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Investigation of Mechanical Properties and Durability of Green Concrete by using Locally Available Waste Material

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ABSTRACT

Throughout the world, concrete is being widely used for the construction of most of the building, bridges, dams, canal etc. Hence, it has been properly labeled as backbone to the infrastructure development of a nation. To meet out this rapid infrastructure development a huge quantity of concrete is required. Structural concrete is a complex material, if we understand it thoroughly than it can leads us to both environmental and economic benefits. Concrete as a homogeneous material has to do so much to offer and the new technological challenges to be investigated. It also has to withstand against bending, cracking, weather effect,etc.

There is a growing awareness in India about extensive damage being caused to the environment due to accumulation of waste materials from industrial plants, power houses, colliery pits and demolition sites and it has become one of the major environmental, economic and social issues. Waste material is the material unused, unwanted and rejected as worthless into the environment in our society as whole. Waste materials coming out of industry nowadays is posing a great environmental problem in disposing them into the air, water and on the land. But, with proper utilization of these materials in construction industry will greatly help the society to have a better and pleasant environment. The use of the waste material will not be only the partial solution to environmental and ecological problem but it will also significantly improve the properties ofconcrete.

RHA is produced from the burning of rice husk which is a by-product of rice milling. This husk is burnt at high degree temperature in furnace and converted into silica and formed as siliceous material. The partial replacement of cement by siliceous material (RHA) has been made to carry out high compressive strength and durability of concrete. The use of RHA in concrete can not only improve the various properties of concrete – both in its fresh and harden states, but also can contribute to economy in construction cost.

Keywords: Rice Husk Ash, Waste Material, concrete, Environment

INTRODUCTION

Concrete is the single most widely material in the world. It is very strong and versatile mouldable material. Concrete is man-made material use as building binding material in construction era. Now a day concrete is used with advance and improved technology to give strength and durability to the structures against sliding, cracking, overturning, buckling etc. It is estimated that the present consumption of concrete in the world is of the order of 10 billion tones every year. It is the most readily available material on the job and also it has the ability to withstand against water effect, weather effect and fire resistance. The concrete is strong against cyclic loading and maintenance as it is non- corrodematerial.

Growth of population, increasing urbanization, rising standards of living due to technological innovations have contributed to an increase both in the quantity and variety of solid wastes generated by industrial, mining, domestic and agricultural activities. Globally the estimated quantity of wastes generation was 12 billion tones in the year 2002 of which 11 billion tones were industrial wastes and 1.6 billion tones were municipal solid wastes

Among the all types of wastes if such a waste should be use as, for partial replacement of concrete constituents which is effectiveness and usable than a construction can be economic. Such concrete has

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different properties, strength, and durability as compare with normal concrete. However, recently the environmental issues, restrictions of local and natural sources and disposal of waste material are gaining great importance. Today, it becomes more difficult to find a natural resource for fine and coarse aggregate and also how to minimize the use of cement? Therefore, the alternative material for fine aggregate and cement from others sources such as from the byproduct of agriculture has been investigated. The agriculture byproduct that has been identified are rice husk and coconut shell. Coconut shell being hard and not easily degrade material if crushed to size of sand can be a potential material to substitute sand and similarly rice husk ash which is highly siliceous material can be substitute ofcement.

Rice Husk Ash: A Highly Active Pozzolana

Among the all agriculture wastes, which can be used as pozzolonic material for concrete, rice husk has a large potential, due to its availability, high silica content and low cost. The rice husk is the outermost layer of the paddy grain that is separated from the rice grains during the milling process. Around 20% of paddy weight is husk and on combustion of this amount of husk would yield about 18% to 20% weight of husk as ash. Rice husk ash in some respects resembles silica fume, particularly in its large specific surface area and high content of amorphous silica.

Figure 1 - Rice Husk Ash

Rice husk

Rice husk is the outer covering part of the rice kernel and consist of two interlocking halves because the husk is non edible, it should be removed from the rice grain. This can be done either by hand threshing or by variety of specialized machinery. Therefore rice husk is a byproduct of the process of obtaining rice grain.

