An Investigation On Characteristics Properties Of High Performance Self Compacting Concrete For Two Different Grades

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ABSTRACT

Strong Material is a key factor in measuring strength of a Structure. The fact that India is a developing nation having Mega structure and line up in the strongest nations of the world. For strong structure strength of material used should be high enough.

What if the concrete used is having a high strength and we are also able to save the material and make it eco Friendly. That's the better idea to make the structure ecofriendly and also the use of material is less.

The main objective of the project is to expedite the improvement of infrastructure with the help of High-Performance Concrete. The project has one of the major advantages that we can use the waste material produced during farming and use that thing in the improvement of strength of material and use it in the construction part of mega structures.

This Project addresses the potential use of Rice Husk Ash (RHA) as a cementitious material in concrete mixes. RHA is produced from the burning of rice husk which is a by- product of rice milling. The ash content is about 18-22% by weight of the rice husks. Research has shown that concrete made with RHA as a partial cement substitute to levels of 5%, 10%, 15% and 20% by weight of cement has superior performance characteristics compared to normal concrete. Also, the use of RHA would result in a reduction of the cost of concrete construction, and the reduction of the environmental greenhouse effects.

Due to growing environmental concerns and the requirement to conserve energy and resources, efforts have been made to burn the husk at a controlled temperature and atmosphere, and to utilize the ash so produced as a supplementary cementing material.

1. INTRODUCTION

Global production of rice is approximately 580 million tons a year and this is rising, as the world population and the consumption of rice increases day by day. Table 1 shows the most rice-growing countries in the world and the potential husk and ash production. The milling of rice produces rice husk, which is a waste material. Rice husk is generated on average at a 20% rate by weight of the rice that is processed. Most of the husk is burned or dumped as waste. The burning of the husks produces ash at an average of 18% by weight of the husks. Prior to 1970, RHA was usually produced by uncontrolled combustion, and the ash so produced was generally crystalline and had poor pozzolanic properties.

Due to growing environmental concerns and the requirement to conserve energy and resources, efforts have been made to burn the husk at a controlled temperature and atmosphere, and to utilize the ash so produced as a supplementary cementing material.

Workability, strength, and durability are the three basic properties of concrete. Amount of useful internal work necessary to overcome the internal friction to produce full compaction is termed as Workability. Size, shape, surface texture and grading of aggregates, water-cement ratio, use of admixtures and mix proportion are important factors affecting the workability of Concrete.

Figure 1: Rice Husk

Figure 2: Rice Husk Ash

Durability is mainly influenced by environmental exposure condition, freezing - thawing, contact to the aggressive chemicals, type and quality of constituent materials, water-cement ratio, workability, shape and size of member, degree of compaction, efficiency of curing, effectiveness of cover concrete, porosity and permeability. During service life of structures, penetration of water and aggressive chemicals, carbonation, chloride ingress, leaching, sulphate attack, alkali-silica reaction and freezing-thawing are resulting deterioration. Loading and weathering inter link voids and micro-cracks present in transition zone and network of same micro cracks gets connected to cracks on concrete surface which provides primary mechanism of the fluid transport to interior of concrete. Subsequent increase of penetrability leads to easy ingress of water, oxygen, carbon dioxide and acidic ions etc into concrete resulting cracking, spalling, loss at mass, strength and stiffness.

1.2 SALIENT FEATURES

Concrete with RHA shows more resistant to extreme conditions in comparison to plain cement concrete.

- It is more economical than plain cement concrete.
- It increases the workability of concrete.
- Due to addition of RHA concrete becomes more cohesive and more plastic.
- Bulk density of RHA content decreases with increase in RHA content.
- Use of RHA as an alternative to cement reduces corrosion and increases durability of concrete strength.

- RHA increases the impermeability characteristics of concrete.
- RHA reduces the impact on environment and capital cost of structure.
- RHA is also used for building load bearing blocks brick tiles at low cost.
- Replacement of cement with RHA leads to increase in compressive strength.
- Ideal mix is obtained at 20% replacement of RHA.

Rice husk can be burnt into ash that fulfils the physical characteristics and chemical composition of mineral admixtures.

Pozzolanic activity of rice husk ash (RHA) depends on:

➢ Silica content

➢ Silica crystallization phase

➢ Size and surface area of ash particles.

