Experimental Investigation using Agro-Waste as Partial Replacement of Coarse Aggregate

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Abstract- Malaysia and South India being a major rubber trees growing country has been generating a largeamount of rubber seed shell which regarded as waste. At the same time, the growing construction industry which boosts the concrete production trade has results in higher consumption of natural coarse aggregate which open the door for depletion of this material in future. This study focuses on investigating the possibility of integrating crushed rubber seed shell(RSS) as partial coarse aggregate replacement material in concrete making. The M25 grades concrete are used in this project. Total of five mixes consisting various content of crushed rubber seed shell as partial coarse aggregate replacement ranging from 0, 5, 10, 15, 20 and 25% respectively. The 5% of Metakaolin is used as constant for all mixes to reduce the cement content. All the specimens were water cured before tested at 7,14 and 28 days. Generally, workability, compressive strength and flexural strength decrease with the increase in the crushed rubber seed shell replacement level.

Keyword: Rubber seed shell, Metakaolin, compressive strength, split tensile strength

1.Introduction

Malaysia is one of the major rubber tree growing country which produces latex for material production also produces rubber seeds with hard shell which falls from the tree and left to biodegrade. Since the Malaysian annual production of rubber seed is projected to be 1.2 million metric tons (Eka *et al*., 2010), it is seen that this freely available waste could be explored its potential for the benefit of mankind. At the same time, the increasing demand for concrete product for the use in developing construction industry has lead towards continuous consumption of aggregate from natural resources in increasing quantity which would create ecological imbalance. Since, the high consumption of raw material by construction industry which becomes one of the main factors of natural resources depletion and environmental damage can be handled through integration of waste material in concrete production (Wai *et al*., 2012).
Strength of a normal concrete containing Crushed Rubber Seed Shell (CRSS) as partial coarse aggregate replacement material

1.1 Application of rubber seed shell as coarse aggregate

Rubber seed shell is also the contributor to the nation's pollution problem as a solid waste in the form of waste rubber seed shells. In view of huge demand, naturally available conventional aggregates are depleting fast and becoming scarce. Waste rubber seed shell may also be considered as one of the replacement alternative. In the experimental study observed that there is no need to treat the rubber seed shell before use as an aggregate except for water absorption. The study was carried out for various percentage of rubber seed shell content as partial replacement of conventional aggregate. They observed that replacement of appropriate rubber seed shell content produces workable concrete with satisfactory strength.

1.2 Experimental investigation

The present study was carried out for M25 grade concrete, the mix which has characteristic strength of 25MPa. Mix design was done as prescribed by Indian Standard. A total of 18 cubes, 18 cylinder and 3 beams were tested in this experimental investigation. Tests, as prescribed by Indian Standards, were performed to determine the properties of the ingredients. The water cement ratio used is 0.45.The coarse aggregate was replaced by rubber seed shell in the proportion of 0,5,10,15,20 and 25% by volume respectively.7 days ,14days and 28days compression strength, split tensile strength and flexural strength was obtained from this concrete mix. The size of the cube used for the compression strength test is 150x150x150mm. The size of the cylinder used for the split tensile strength is diameter 150mm and the length 300mm.

1.3 Materials Used

In this study, the materials used were Ordinary Portland Cement, Potable Water, Manufactured Sand, and Crushed Coarse Aggregates. Rubber seed shell was used as a partial replacement of conventional crushed coarse aggregate. Details of materials used are provided in following section.

1.3.1 Cement

Ordinary Portland cement of 53 grade was used in this study. Tests for cement were carried out according to standards and the results are presented in Table 2.

Table 1 Test of Cement

Sl. No	Particulars	Test Result	Requirment of standards
1	Fineness(By sieve of 90µ(%))	7	10(Maximum)
2	Specific gravity (Le-chatelier apparatus)	3.15	3.15

1.3.2 Metakaolin

Metakaolin is the anhydrous calcined form of the clay mineral kaolinite. Minerals that are rich in kaolinite are known as china clay or kaolin, traditionally used in the manufacture of porecelain. The particle size of metakaolin is smaller than cement particles. Metakaolin is one of the most widely used mineral admixtures these days for HPC mixes. It helps concrete obtain both higher performance and economy. The calcium hydroxide, which forms up to 25% of hydrated Portland cement does not contribute to concretes durability or strength.