Figure 2 - Rice husk

Nature of RiceHusk

Rice husk is composed of two parts: i) organic matter, ii) inorganic mineral matter. The organic matter consists of cellulose, lignin, pentosans and a small amount of portion and vitamin. The major component of the inorganic mineral matter is silica.

Chemical composition of Rice HuskAsh

Chemical analysis of the ash, obtain by complete burning of rice husk, reveals silica as the main component, with only minor amount of alkalis and trace elements. The silica content of RHA is reported to vary between 85%- 94%. The major impurity of the ash is formed by alkalis, of which potassium is the predominant constituent.

Rice Husk AshProduction

Large quantities of rice husk ash were produced by burning local rice husk in a simple prototype incinerator. The drum and the detachable chimney of the incinerator are made from galvanized iron sheet. The incinerator is light in weight and can be easily carried by two persons. Detail of the incinerator is shown in figure below.

The fire is started from the bottom using a small amount of west papers or wood. The husk burn by themselves once ignited. No control is required during burningprocess.

Rice Husk Ash

1. Rice husk ash is an agricultural waste which is produced in millions of tons. Rice husk ash (RHA) is obtained by the combustion of rice husk and has been found to be super Pozzolana.
2. Thus, due to growing environmental concern and the need to conserve energy and resources, utilization of industrial wastes as supplementary cementing materials has become an integral part of concrete construction.
3. RHA is very reach in silicon dioxide which makes it very reactive with lime due to its non-crystalline silica content and its specific surface. It has about 85-90% silica.
4. This study investigated the engineering properties of RHA as a material for concrete production. The results shows that RHA is a super pozzolana and very suitable as a partial replacement of OPC.
5. Rice Husk Ash is a Pozzolanic material. It is having different physical & chemical properties. The product obtained from R.H.A. is identified by trade name Silpoz which is much finer than cement.

Figure 3 – Powder form Rice husk Ash

MIX DESIGN

Mix design for M_{30} grade of concret.

Concrete mix design may be defined as the art of selecting suitable ingredients of concrete and determine their relative proportion with the object of producing concrete of certain minimum strength and durability as economically as possible.

Objective of mix design

- To achieve the designed /desired workability in the plastic stage.
- To achieve desired minimum strength in the hardened stage.
- To achieve the desired durability in the given environmental condition.
- To produce the concrete as economically as possible.

Steps of Mix Design

- Calculation of target strength of concrete.
- Selection of water-cement ratio.
- Determine of aggregate air content.
- Selection of water content for concrete.
- Selection of cement content for concrete.
- Calculation of aggregate ratio.
- Calculation of aggregate content for concrete.
- Trial mixes for testing concrete mix design strength.

Design proposal of M30 grade of concrete

Proportions comes out as			
Water	**Cement**	**Coarse aggregate**	**Fine aggregate**
191.58	425.733	1127.048223	690.7714914
Ratio			
0.45	1	2.647310264	1.622545

CONCRETE TEST

Slump test

- The internal surface of the mould is thoroughly cleaned and freed from superfluous moisture and adherence of any old set concrete before commencing the test.
- The concrete slump test measures the consistency of fresh concrete before it sets.
- The difference in level between the height of the mould and that of the highest point of the subsided concrete is measured. This difference in height in mm is taken as slump of concrete.
- It is performed to check the workability of freshly made concrete, and therefore the ease with which concrete flows.
- It can also be used as an indicator of an improperly mixed batch.
- The slump test is used to ensure uniformity for different loads of concrete under field conditions.
- In case of a shear slump, the slump value is measured as the difference in height between the height of the mould and the average value of the subsidence. Shear slump also indicates that the concrete is non-cohesive and shows the characteristic of segregation.

