand is quite high in developing countries to satisfy the rapid infrastructural growth, in this situation developing country like India facing shortage in good quality natural sand. Particularly in India, natural sand deposits are being depleted and causing serious threat to environment as well as the society. In past decade variable cost of natural sand used as fine aggregate in concrete increased the cost of construction. In this situation research began for inexpensive and easily available alternative material to natural sand. Some alternatives materials have already been used as a part of natural sand e.g. flyash, slag limestone and siliceous stone powder were used in concrete mixtures as a partial replacement of natural sand. Natural river sand, if replaced by hundred percent quarry rock dust from quarries, may sometimes give equal or better than the reference concrete made with natural sand, in terms of compressive and flexural strength. Now a day's sustainable infrastructural growth demands the alternative material that should satisfy technical requisites of fine aggregate as well as it should be available abundantly.

In this study, the important mechanical properties of coconut shell concrete(CSC) using quarry dust, namely compressive, flexural, splitting tensile strengths and impact resistance have been measured.

2. Materials used:

In this experimental study the composition of concrete materials like cement, crushed granite stone, coconut shell, quarry dust, fine aggregate and water used are described as follows:

2.1. Coconut shell as coarse aggregate:

The freshly discarded shells were collected from the pattukottaiand they were well seasoned.The seasoned CS is crushedby a mini crusher, which was developed and erected in SRM Universityspecifically for this purpose. The crushed edges were roughand spiky and the lengths were restricted to a maximum of 12 mm.The surface texture of the shell was fairly smooth on concave andrough on convex faces. CS aggregates used were in saturated surface dry (SSD) condition. The physical properties of CS were comparedwith crushed granite listed in Table1.

2.2. Quarry dust:

Quarry dust is fine rock particles. When boulders are broken into small pieces quarry dust is formed. It is grey in colour and it is like fine aggregate. The quarry dust was obtained from local resource for the investigation.

2.3. Other concrete mix constituents:

Ordinary Portland Cement (OPC) 53 Grade conforming to Indian Standard IS 12269:1987 was used as a binder. River sand (from Palarriver bed) was used throughoutinvestigationas the fine aggregate conforming to grading zone III as per IS 383:1970. Thepotable water from the University was used for mixing and curing.Specimens were cast in such a way as to produce full compaction of the concrete with neither segregation nor excessive laitance. Compaction was achieved through use of a table vibrator.

Table.1 Properties of Material

SI. No	Physical and Mechanical properties	Coconut shells	Crushed granite	River sand	Quarry dust
1	**Maximum size(mm)**	12.5	12.5	-	-
2	**Waterabsorption (24h)%**	24.00	-	-	-
3	**Specific gravity**	1.05-1.20	2.82	2.57	2.64
4	**Crushing value (%)**	2.58	6.30	-	-
5	**Bulk density(kg/m³)**	650	1650	1466	1654
6	**Fineness modulus**	6.26	6.94	2.56	2.54
7	**Shell thickness(mm)**	2-8	-	-	-

3. Experimental investigation:

In this experimental program to assess mechanical properties total 4 mixes were done. The mechanical properties (Compressive, flexural, split tensile strength and impact resistance) and workability (slump and compaction factor) were studied on conventional concrete with river sand,

Conventional concrete with quarry dust, coconut shell concrete with river sand, coconut shell concrete with quarry dust. From the literatures twoMix proportions were considered [3]. The mix proportions for conventional concrete with river sand and conventional concrete with quarry dust is 1:2.22: 3.66 &0.55 with maximum cement content of 320 kg/m³ is considered. The mix proportions for coconut shell concrete with river sand and coconut shell with quarry is 1:1.42: 0.65

& 0.42 is considered. The above mixes were confined to M25 grade concrete mix design.

3.1. Compressive strength:

The compressive strength of 100 mm cubes was measured according to IS 516:1959. 4 Mix was used to study the flexural, splitting tensilestrength and impact resistance.

3.2. Flexural strength test:

Four-point load method was adopted to measure the flexural strength of CSCQ.

ASTM guidelines, beams of 100 × 100 × 500 mm

Size as shown in Fig. 2, 3was adopted.Theload was applied without shock and was increased until the specimenfailed, and the maximum load applied to the specimen duringthe test was recorded. The appearances of the fractured faces ofconcrete failure were noted. The results are presented in Table.4. The flexural strength of the specimenswas calculated as follows:

Modulus of rupturef_b = (PL)/ (bd²)

Where

P = Maximum load applied (N).

L = Supported length of thespecimen (mm).

b = Measured width of the specimen (mm).

d = Measuredwidth of the specimen at the point of failure (mm).

