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Experimental investigation on properties of concrete with rice husk ash and water hyacinth ash.

Investigación experimental sobre las propiedades del hormigón con ceniza de cáscara de arroz y ceniza de jacinto de agua.

Nibin varghese, Vasudev R

Department of Civil Engineering, Toc H Institute of Science and Technology, Ernakulam, India

Corresponding author's email: nibinv8@gmail.com

ABSTRACT

The purpose of this experimental investigation is to study the properties of M30 grade concrete with Ricehusk ash (RHA) and Water hyacintha ash (WHA) when used as a partial replacement for cement. Ricehusk ash is a by- product of thermally treating rice husks. It is highly pozzolanic and has been used as a partial replacement for cement in concrete production and Water hyacinth grows vigorously in ponds and doubles the quantity within two weeks. The studies have been done to evaluate water hyacinth ash in the replacement of cement. This study seeks to determine the effect of RHA and WHA on the strength and other properties of concrete. To conduct this investigation, a series of concrete mixtures were prepared with various percentages of RHA (5%, 10%, 15%, and 20%) for finding the optimum percentage. To the optimum concrete made with rice husk ash different percentage of cement is replaced with water hyacinth ash (5%,10%,15%,20%) and the optimum is obtained. The mix proportions were determined according to the standards. The mixtures were then tested to determine the compressive strength and split tensile strength of the concrete. The results of the investigation showed that the replacement of cement by RHA enhanced the strength properties of concrete in 15% replacement of cement with RHA shows the maximum compressive strength value. The replacement of cement by WHA 10% with optimum RHA 15% enhanced the strength properties of concrete. Replacement of cement by 10% WHA with optimum RHA shows the maximum compressive and tensile value.

Keywords: Ricehusk ash, Water hyacinth ash, Compressive, Tensile.

RESUMEN

El propósito de esta investigación experimental es estudiar las propiedades del concreto grado M30 con ceniza de cáscara de arroz (RHA) y ceniza de jacinto de agua (WHA) cuando se usa como reemplazo parcial del cemento. La ceniza de cáscara de arroz es un subproducto del tratamiento térmico de la cáscara de arroz. Es altamente puzolánico y se ha utilizado como sustituto parcial del cemento en la producción de hormigón. El jacinto de agua crece vigorosamente en estanques y duplica su cantidad en dos semanas. Los estudios se han realizado para evaluar la ceniza de jacinto de agua en la sustitución del cemento. Este estudio busca determinar el efecto de RHA y WHA sobre la resistencia y otras propiedades del concreto. Para realizar esta investigación se prepararon una serie de mezclas de concreto con varios porcentajes de RHA (5%, 10%, 15% y 20%) para encontrar el porcentaje óptimo. Al óptimo concreto elaborado con ceniza de cáscara de arroz se reemplaza diferente porcentaje de cemento con ceniza de jacinto de agua (5%,10%,15%,20%) y se obtiene el óptimo. Las proporciones de la mezcla se determinaron según las normas. Luego se probaron las mezclas para determinar la resistencia a la compresión y la resistencia a la tracción dividida del concreto. Los resultados de la investigación mostraron que el reemplazo del cemento por RHA mejoró las propiedades de resistencia del concreto; un reemplazo del 15% del cemento por RHA muestra el valor máximo de resistencia a la compresión. La sustitución del cemento por WHA 10% con un óptimo RHA 15% mejoró las propiedades de resistencia del hormigón. La sustitución del cemento por un 10% de WHA con un RHA óptimo muestra el valor máximo de compresión y tracción.

Palabras clave: Ceniza de cáscara de arroz, Ceniza de jacinto de agua, Compresión, Tracción.

INTRODUCTION

Rice husk ash and Water hyacinth ash is a promising material for replacing cement for construction purposes due to its properties, such as its low cost, high silica content, and low alkali content. It is also an environmentally friendly and sustainable material, as it is a waste material from the agricultural industry. Replacement of cement with RHA and WHA is a potential solution to reduce the number of CO2 emissions from the production of cement, as well as to reduce the cost of construction materials. This has been implemented in many countries, such as India, Japan, and Thailand, where RHA and WHA is being used as a partial or complete replacement for cement in concrete mixtures.

