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Investigation on Crushed Materials as Aggregate in Concrete

Ramesh J[1], Kalaiarasi M S[2]

[1]*Assistant Professor, Prince Shri Venkateshwara Padmavathy Engineering College, Chennai, Tamil Nadu, India.*
[2]*Student, civil engineering, Prince Shri Venkateshwara Padmavathy Engineering College, Tamil Nadu, India*

Abstract - *The crushed materials have found the greatest scope in the field of construction due to the constant decline in the availability of conventional building materials. The solid wastes such as coconut shell and rubber tyres in the form of crumb which pose serious environmental hazards were taken in this study which in turn proves to be more beneficial. Replacements were made for both fine and coarse aggregates. Concrete mix with crumb rubber as fine aggregate in proportions of 2%, 4%, 6%, 8%, 10% were casted. In the same way concrete mix with coconut shell as coarse aggregate in proportions of 5%,7%,9%,11%,13% were casted and a comparative study on both mixes were made. With 2% replacement of sand the concrete showed 18% increase in compressive strength and with 5% replacement of gravel it showed 1.3% increase in compressive strength. Concrete mix made with 2% of crumb rubber and 5 % of coconut shell showed 10 % increase in compressive strength.*

Key Words: **Crushed materials, Coconut shell concrete, Rubberized concrete**

1. INTRODUCTION

Concrete is the single most material used in the world as it serves as a remarkably good building material. Concrete has a number of performance characteristics that can improve the sustainability of a building or structure. Due to increase in the infrastructural development, there has been a gradual decline in the availability of raw materials which lead to its increasing demand. In order to overcome such problems and to facilitate economy in construction several crushed materials like crushed glass, granite, rocks, bricks, limestone and many other alternatives are employed in construction [1]. The solid waste pose a serious threat to the environment as their disposal becomes tedious and harmful [2] Thus rather than disposal reuse of these generated wastes are preferred and one such attempt is the utilization of solid and agricultural wastes as a construction material [3] [4].

Of the various solid wastes available coconut shell and crumb rubber were taken in this study. The coconut shell is found to have less density, good absorbance to shock, high resistance against crushing, impact and abrasion compared to other materials and found to reduce the material cost in construction [5]. The properties of coconut shell like impact value, water absorption were studied [6]. The crumb rubber also shows good resistance against sulphate attack, waterproofing properties, freezing and thawing properties, crack resistant and improved toughness .Their physical properties were tested as per IS standards.

Crushed coconut shell and crumb rubber were utilized in this study as a replacement of coarse and fine aggregate respectively in separate concrete mixes[7] [8]. An effective analysis is made on the workability and compressive strength of concrete containing both coconut shell and crumb rubber in a single concrete mix.

After 7, 14 and 28 days of curing the specimens were tested for their compressive strength. The coconut shell concrete showed appreciable compressive strength at 28 days at 5% replacement of coarse aggregate and the 2% of crumb rubber in concrete proved to be efficient with 18% increase in compressive strength. The combined mix with simultaneous replacement of both fine and coarse aggregates showed 10% increase in the overall compressive strength. Moreover the fresh concrete mix was found to have good workability.

2. EXPERIMENTAL INVESTIGATION

2.1 Materials

2.1.1 Coconut Shell

Coconut shell is one of the commonly generated agricultural wastes in India. Since it is non-biodegradable in nature it creates a threat to the environment. It serves as a habitat of many contagious organisms resulting in health hazards. In this study, the coconut shell was collected from the locally available sources. The husk and fibers were removed and surface was cleaned without any dust [9]. The major advantage of coconut shell is that there won't be any change in their properties once embedded in concrete and easily available. Further it does not require any pretreatment other than presoaking it before 24 hours of casting so as to ensure good workability of the mix i.e., in saturated dry condition[10]. The coconut shells were crushed to smaller sizes and those which passed through 12.5 mm IS sieve and retained on 10 mm sieve were taken for this study.

Fig-1: Crushed Coconut Shells

2.1.2 Crumb Rubber

Crumb rubber is generally a form of scrap tyre obtained from automobile and truck tyres [11]. Generally the scrap tyres consist of 20% carbon, 7% hydrogen, 1.2% zinc oxide, 1.3% sulfur, 15% iron and 5.5% other components [12]. The crumb rubber is produced by reducing the size of scrap tyres by removing 99% or more of the steel and fabric from scrap tyres. Most commonly ambient process and cryogenic process were employed in their production [13]. Utilization of crumb rubber as fine aggregate in concrete reduces the landfill problems thus reducing the environmental hazard. Also the rubberized concrete is more flexible and prevents brittle failure.