3.3 Split tensile strength

Table.2 Experimental program

Description	Fresh concrete Density(kg/m³)	Slump(mm)	Compactionfactor	DemouldedconcreteDensity(kg/m³)
CC	2477	8	0.90	2510
CSC	2138	5	0.88	1982
CQC	2586	0	0.91	2465
CSQC	2247	0	0.91	2091

As per ASTM guidelines 100mm diameter × 200 mm long cylinders were used for splitting tensile strength test shown in Fig. 5, 6.The test specimen was placed in the centering with packing stripand/or loading pieces carefully positioned along diametrically verticalplanes at the top and bottom of the specimen.The maximumdiametrical load applied was recorded.The measured splitting tensilestrength f_{sp} of the specimen was calculated using the followingformula:

Table. 3 Properties of concrete

SI. No	parameters	No. mixes and total No. of specimens	Age during testing
1	**Compressive strength**	4 Mixes 9 cubes in each mix total 36 Cubes	3 - Days, 7 - days, 28 - days.
2	**Flexural strength**	4 Mixes 9 beams in each mix total 36 Beams	3 - Days, 7 - days, 28 - days.
3	**Splitting tensile strength**	4 Mixes 9 cylinders in each mix total 36 Cylinders	3 - Days, 7 - days, 28 - days.
4	**Impact resistance**	4 Mixes 9 discs in each mix total 36 Discs	3 - Days, 7 - days, 28 - days.

$Fsp = 2P/(\pi DL)$

Where

P = maximum load applied to the specimen (N).

D = crosssectional diameter of the specimen

(Mm) and

L = length of the specimen(mm).

3.4. Impact resistance:

The method developed by ACI committee 544.1R-82 for the determination of impact resistance of concrete was adopted. The test specimens used for the impact tests were 152.4 mm in diameter and 63.5 mm thick. During this test, the number of blows was counted till the first crack appeared (initial crack) on each specimen and counting was continued till the specimen was broken into a number of pieces.

4. Discussions on test results:

The results obtained from mechanical properties (compressive, flexure, split tensile strength and impact resistance) are compared with conventional concrete with river sand, conventional with quarry dust, coconut shell concrete, coconut shell with quarry dust.

4.1. Workability and density:

Coconut shell concrete with quarry dust has less workability and more density. Generallyquarry dust has more fine particles compared to river sand, these fine absorb more water content. Bulk density of quarry dust is more compared to river sand. Hence density of coconut shell concrete with quarry dust is more compared to coconut shell concrete. Particles compared to river sand.

Table. 4 Test results

Description	Compressive Strength (N/mm²)	Flexural Strength (N/mm²)	Split tensile strength
CC	28.70	4.74	3.40
CCQ	31.10	4.83	3.64
CSC	26.40	4.55	2.68
CSQ	28.36	4.62	2.74

Table. 5 Test results

Description	Avg. Number Of blows for Initial crack	Avg. Number Of blows for Final crack
CC	17	20
CCQ	19	22
CSC	26	32
CSQ	27	34

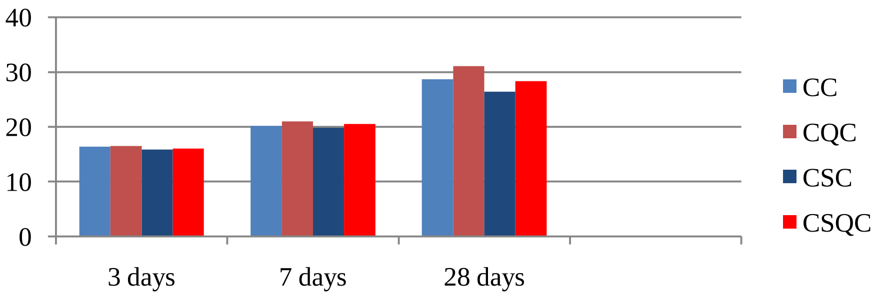
4.2. Compressive strength:

The compressive strength of coconut shell concrete with quarry dust at 28 days is comparable with conventional concrete, conventional concrete with quarry dust.Compressive strength of coconut shell concrete with quarry dust is increased by 7% as compared with coconut shell concrete with river sand. An examination of the failure surface showed breakage of coconut shell aggregate indicating that the individual shellStrength had a strong influence on the resultant concrete strength.

FIGURE1: compressive strength test specimens

FIGURE 2:Split tensile strength test specimens

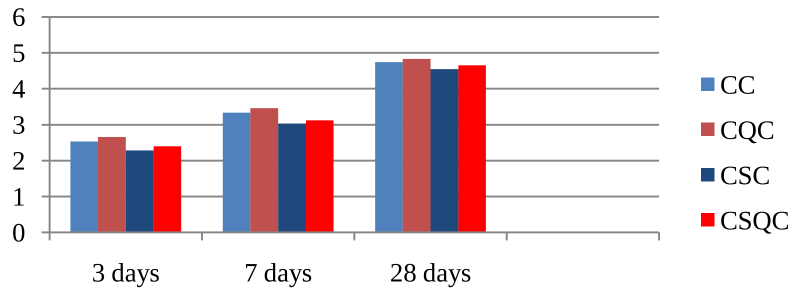
FIGURE 3:flexural strength test specimens



