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Mechanical properties of concrete by partially replacing cement by agricultural waste – Rice husk Ash

KU.Mani Kandhan[1], C.Keerthana[2], P.Devaraj[2], K.Manoj[2], S.Aswini[2]

[1]Assistant Professor, Department of Civil Engineering, Nandha Engineering College, India

[2]UG Students, Department of Civil Engineering, Nandha Engineering College, Erode, India

ABSTRACT

High demand of natural resources due to rapid urbanization and the disposal problem of agricultural wastes in developed countries have created opportunities for use of agro-waste in the construction industry. Many agricultural waste materials are already used in concrete as replacement alternatives for cement, fine aggregate, coarse aggregate and reinforcing materials. This paper reviews some of the agro-waste material, which is used as a partial replacement of cement in concrete. Different properties of fresh and hardened concrete, their durability and NDT when admixed with agro-wastes are reviewed. It has been seen that the agro-waste concrete containing rice husk ash showed better workability than their counterparts did. Agro-waste concrete containing rice husk ash achieved their required strength by 20% of replacement as cement, which were maximum among all agro-waste type concrete. Close relations were predicted among compressive strength, flexural strength, tensile strength, ultrasonic pulse velocity and ductility test of agro-waste concrete. After the review, it is of considerable finding that more research is deserved on all cement replacing agro-waste materials, which can give more certainty on their utilization in concrete.

Keywords: Agro-Waste Concrete; Agricultural Waste; Sustainable Concrete, Rice Husk Ash

INTRODUCTION

Concrete is a mixture of cement, fine aggregate and coarse aggregate, which is mainly derived from natural resources. Increasing population, expanding urbanization, climbing way of life due to technological innovations has demanded a huge amount of natural resources in the construction industry, which has resulted in scarcity of resources. This scarcity motivates the researchers to use, solid wastes generated by industrial, mining, domestic and agricultural activities. It is observed that in India more than 600 MT wastes have been generated from agricultural waste, which is seriously leading to a disposal problem. Reuse of such wastes as sustainable construction materials take care of the issue of contamination, as well as the issue of area filling and the expense of building materials. In India the major quantity of solid wastes as follows as lime stone, jute fiber, bagasse, coal mine, rice husk ash, marble dust, red mud etc.., expressed that research on the utilization of agricultural waste, as a cement substitution is generally new and more research is needed for long-term durability properties of concrete. They also studied the relationship between the concrete made using this type of materials; environmentally friendly concrete and green building rating systems. The current Green Building Rating (GBR) systems evaluate the sustainability of buildings according to various categories of which the construction material is one such category in most of the systems. Issues like emission of carbon dioxide, use of energy, water, aggregates, fillers and demolition waste in concrete look less

Author for correspondence:
Department of Civil Engineering, Nandha Engineering College, Erode, India

compatible with environmental requirement of a modern sustainable construction industry. At the same time, concrete made using agricultural wastes has shown better mechanical and durability properties in research which can result in sustainability points in the energy.[1, 2]

Literature Review

A Review of Partial Replacement of Cement with Some Agro Wastes. The use Rice husk ash (RHA) to partially replace cement as a binder was reviewed. Analysis of results, using oxide composition, compound composition obtained using Bogue's model, and results of test conducted in the laboratory, showed that only the replacement of cement with 10% RHA exhibited a convincing increase in compressive strength of 7.14% above that obtain with the use of cement. Decrease in compressive strength observed with other agro waste was attributed to increase in SiO_2 component and decrease in CaO component of cement-agro wastes mixtures. Incorporation of lime into the mixture is here recommended for increase in strength.

MATERIAL PROPERTIES

Cement

Cement is a binding material in concrete which binds the other material to forms a compact mass. Types of cement

- OPC 33 grade
- OPC 43 grade
- OPC 53 grade

In this project work OPC 53 grade cement is used for experimental study.

Table 2.1 Properties of Cement

Fineness value	8.5
Consistency	29.5%
Initial setting time	25mins
Final setting time	575mins
Specific gravity	3.16

Water

Water conforming to the requirements of IS 456-2000 is found be satisfactory for making concrete. In the present investigation, portable drinking water available in the institution was used for mixing and curing the concrete.

Coarse Aggregate

Locally available crushed stone aggregates of nominal size 20mm wherever possible size of aggregate 20mm used in the project.