Figure 4 - Slump testing

Table 1 – Slump Value

SR.NO	Description	Average Value
1	Slump value for normal concrete	82 mm
2	Slump value for RCA concrete	74 mm
3	Slump value for Modified RCA concrete	80 mm

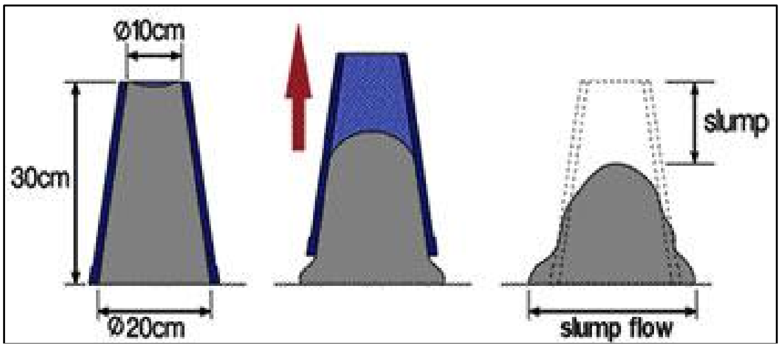

Figure 5 – Slump Cone Size

Compressive strength test

The compressive strength of any material is defined as the resistance to failure under the action of compressive forces.Cubes stored in water or a mist chamber shall be tested within one hour of removal from the water or mist chamber, whilst they are still wet. Surface water and grit on the cube shall be wiped off and projecting fins removed.The cube dimensions between the centers of the three pairs of opposing faces shall be measured with a caliper or other means which provide the same accuracy of measurement and recorded to the nearest 0.1 millimeter. A cube whose dimensions differ from the nominal dimensions by more than 1 mm on width or 2 mm on height as cast shall be recorded as 'oversize' or 'undersize' as appropriate. Especially for concrete, compressive strength is an important parameter to determine the performance of the material during service conditions.

Cube size 150mm X 150mm X 150mm

Table 2 - Compressive Strength Testing Of Cube Results

Sr. No.	Replacement of Cement by RHA	Compressive Strength (N/mm2)							
		7 Days				28 Days			
		Spe. 1	Spe. 2	Spe. 3	Average	Spe. 1	Spe. 2	Spe. 3	Average
1	0%	22.02	20.50	21.81	21.44	36.90	36.82	36.57	36.76
2	5%	20.1	22.46	24.62	22.39	37.22	37.15	37.28	37.21
3	10%	22.56	23.04	24.12	23.24	38.02	37.70	37.80	37.84
4	15%	24.72	21.45	24.65	23.61	38.42	38.80	37.44	38.22
5	20%	24.85	24.87	25.04	24.92	38.56	38.62	38.85	38.67
6	25%	25.44	26.54	23.62	25.20	39.40	39.15	39.09	39.21
7	30%	25.04	19.87	20.23	21.71	36.82	36.85	37.08	36.91

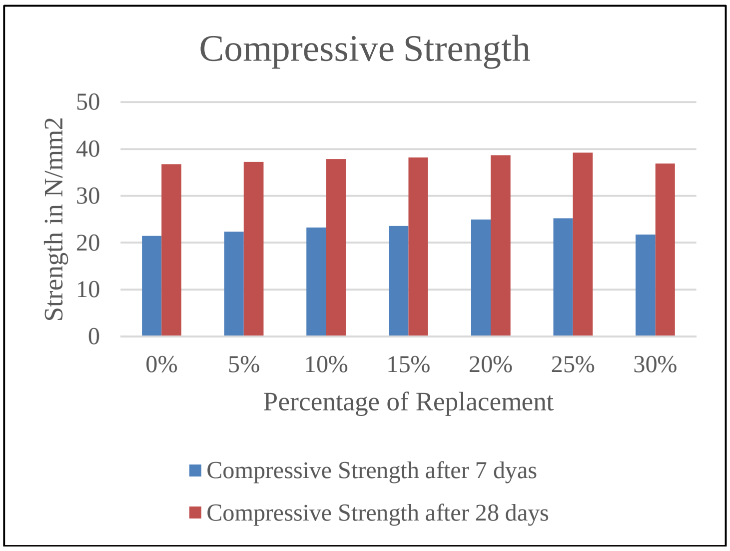

Figure 6 – Compressive strength of Concrete

SPLITTING TENSILE STRENGTH

This Section describes the method of determining the tensile splitting strength of cylindrical concrete test specimens.The concrete is very weak in tension due to its brittle nature and is not expected to resist the direct tension. The concrete develops cracks when subjected to tensile forces.Thus, it is necessary to determine the tensile strength of concrete to determine the load at which the concrete members may crack.The load shall be applied steadily and without shock such that the stress is increased at a rate within the range of 0.04 MPa/s to 0.06 MPa/s. Once adjusted, the rate shall be maintained at ± 10 % until failure. The maximum load applied to the specimen shall be recorded. The rate of increase of load may be calculated from the following expression:

$S = L \text{ X } D (\pi/2)$

Where,

L is the average measured length of the specimen (in mm)

*D*is the average measured diameter of thespecimen (in mm)

S is the increase in rate of stress, in MPa/s

Cylinder size 150mm diameter and 300mm height.