RHA and WHA also have many advantages over cement, such as improved workability, higher strength, increased durability, and better resistance to freeze-thaw cycles. Furthermore, the inclusion of RHA and WHA in concrete can reduce the overall permeability of the concrete, making it more resistant to water damage. Thus, the replacement of cement with RHA and WHA can be a great solution for sustainable construction and can help to reduce environmental impacts.

This study aims to investigate and identify the effects of RHA and WHA on the physical, mechanical and durability properties of concrete. An experimental investigation was conducted with concrete mixtures containing different proportions of RHA and WHA. The samples were prepared according to the relevant codes and subjected to tests for determining compressive strength and split tensile test. The results obtained from the experiments were analyzed to evaluate the performance of the concrete mixtures containing different proportions of RHA and WHA.

MATERIALS AND METHODS

The materials used in the experimental work are, cement (OPC), fine aggregate, coarse aggregate, water, super plasticizer, water hyacinth ash, Rice husk ash. Each material was acquired from different vendors. Various test was done on material to find out the material properties and to determine that all the material are suitable for the experiment. All the tests done and the values of all physical properties of materials used for investigation are confirming to relevant IS codes of practice.

Cement - Ordinary Portland Cement (OPC) are the commonly used cement in the world. It is manufactured by mixing limestone and other raw materials which consist of argillaceous, calcareous and gypsum. In this experiment 53 grade OPC is used.

Fine aggregate - The most important function of fine aggregates is to assist in providing workability and uniformity in mixture Manufactured sand (M Sand) is used as fine aggregate. It is a better substitute to river sand, as it has no silt, organic impurities and mostly well graded.

Coarse aggregate - Coarse aggregates provide strength, toughness and hardness to concrete.. Crushed gravel of size 20 mm downgraded from a local crusher is used as coarse aggregate.

Superplasticizer - Superplasticizer used here is a second-generation superplasticizer of polycarboxylic ether (PCE) based polymers. These are added to improve the workability of the concrete and also reduce the water consumption.

Water hyacinth ash – Pozzolonic material, high silica and calcium content and low alkali content.

Rice husk ash - Pozzolonic material, high silica and calcium content and low alkali content.

Table1 Properties of material

MATERIAL	PROPERTY	RESULT	ƆWABLE LIMIT
	Fineness	8.3%	10%
Cement	Specific gravity	3.13	3.1–3.16
	Standard Consistency	34%	25–35%
Fine	Specific gravity	2.61	2.5-3
aggregate	Water absorption	2.3%	3%
Coarse	Specific gravity	2.61	2.6 –2.8
aggregate	Water absorption	2.3%	0.1-2%

MIX PROPORTION

Mix design was done as per IS 10262: 2019. The mix proportion and mix designation are given below.

Table 2 Mix proportion

MixID	Cement kg/m^3	RHA kg/m^3	WHA kg/m^3	Fine kg/m^3	Coarse kg/m^3	Water kg/m^3
CM	400	-	-	655	1259	144
RHA5	380	20	-	655	1259	144
RHA10	360	40	-	655	1259	144
RHA15	340	60	-	655	1259	144
RHA20	320	80	-	655	1259	144
R15W5	360	60	20	655	1259	144
R15W10	320	60	40	655	1259	144
R15W15	280	60	60	655	1259	144
R15W20	240	60	80	655	1259	144

Where

CM – Control Mix

RHA 5 - M30 grade containing 5% Rice husk ash

RHA 10 - M30 grade containing 10% Rice husk ash

RHA 15 - M30 grade containing 15% Rice husk ash

RHA 20 - M30 grade containing 20% Rice husk ash

R15W5 - M30 grade containing 5% Water hyacinth ash with 15% of Rice husk ash

R15W5 - M30 grade containing 10% Water hyacinth ash with 15% of Rice husk ash

R15W5 - M30 grade containing 15% Water hyacinth ash with 15% of Rice husk ash

R15W5 - M30 grade containing 20% Water hyacinth ash with 15% of Rice husk ash

CM mix ratio= 1: 1.85 : .4

Water cement ratio = 0.42

Superplasticizer used was 0.4%

RESULTS AND DISCUSSION

The test conducted on concrete of different mix where test, compression strength test slump and split tensile strength test to obtain fresh and hardened properties of concrete. All the test was done confirming to relevant IS codes of practice.