Table 2.3 Properties of Coarse Aggregate

Description of test	Test result obtained	Permissible limits as per IS:383-2016
Specific gravity	2.72	Minimum 2.5
Fineness modulus	7.86	NIL
Unit weight (kg/m^3)	1603	NIL

Fine Aggregate

A concrete with better quality can be made with sand consisting of rounded grains rather than angular grains. In this study, M-sand has been used as fine aggregate.

Table 2.4 Properties of Fine Aggregate

Description of test	Test result obtained	Permissible limits as per IS 383:2016
Specific Gravity	2.69	Minimum 2.5
Fineness modulus	3.06	NIL
Unit weight of sand (kg/m^3)	1687	NIL

RHA (Rice Husk Ash)

Rice husk is one of the fundamental agrarian wastes obtained from the external covering of rice grains amid the processing procedure. The rice husk has no useful application and is treated as a waste material that creates the pollution problem. Because of low nutrition property of rice husk, it is unsuitable and does not have edibility yet in a few nations. It has been utilized generally as fuel for rice plants and electric power plants as a compelling technique to reduce the volume of rice husk waste. Many researchers in the past had used rice husk ash as a cement replacement material in concrete. After colossal researches tested the properties of self-compacting concrete using rice husk and limestone as a cement replacement. It was reported that use of rice husk ash in self-compacting concrete reduced the unit weight, flow ability, porosity, water absorption, compressive strength, ultrasonic pulse velocity and the cost. The use of rice husk as cement replacing material, fire making, litter material, marking the concrete, board production, as silicon carbide whiskers to reinforce ceramic cutting tools and cement replacement in concrete in low-cost housing.[3,4]

Table 2.5 Properties of RHA

S. No	Test Properties	RHA
1	Specific Gravity	2.03
2	Water absorption (%)	-
3	Fineness modulus	95 microns

Slump Test

This is a test extensively used in construction site. It is very useful in detecting the variation in the uniformity of mix of given nominal proportion. It also gives an idea of water cement ratio need for concrete to be used for different works.

MIX PROPORTION

In this study, control mix was designed as per IS 10262:2009 for M_{30} grade. RHA is replaced by cement by 0%, 10%, 20%and 30%. The details of the mix proportions of concrete were given in following table 3.1.

Table 3.1 Mix Design

Title	Specification
Grade of Concrete	M30
Type and Grade of Cement	OPC 53 Grade
Size of Coarse Aggregate	20mm
Specific Gravity of Coarse Aggregate	2.77
Specific Gravity of Fine Aggregate	2.67
W/C Ratio	0.5

Table 3.2 Mix Proportion Details

Materials	Cement in kg	% of RFA	FA in kg	CA in kg	WaterLit
Conventional	32.98	-	79.62	140.65	14
10%	29.69	3.29	79.62	140.65	14
20%	26.51	6.58	79.62	140.65	14
30%	23.12	9.87	79.62	140.65	14

EXPERIMENTAL METHODOLOGY

Compressive Strength Test

Fig 4.1 Compressive Strength Test

For cube compression tests on concrete, cube of size 150mm were employed. All the cubes were tested in saturated condition after wiping out the surface moisture from the specimen. For each trial mix, three cubes were tested at the age of 7, 14 and 28 days of carrying 400 tons capacity HELICO compression testing machine referred to BIS: 516-1959.

Table 4.1 Compressive Strength Test

Materials	Compressive strength in N/mm^2		
	7 Days	14 Days	28 Days
Conventional concrete	21	27.6	36.28
	18.75	22.55	34.32
	21.14	26.09	35.88
	20.29	25.41	35.49
10% of RHA with cement	22.01	26.67	36
	19.26	25.41	38
	21.90	28.12	35
	21.05	26.73	36.3
20% of RHA with cement	21.5	23.01	36
	18.6	26.82	35
	21	27.32	37
	20.36	25.71	36
30% of RHA with cement	19	23.65	36.21
	15.53	22.36	32.18
	20.38	26.79	34.18
	18.45	24.26	34.22