Table 2 Test of metakaolin

Sl.	Particulars	Test	Requirment of standards
1	Fineness(By sieve of 90µ(%))	5.5	10(Maximum)
2	Specific gravity (Le-chatelier apparatus)	2.53	3.15

1.3.3 Fine aggregate

Manufactured sand conforming to Zone I was used as fine aggregate in this work. Various tests were conducted on manufactured sand as per standards to find the properties of manufactured sand. Sieve analysis for the fine aggregate is presented in Table 3 and the test results for its properties are presented in Table

Table 3 Sieve analysis offine aggregate(Manufactured Sand)

IS sieve number	Weight retained FA (g)	Cumulative weight retained(g)	Cumulative % weight retained
4.75	0	0	0
2.36	100	100	10
1.18	210	310	31
600µ	160	470	47
300	280	750	75
150	200	950	95

1.3.4 Crushed coarse aggregate

Crushed coarse `aggregate CA of 20mm size nominal aggregate was used in this project .The aggregates were tested in accordance with standards to know there properties. Its sieve analysis is presented in table 4 and the test results for its properties are presented in table 5

Table 5 Particle size distribution of CA

IS sieve number	Weight retained CA (kg)	Cummulative weight retained (g)	Cumulative % weight retained
20mm	0	0	0
12.5mm	715	715	71.5
11.2mm	180	895	89.5
10mm	65	960	96.0
4.75mm	40	1000	100

1.3.5 Water

Water is an important ingredient of concrete as it actively participates in the chemical reaction with cement. The pH value of water lies between 6 to 8 the indicate the water is free from organic matters. The portable water from the college was used for mixing and curing throughout the project.

1.3.6 Rubber seed shell

Rubber seed shell collected from the local rubber estate. The range of particle sizes of the coconut shell was kept between 5 to 20 mm for use in concrete. It was submerged in water for 24 hr before using it as aggregate. The surface texture of the shell was fairly smooth on concave and rough on convex faces. Shells were broken by hammer into smaller size.

Fig 1 . Rubber seed shell (left side) and crushed rubber seed shell (right side)

Table 5 Particle size distribution of rubber seed shell

Sl. no	IS sieve number	Weight retained coarse aggregate (kg)	Cummulat ive weight retained(g)	Cumulative % weight retained
1	20mm	0	0	0
2	12.5mm	500	500	50
3	11.2mm	184	684	68.4
4	10mm	118	820	82.0
5	4.75mm	180	1000	100

Table 6 Properties of aggregate

Description	FA	CA	RSS
Specific gravity	2.59	2.53	1.89
Water absorption(%)	0.5	1.3	11
Impact test	-	7.0	17.9
Surface texture	-	Rough	Smooth surface
Shape	-	Angular	Flaky

1.4 Experimental methods

1.4.1 Compressive strength test

Specimen were taken out from curing tank and tested in wet condition as per IS516-1959. Cube of size 150x150x150mm size were tested using compression testing machine having maximum capacity of 2000KN. Average compression strength of three cubes was taken. Compressive strength tests were conducted at the age of 7,14 and 28days under full water curing and the results

shown in the table

Table 6 Compressive strength for 7days

Sl.No	Specimen type	% replacement of RSS	Average strength (N/mm²)
1	Cube	0	18.96
2	Cube	5	17.19
3	Cube	10	15.85
4	Cube	15	15.26
5	Cube	20	14.37
6	Cube	25	11.70

Table 7 Compressive strength for 14days

Sl.No	Specimen type	% replacement of RSS	Average strength (N/mm²)
1	Cube	0	23.11
2	Cube	5	18.07
3	Cube	10	17.17
4	Cube	15	16.74
5	Cube	20	15
6	Cube	25	12.88

Table 8 Compressive strength for 28days

Sl.No	Specimen type	% replacement of RSS	Average strength (N/mm²)
1	Cube	0	27.41
2	Cube	5	18.67
3	Cube	10	17.92
4	Cube	15	16.88
5	Cube	20	16.15
6	Cube	25	14.96