Graph 1: Comparison of compressive strength

4.3. Flexural strength:

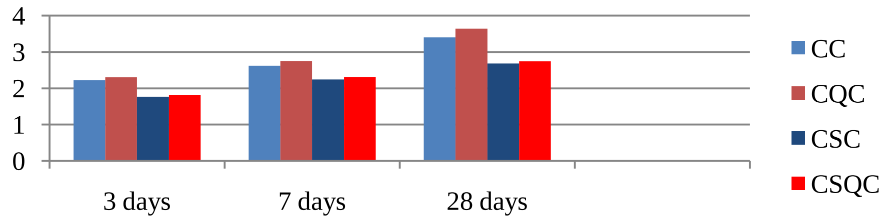
Flexural strength of coconut shell concrete with quarry dust at 28 days is 4.65 N/mm^2 (16.4 % of compressive strength). For conventional concrete the flexural strength is usually 10 - 15% of compressive strength. Compared to flexural strength as per IS 456: 2000, $0.7\sqrt{f_{ck}}$ where f_{ck} is compressive strength of conventional concrete, these values are higher by 19.35%. Compression strength of conventional concrete with quarry dust these values are higher by 16.2%. Flexural strength of coconut shell with quarry dust is increased by 2.15% as compared to coconut shell concrete with river sand.



Graph 2: Comparison of flexural strength

4.4. Split tensile strength:

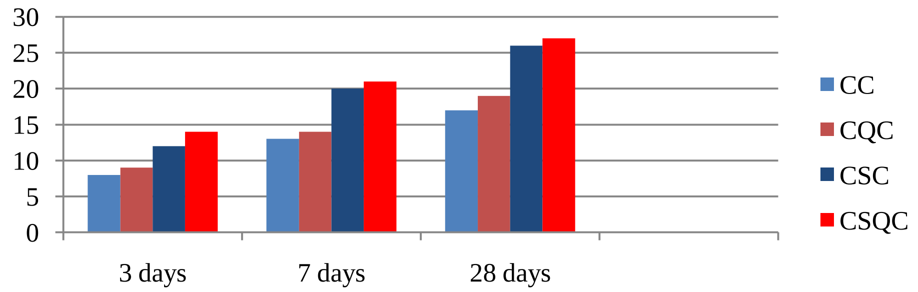
Splitting tensile strength of coconut shell with quarry dust at 28 days is 2.84 N/mm² (10.01% of compressive strength), conventional concrete is 3.40 N/mm² (11.8% of compressive strength), and conventional concrete with quarry dust is 3.64 N/mm² (11.7% of compressive strength). Splitting tensile strength of coconut shell concrete with quarry dust is increased by 5.6% as compared to coconut shell concrete with river sand.



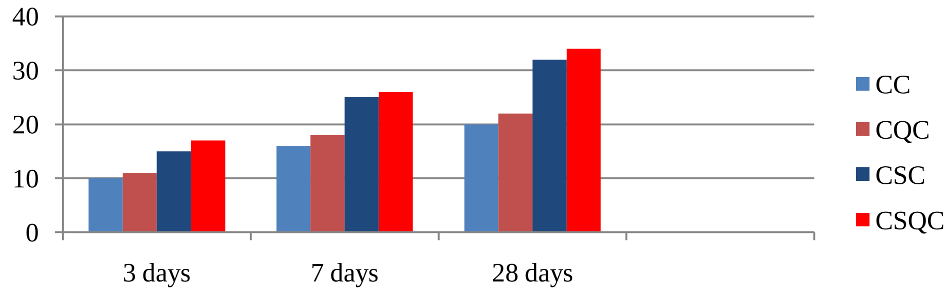
Graph 3: Comparison of split tensile strength

4.5 Impact resistance:

Impact resistance generally increased with concrete strength both for initial crack and for failure. But in this study coconut shell concrete with quarry dust at 28 days has 27 - 34 blows, which has more number of blows compared to conventional concrete (17 - 20), conventional concrete with quarry dust (19 - 22), coconut shell concrete with river sand (26 - 32). This increase may be due to the fibrous nature of the coconut shell aggregate and its high impact resistance.



Graph 4: Comparison of initial crack



Graph 5: Comparison of final crack

5.Conclusion:

The flexural strength of coconut shell concrete with quarry dust is approximately 16.4% of its respective compressive strengths (28.36 N/mm²). The splitting tensile strength of coconut shell with quarry dustis approximately 10.01% of its respective compressivestrengths. The impact resistance of coconut shell concrete with quarry is high when compared with conventional concrete with river sand, conventional concrete with quarry dust and coconut shell concrete with river sand.

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