In addition, ash must contain only a small amount of carbon.RHA that has amorphous silica content and large surface area can be produced by combustion of rice husk at controlled temperature. Suitable incinerator/furnace as well as grinding method is required for burning and grinding rice husk in order to obtain good quality ash. Although the studies on pozzolanic activity of RHA, its use as a supplementary cementitious material, and its environmental and economical benefits are available in many literatures, very few of them deal with rice husk combustion and grinding methods.

PHYSICAL PROPERTIES

- Some other physical properties of Rice Husk Ash is that it feels soft when it touches the hand.
- It left the grey colour in Hand and touched.
- The particle size is really very small with irregular shape.

Sr.No.	Particulars	Properties
01	Colour	Grey
02	Shape Texture	Irregular
03	Mineralogy	Non Crystalline
04	Particle Size	<45 micron
05	Odour	Odourless
06	Specific Gravity	2.3

Table 2: Physical Properties of RHA

CHEMICAL PROPERTIES

Sr. No.	Particulars	Proportion
01	Silicon dioxide	86.94%
02	Aluminum oxide	0.2%
03	Iron oxide	0.1%
04	Calcium Oxide	0.3-2.2%
05	Magnesium Oxide	0.2-0.6%
06	Sodium Oxide	0.1-0.8%
07	Potassium Oxide	2.15-2.30%
08	Ignition Loss	3.15-4.4%

Table 3: Chemical Properties of RHA

High performance concrete (HPC)

High performance concrete (HPC) exceeds the properties and constructability of normal concrete. Normal and special materials are used to make these specially designed concrete that must meet a combination of performance requirements. Special Blend, mplementation, and curing practices may be needed to produce and manage high-performance concrete. High performance concrete was mainly use in tunnels, bridges, high-rise buildings and its strength, durability, and high modulus of elasticity. It was also used in the repair of shotcrete, poles, parking garages, and agricultural applications.

High performance concrete characteristics are developed applications and specific environments; some properties are

- High abrasion resistance
- High durability and long life in severe environments
- Low permeability and diffusion
- High strength
- High early strength
- Resistance to chemical attack
- High resistance to frost and deicer scaling damage
- Toughness and impact resistance

- Volume stability
- Ease of placement
- Compaction without segregation
- Inhibition of bacterial and mold growth

High performance concrete are made with care selected ingredients of high quality and optimized mix drawings; these are grouped, mixed, placed, compacted and hardened to the highest industry standards. Typically, such concretes have a low ratio of water to cementing materials from 0.20 to 0.45. Plasticizers are typically used to make these fluid concretes and achievable.

Supplementary Cementing Materials

Fly ash, silica fume, or slag are often required in the production of high strength concrete; the strength gain obtained with these Supplementary Cementing Materials cannot be achieved by using only additional cement. These supplementary cementitious materials are generally added at levels of 5% to 20% by mass or more doses of cementing material. Some specifications will allow to use up to 10% silica fume, unless evidence is available indicating that the concrete product with a rate larger dose will have a satisfactory strength, durability and volume stability. The water-cementing materials ratio must be adjusted so that equal workability becomes the basis of the comparison between the test mixtures. For each set of documents, there will be a cement content of cementitious materials with optimal strength booster that does not continue to increase with greater amounts and the mixture becomes too sticky to handle properly. Blended cements containing fly ash, silica fume, slag or calcined clay can be used to make high-strength concrete with or without the addition of supplementary cementitious materials.

2. **LITERATURE REVIEW**

D.V. Reddy, Ph.D, P.E.(Professor and Director of the Center for Marine Structures & Geotechnique) The cement has been the major building material in today's construction because of its binding and high compressive strength properties. Beside this, it also causes release of greenhouse gas carbon dioxide which causes global warming and other environmental issues.

Researches were done to decrease the carbon footprint and use of waste material to be used in construction. The rice husk ash is a waste material which have shown promising results if replaced with cement in production of concrete.

Previous researches done by researcher's shows that it enhances the corrosion resistance capability of produced concrete with RHA and increase in compressive strength.

The research done in past by –

P.E, Department of Civil Engineering, Florida Atlantic University mainly on 10 % and 20 % replacement have done research with replacement of 5%, 10%, 15%, 20% and determined the compressive, flexure strength and split tensile strength of the hardened concrete.