Table 3 - Splitting Tensile Strength Testing Of CylinderResults

Sr. No.	Replacement of Cement by RHA	Split Tensile Strength (N/mm2)							
		7 Days				28 Days			
		Spe. 1	Spe. 2	Spe. 3	Average	Spe. 1	Spe. 2	Spe. 3	Average
1	0%	3.22	3.34	3.45	3.33	4.35	4.25	4.32	4.30
2	5%	3.45	3.56	3.47	3.49	4.45	4.65	4.75	4.61
3	10%	4.05	3.86	4.85	4.25	5.08	5.12	4.93	5.04
4	15%	4.98	5.15	5.56	5.23	5.25	5.18	5.35	5.26
5	20%	5.33	5.48	5.28	5.36	5.32	5.45	5.28	5.35
6	25%	5.53	5.45	5.60	5.52	5.50	5.38	5.28	5.38
7	30%	5.20	5.06	4.48	4.91	5.25	5.05	5.45	5.25

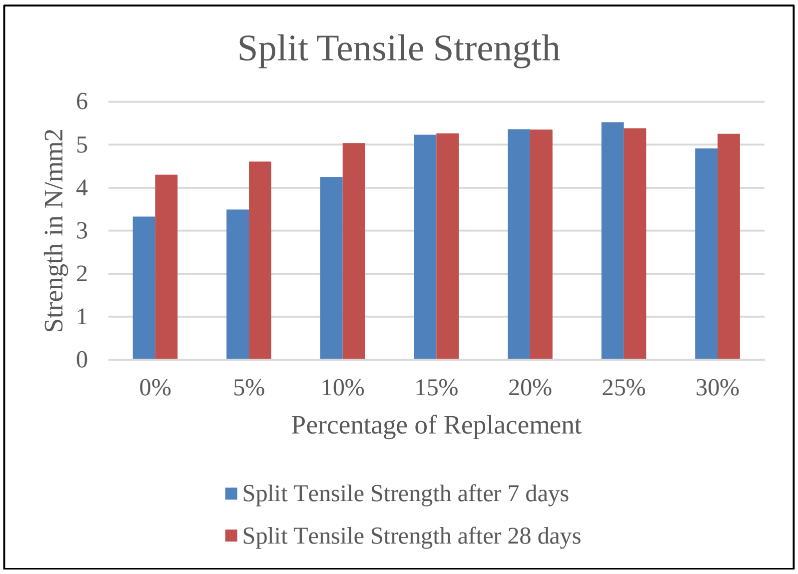

Figure 7 – Split Tensile Strength of Concrete

FLEXURAL STRENGTH

This Section describes the method of determining the flexural strength of a test specimen of hardened concrete. The test specimen shall be correctly centered in the machine with the trowelled surface vertical. The rollers shall be placed at right angles to the longitudinal axis of the specimen. There shall be no packing between the specimen and the rollers. Flexural strength is one measure of the tensile strength of concrete. It is a measure of an unreinforced concrete beam or slab to resist failure in bending. Flexural Strength of Concrete is about 10 to 20 percent of compressive strength depending on the type, size and volume of coarse aggregate used. The reference direction of loading shall be perpendicular to the direction of casting of the specimen. All loading and supporting rollers shall be in even contact with the test specimen before load is applied. After the application of the initial load, which does not exceed approximately 20 % of the failure load, test load shall be applied without shock such that the stress is increased continuously at a selected constant rate of ± 10 % within the range of 0.04 MPa/s to 0.06 MPa/s. Test load shall be applied until no greater load can be sustained.