A. Compressive strength test

The cube specimens of standard size were casted and tested for compression strength in accordance with the IS 516:1956 (reaffirmed 2011). Compressive strength of concrete was calculated by crushing to failure of the test cubes by means of compression testing machine.

B. Split tensile strength test

The cylinder specimen for split tensile strength was casted and tested in in accordance with the IS 516:1956 (reaffirmed 2011). Split tensile strength of concrete was calculated by crushing to failure of the test cylinder by means of compression testing machine in the axial direction of the cylinder.

SPECIMEN PREPARATION

Specimens are prepared with different mixes concrete such as addition of RHA to the mix as 5% ,10%, 15% and 20% .To the optimum concrete made with rice husk ash different percentage of cement is replaced with water hyacinth ash (5%,10%,15%,20%) and the optimum is obtained.

Compressive strength test was conducted on the prepared cubes and the load at failure of each cube was noted. The cubes after 7- day and 28-day curing were tested and their average value is reported. Table 3& 4 shows the compressive strength of mix .

Table 3 Compressive strength with RHA

MixID	7thdaycompressivestrength $(N/mm2)$	28thcompressivestrength $(N/mm2)$
CM	27.5	37.2
RHA5	28.6	37.9
RHA10	31.63	40.31
RHA15	33.11	42.73
RHA20	24.45	32.5

The observed 7 and 28-day compressive strength of hardened concrete specimen shows that there is an increase in compressive strength of concrete with RHA concrete than that of control mix. This increase in strength of concrete that form the calcium silica hydrate (C-S-H) gel and also calcite content. It is observed that at 15% of RHA shows maximum compressive strength then after that the for higher percentage strength reduces. This due to the CSH formation is completed and there is no further component left for reaction. The replacement of cement by WHA 10% with optimum RHA 15% enhanced the strength properties of concrete. Replacement of cement by 10% WHA with optimum RHA shows the maximum compressive strength value.

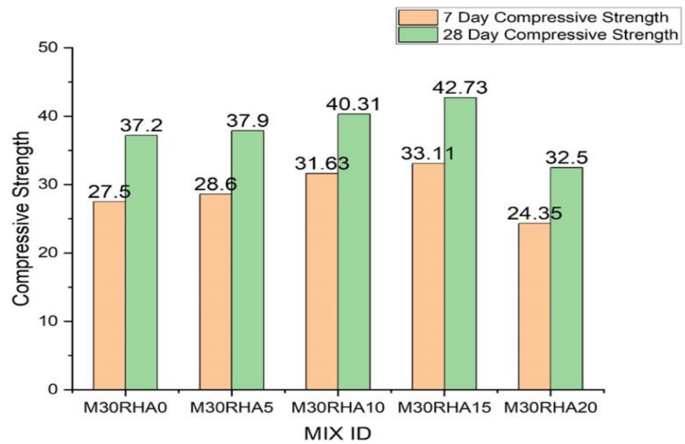

Fig.1 Variation in compressive strength with RHA

Table 4 Compressive strength of RHA with optimum WHA

MixID	7thday compressive strength ($N/mm2$)	28thcompressive strength ($N/mm2$)
RHA15	27.5	37.2
R15W5	28.6	37.9
R15W10	31.63	40.31
R15W15	33.11	42.73
R15W20	24.45	32.5