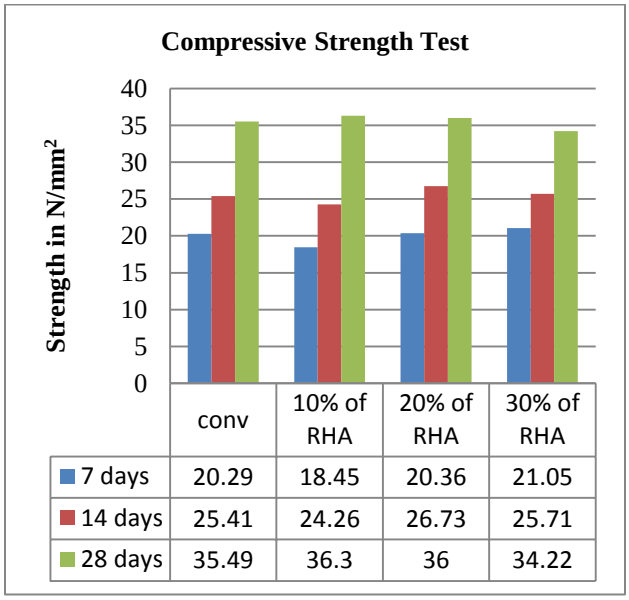

Fig 4.2 Compressive Strength Test

Split Tensile Test

Tensile strength is one of the basic and important properties of concrete. The results are required for the design of concrete subject to transverse shear, torsion, shrinkage and temperature effects. Its value is also used in the design of pre-stressed concrete structures, liquid retaining structures, roadways and runway slabs.

Table: 4.2 Split Tensile Strength

Mix	At 28 Days(N/mm²)
Conventional	5.9
10% of RHA with cement	6.7
20% of RHA with cement	6
30% of RHA with cement	5.3

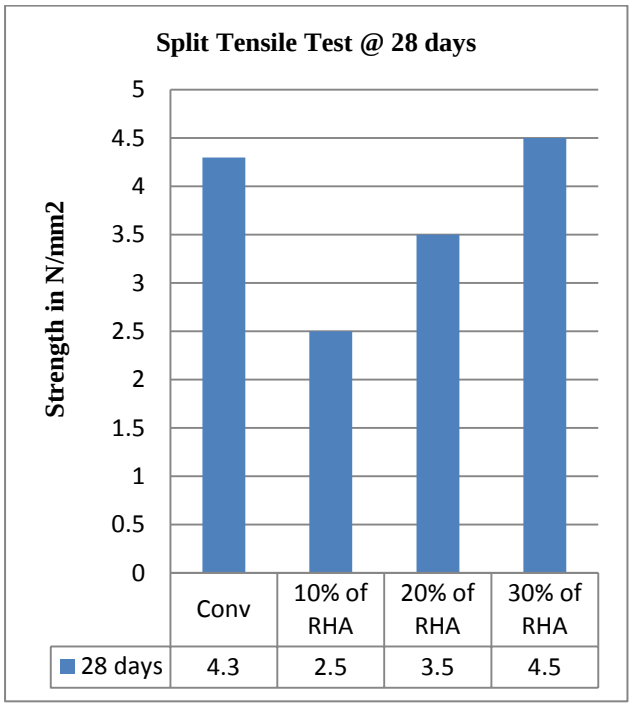

Fig 4.2 Split Tensile Test

Table: 4.3 Flexural Strength

Mix	At 28 Days(N/mm²)
Conventional	2.8
10% of RHA with cement	3
20% of RHA with cement	2.5
30% of RHA with cement	2.3

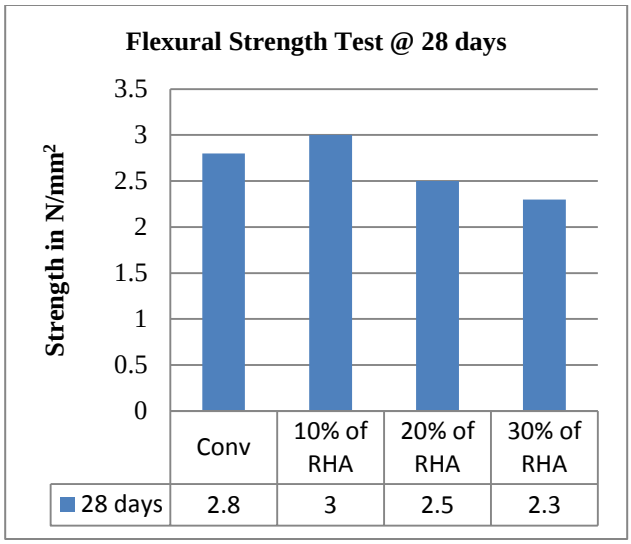

Fig no: 4.3 Flexural Strength Test

RESULTS & DISCUSSION

- Specific gravity of RHA is higher than M-sand.
- Based on various researches it is observed that 10% replacement of RHA generally gives maximum strength compared to conventional concrete.
- This concrete more economical compared to conventional concrete using M-sand.
- Workability of the concrete goes on continuously increasing in the percentage of RHA.
- Compressive strength of concrete is increased by addition of RHA.

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