Fig-2 Crumb Rubber

2.1.3 Aggregates

The coarse and fine aggregates of desired sizes as per Indian standards were collected from the locally available sources. Preliminary tests were conducted in order to study their properties as per various codes.

2.2 Mix Proportions

In this study PPC confirming to IS 1489-1991 (part 1) with a specific gravity of 2.91 was employed. The mix proportion was found to be 1:1.35:3.3. No other additives were added. The water cement ratio was taken as 0.5.

Table -1: Mix Proportion with Crumb Rubber

Mix ID	% Replacement	Fine aggregate (g/m^3)	
		Sand	Crumb Rubber
0	0	514.31	0
1	2	504.048	10.262
2	4	495.738	20.572
3	6	483.451	30.859
4	8	473.165	41.145
5	10	462.879	51.431

Table-2: Mix Proportion with Coconut Shell

Mix ID	% Replacement	Coarse Aggregate (g/m^3)	
		Gravel	Coconut Shell
6	5	1199.023	63.107
7	7	1173.781	88.349
8	9	1148.538	113.592
9	11	1123.296	138.834
10	13	1098.053	164.077

Table-3: Mix Proportion for Combined Mix

Mix ID	% Replacement		Fine Aggregate (g/m3)		Coarse Aggregate (g/m3)	
	FA	CA	sand	CR	gravel	CS
11	2	5	504.05	10.26	1199.02	63.1

2.3 Mixing and Casting of Concrete Cubes

The mixing duration is a major parameter to attain a homogeneous mix with uniform consistency of concrete. Initially the source material and aggregates were mixed in the pan in dry condition and then required quantity of water is added. Cubes were casted in moulds of size 150x150x150 mm. 9 cubes were casted for each mix totally counting to 108 specimens.

2.4 Curing of Concrete

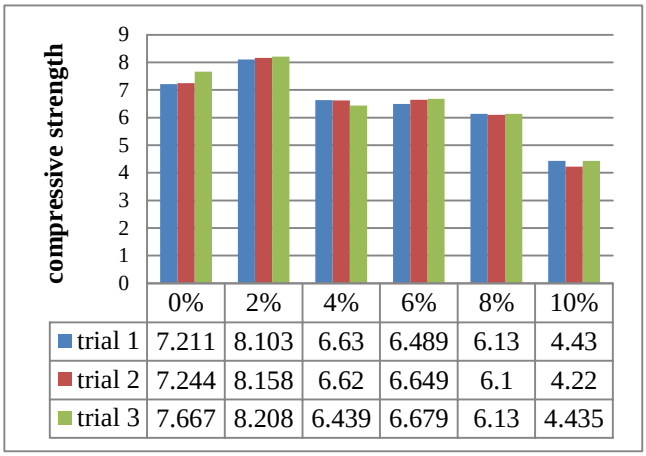
After the concrete was casted, they were demoulded after 24 hours followed by curing in the ambient condition. The curing period was taken as 7, 14 and 28 days.

Fig-3: Curing of Concrete Cubes

3. RESULTS AND DISCUSSION

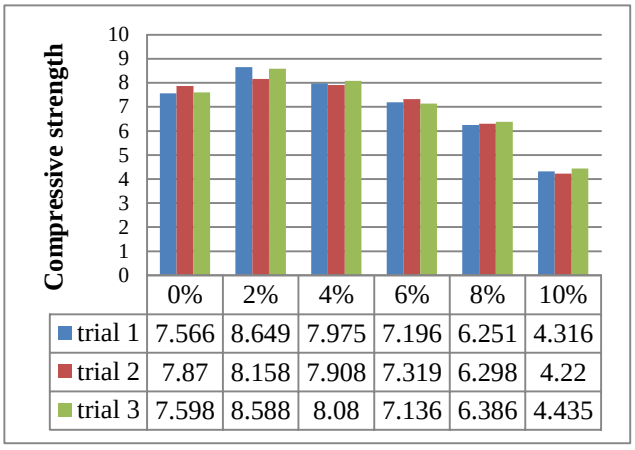
3.1 Compressive Strength

The average strength of concrete was tested after 7, 14 and 28 days of curing. The compressive strength was found to decrease with increase in percentage of replacement but the workability was found to be good. The average compressive strength was shown in the following figure. The combined mix showed 10% increase in the final compressive strength. The rubberized concrete proved to be efficient with 18% increase in strength and the coconut shell concrete showed comparable strength to that of the conventional concrete.