Once adjusted, the rate of loading shall be maintained without change until failure occurs. The maximum load applied shall be recorded.

The flexural strength fcf (in MPa) is given by the equation:

f_{cf}= (450 X F)/(d_1 X d_2^2)

Where,

F is the maximum load (in N)

d_1&d_2 are the width and depth of the specimen respectively (in mm)

Beam size 150mm X 150mm X 700mm

Table 4 - Flexural Strength Testing Of Beam Results

Sr. No.	Replacement of Cement by RHA	Flexural Strength (N/mm2)							
		7 Days				28 Days			
		Spe. 1	Spe. 2	Spe. 3	Average	Spe. 1	Spe. 2	Spe. 3	Average
1	0%	3.22	3.18	3.08	3.15	4.02	3.96	4.25	4.08
2	5%	3.25	3.32	3.12	3.23	4.22	4.18	4.25	4.21
3	10%	3.45	3.38	3.48	3.43	4.30	4.52	4.80	4.54
4	15%	3.60	3.52	3.55	3.55	4.65	4.35	4.85	4.61
5	20%	4.15	3.96	4.08	4.06	4.98	5.05	4.85	4.96
6	25%	4.25	4.08	4.22	4.18	5.15	5.26	4.96	5.12
7	30%	3.98	4.11	3.85	3.98	4.99	5.13	4.95	5.02

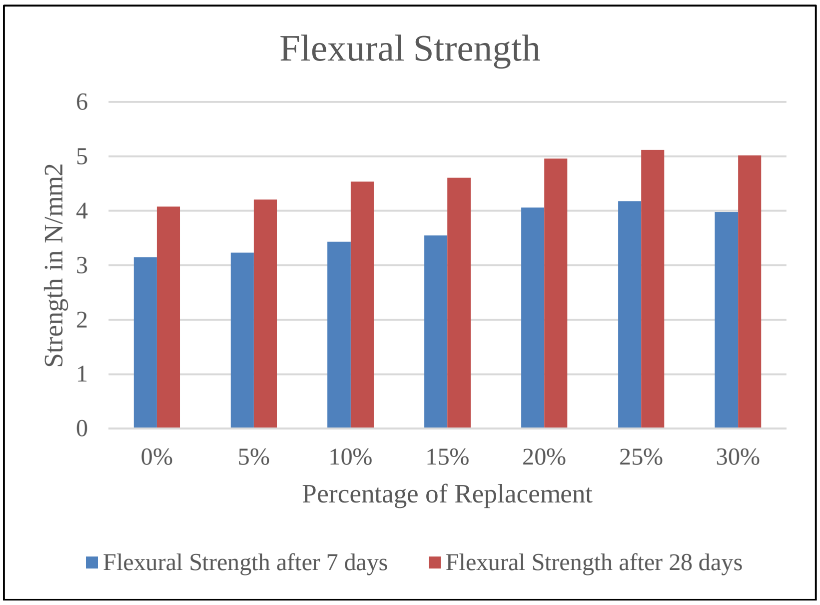

Figure 9 – flexural strength of concrete

DISCUSSIONS

According to IS code 456:2000 compressive strength of concrete after 7 days should be more 70% of total strength. Here, strength is 27.34 N/mm^2 which is more than 21 N/mm^2. Hence Ok.

According to IS code 456:2000Flexure strength of concrete after 7 days should be not less than 0.3 N/mm^2. Here, strength is 3.08 N/mm^2 which is more than 0.3 N/mm^2. Hence Ok.

CONCLUSION

As we can see the concstruction of different structure is increased day by day. So, the higher amount of cement was utilize. The cement have a one negative property. After contruction during the one year heat of hydration of cement was continued. Because of heat of hydration it released carbon dioxide and heat in to the atmosphere. Whichis the one of the reson of global warming. So, now a days RHA is used in concrete in place of cement.

Comparing to cement RHA has a high water absorption. So, as oer results the slumpo value of concrete containing RHA was a little beat less than the normal concrete.

As per the results of compressive strength, flexural strength and split tensile strength we can easily see 25% replacement of RHA gives a good or we can say that better than IS requirement strength.

According to the survey of all results the use of RHA was quite financially beneficial.

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