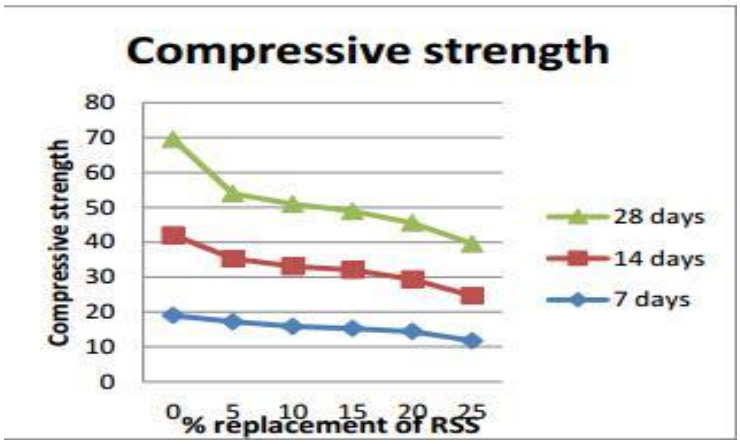

Fig 2. Compressive Strength for 7, 14, 28 days

1.4.2 Split tensile strength

Split tensile strength test on concrete cylinder is a method to determine the tensile strength of concrete. The procedure based on the code IS 5816-1999. The size of the specimen used for the split tensile test is diameter of the cylinder 150mm and the length of the cylinder is 300mm. Split tensile strength tests were conducted at the age of 7,14 and 28days under full water curing and the results shown in the table

Table 9 Split Tensile Strength- 7 Days

Sl.No	Specimen type	% replacement of RSS	Average strength (N/mm²)
1	Cylinder	0	2.11
2	Cylinder	5	1.69
3	Cylinder	10	1.45
4	Cylinder	15	1.5
5	Cylinder	20	1.31
6	Cylinder	25	0.98

Table 10 Split Tensile Strength- 14 Days

Sl.No	Specimen type	% replacement of RSS	Average strength (N/mm²)
1	Cylinder	0	2.14
2	Cylinder	5	1.93
3	Cylinder	10	1.64
4	Cylinder	15	1.69
5	Cylinder	20	1.41
6	Cylinder	25	1.27

Table 11 Split Tensile Strength- 28 Days

Sl.No	Specimen type	% replacement of RSS	Average strength (N/mm²)
1	Cylinder	0	3.05
2	Cylinder	5	2.07
3	Cylinder	10	1.79
4	Cylinder	15	1.74
5	Cylinder	20	1.46
6	Cylinder	25	1.17

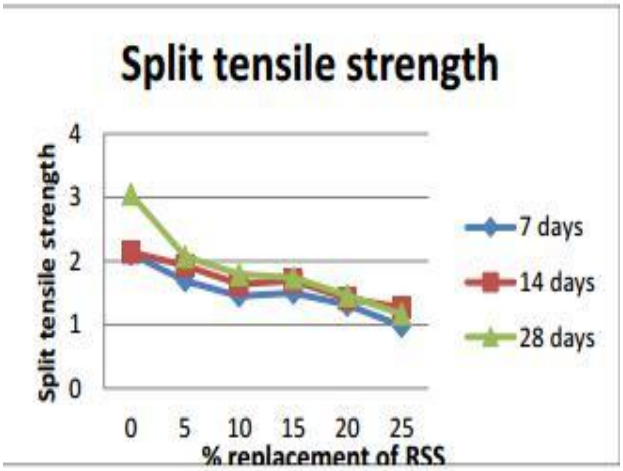

Fig 3. Split tensile Strength for 7, 14, 28 days

2.Conclusion

The present investigation was taken up in view of disposal problem of agro waste rubber seed shell and scarcity of conventional coarse aggregate used for concrete. This experimental study aimed to explore the feasibility and prossibility of partial replacement of conventional coarse aggregate by waste rubber seed shell , for concrete production . Replacement of conventional aggregate by waste rubber seed shell makes the concrete lighter. The percentage of rubber seed shell decrease, density and compression strength of concrete increase and vice versa. There is need to treat the rubber seed shell before use as a aggregate for water absorption. Rubber seed shell concrete offers as a potential construction material and simultaneously solving the environmental problem of reduction in agro waste.

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