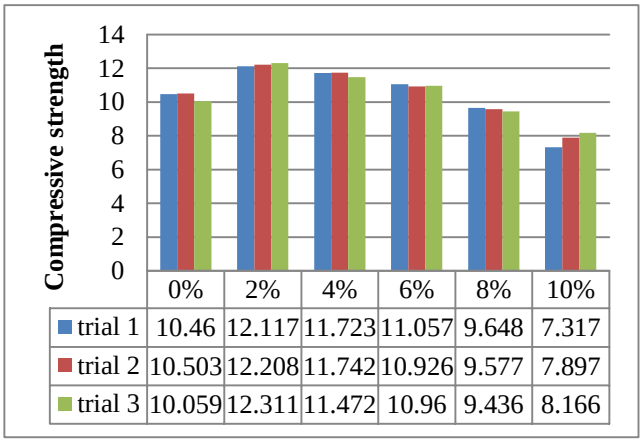
	0%	2%	4%	6%	8%	10%
trial 1	7.211	8.103	6.63	6.489	6.13	4.43
trial 2	7.244	8.158	6.62	6.649	6.1	4.22
trial 3	7.667	8.208	6.439	6.679	6.13	4.435

Chart-1: 7 days Compressive Strength of Crumb Rubber Concrete



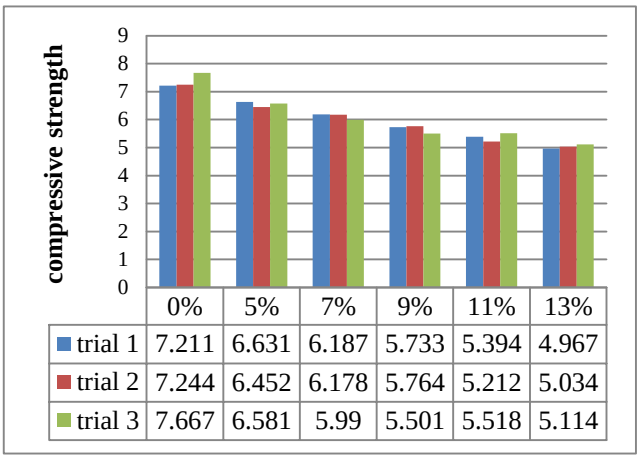
	0%	2%	4%	6%	8%	10%
trial 1	7.566	8.649	7.975	7.196	6.251	4.316
trial 2	7.87	8.158	7.908	7.319	6.298	4.22
trial 3	7.598	8.588	8.08	7.136	6.386	4.435

Chart-2: 14 days Compressive Strength of Crumb Rubber Concrete



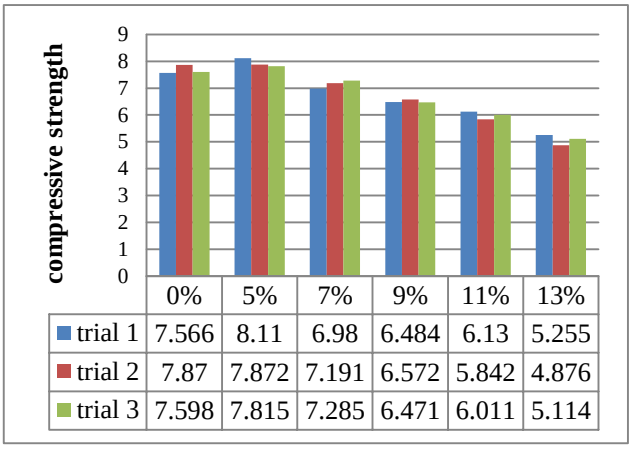
	0%	2%	4%	6%	8%	10%
trial 1	10.46	12.117	11.723	11.057	9.648	7.317
trial 2	10.503	12.208	11.742	10.926	9.577	7.897
trial 3	10.059	12.311	11.472	10.96	9.436	8.166