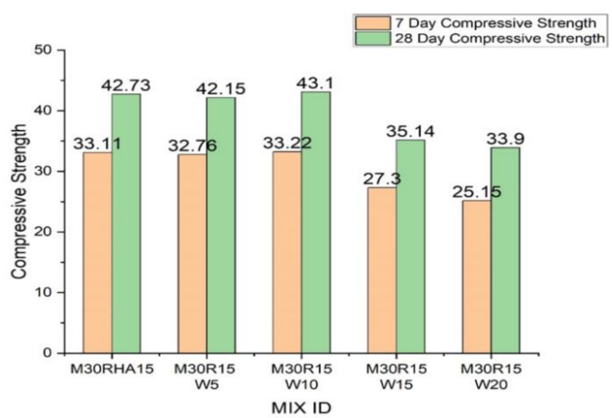

Fig.2 Variation in compressive strength of WHA with optimum RHA

B. Split tensile strength

Split tensile test was conducted and the load at failure of each cylinder was noted. The cylinder after 7-day and 28-day curing were tested and their average value is reported. Table 5 shows the split tensile strength of specimens.

Table 5 Split tensile strength values with RHA

MixID	7thday split tensile strength ($N/mm2$)	28th split tensile strength ($N/mm2$)
CM	2.24	2.97
RHA5	2.4	3.25
RHA10	2.52	3.56
RHA15	2.63	3.78
RHA20	2.12	2.71

The result observed for 7 and 28-day split tensile strength of hardened concrete specimen displays a result similar to that of compressive strength which was observed above. The concrete with 15% RHA displays a maximum Split tensile strength than any other specimen.

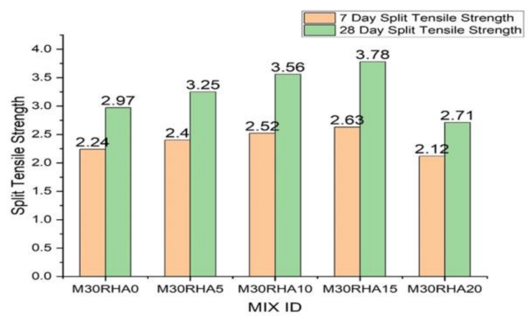

Fig.3 Variation in split strength of RHA

Table 6 Split tensile strength values of WHA with optimum RHA

MixID	7th day split tensile strength ($N/mm2$)	28th split tensile strength ($N/mm2$)
CM	2.63	3.78
RHA5	2.4	3.76
RHA10	2.52	3.81
RHA15	2.63	2.84
RHA20	2.12	2.55

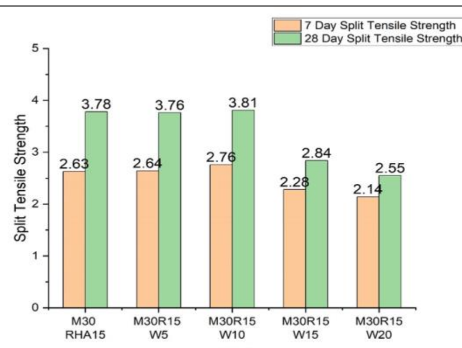

Fig.4 Variation in split strength of WHA with optimum RHA

CONCLUSION

The strength properties of concrete were improved by replacing cement with RHA. The maximum compressive strength values of 33.11 N/mm2 in 7 days and 42.73 N/mm² in 28 days were observed at a 15% replacement of cement with RHA. Replacing cement with 10% WHA and optimum 15% RHA enhanced the concrete's strength properties. The concrete with this mix had the maximum compressive strength of 33.22 N/mm2 on the 7th day and 43.1 N/mm² on the 28th day. The replacement of cement with RHA led to an increase in split tensile strength. The results showed that the maximum split tensile strength values of 2.63 N/mm2 and 3.78 N/mm² were obtained on the 7th and 28th day, respectively, with a 15% replacement of cement with RHA. The split tensile strength test results showed that the inclusion of optimum RHA with 10% WHA in the mix led to an increase in the strength values. The maximum strength value was achieved on the 7th day, with a value of 2.76 N/mm2, and on the 28th day, with a value of 3.81 N/mm². However, the strength started to decrease beyond 28 days. The inclusion of calcium and silica in RHA & WHA enhances the rate of hydration process, there by promoting the pozzolanic reaction and facilitating the formation of C-S-H gel.

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