Chart-3: 28 days Compressive Strength of Crumb Rubber Concrete



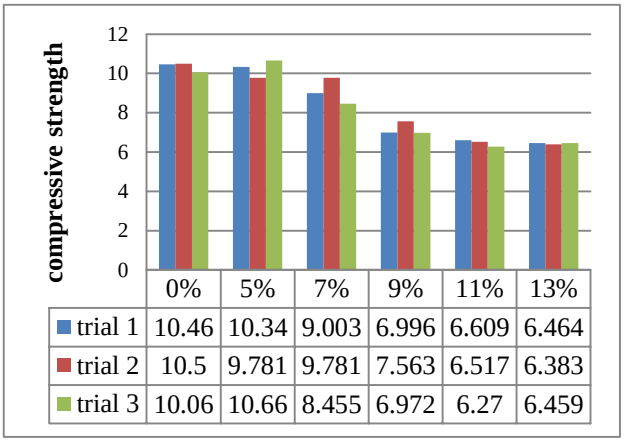
	0%	5%	7%	9%	11%	13%
trial 1	7.211	6.631	6.187	5.733	5.394	4.967
trial 2	7.244	6.452	6.178	5.764	5.212	5.034
trial 3	7.667	6.581	5.99	5.501	5.518	5.114

Chart -4: 7 days Compressive Strength of Coconut Shell Concrete



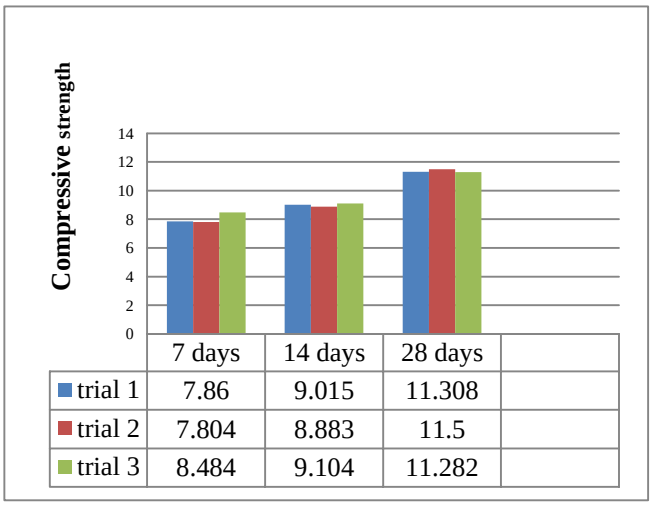
	0%	5%	7%	9%	11%	13%
trial 1	7.566	8.11	6.98	6.484	6.13	5.255
trial 2	7.87	7.872	7.191	6.572	5.842	4.876
trial 3	7.598	7.815	7.285	6.471	6.011	5.114

Chart-5: 14 days Compressive Strength of Coconut Shell Concrete



	0%	5%	7%	9%	11%	13%
trial 1	10.46	10.34	9.003	6.996	6.609	6.464
trial 2	10.5	9.781	9.781	7.563	6.517	6.383
trial 3	10.06	10.66	8.455	6.972	6.27	6.459

Chart-6: 28 days Compressive Strength of Coconut Shell Concrete



	7 days	14 days	28 days	
trial 1	7.86	9.015	11.308	
trial 2	7.804	8.883	11.5	
trial 3	8.484	9.104	11.282	

Chart-7: Compressive Strength of Combined Mix

4. CONCLUSIONS

Based on the inference from the test results it can be concluded as following:

1. Replacement of fine aggregate by crumb rubber concrete proved to be efficient up to 6 %.
2. Replacement of coarse aggregate by coconut shell proved to be efficient up to 5 % of replacement.
3. In both the cases the compressive strength was found to decrease with increase in percentage of replacement. This may be attributed to the increase in porosity and air voids.
4. The workability was found to increase in both the mix with higher percentage of replacement.
5. When 2 % of fine aggregate and 5 % of coarse aggregate was replaced in the same mix by crumb rubber and coconut shell respectively, the compressive strength was found to increase by 10% with good workability.

It can be seen that appreciable compressive strength was obtained with good workability and this reduces the problem of high cost of conventional aggregates. It can be implemented in low cost housing and preferably non load bearing structures.

Further investigations can be carried out on the following:

1. Use of suitable admixtures in the concrete mix can be tested to provide high compressive strength at higher percentages.
2. Properties of the crumb rubber used can be studied in a more detailed manner.
3. The flexural strength, split tensile strength and durability study on concrete may be carried out.

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