D.V. Reddy, Ph. D, P.E. and Marcelina Alvarez, B.S detailed, the use of RHA will not only concrete production of better quality and low cost, but also reduce carbon dioxide (CO2) emissions from cement production. The partial replacement of cement by RHA will result in lower energy consumption associated with cement production. The potential market for rice husk energy systems and equipment has been studied by Velupillai et al. (1997). The reference also addresses economic development, urbanization, living standards, stricter environmental regulations, and consolidation in the rice milling industry is the reduction of certain traditional uses balls, and creating new opportunities for the use of the envelope. He discusses the potential use of rice husk Ash (RHA) as a cementitious material in concrete mixes. RHA is produced by burning rice husk which is a by-product of rice milling. The ash content is about 18 to 22% by weight of rice hulls. Research has shown that concrete containing RHA in partial replacement of cement concentrations of 10% to 20% by weight of cement has superior performance characteristics compared to normal concrete. In addition, the use of ORS would result in a reduction in the cost of concrete construction, and the reduction of the greenhouse effect on the environment.

Mehta , P.K., explain the durability of cement mortar in the presence of rice husk Ash (RHA). The strength and durability of mortar with different replacement levels (10%, 20% and 30%) of ordinary Portland cement (OPC) by the RHA is studied here. RHA was manufactured from an uncontrolled combustion process. The test samples were prepared with 2.73 FM river sand. The samples were stored in a controlled environment to test time. The results show that the addition of RHA has shown better results for 20% replacement level OPC 90 days. In the durability test all samples passed for 20 cycles except 25% replacement level of 30%.

Ramakrishnan S, Velrajkumar G, Ranjith S, explain the behavior of concrete for pavement replacing different percentages of ashes hush up by weight of cement for concrete quality control mixture M40. To study the effect of the rice hull ash (RHA) on the performance of various concrete parameters to produce an economic concrete for rigid pavements.

P.Padma Rao, A.Pradhan Kumar, B.Bhaskar Singh, explains, a feasibility study is made using rice husk Ash as an adjunct to cement already replaced by fly ash (pozzolan Portland cement) in concrete, and an attempt was made to study the strength parameters concrete (compressive and bending strength). For the control of concrete, is the mixture design method is adopted and given that basis, the design for the replacement method was made mix. Five different replacement levels, namely 5%, 7.5%, 10%, 12.5% and 15% were selected for the study concerning the replacement method.

OBILADE, I.O. summarizes the research on the properties of rice husk Ash (RHA) when used as a partial replacement of ordinary Portland cement (OPC) in concrete. OPC was replaced by RHA by weight to 0%, 10% and 20%. 0% replacement served as a control. Compaction factor test was performed on fresh concrete while the compressive strength test was performed on 150mm hardened concrete cubes after 7, 14 and 28 days of curing in water. The results revealed that the compaction factor decreases as OPC percentage replacement with RHA increased. The compressive strength of hardened concrete also decreased with increasing substitution of OPC with the RHA.

Composition of concrete mixture:

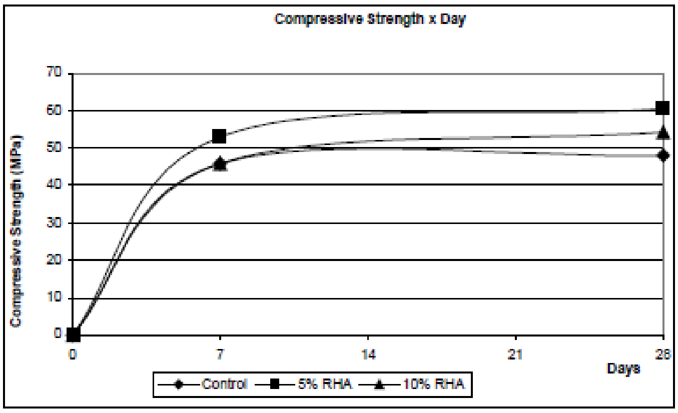
He used the concrete mix proportions. Two doses of CSF, 5% (mixture E) and 10% (mixture F) in the cement replacement, and a mixture control (mixture D) were used. The slump test was fixed in 120 ± 20 mm, therefore, for the blends D and E, the amount of superplasticizer was 0.2% by mass of binder. To the mixture C, the ofsuperplasticizer assay was 0.3%

Cement	Sand	Coarse aggregate	W/C	Cement (kg/m3)		
				Mixture D	Mixture E	Mixture F
1	1.33	2.27	0.42	490.0	465.5	441.0

Compressive strength:

The compressive strength is shown in Table and Figure . The addition of RHA causes an increase in the compressive strength due to the ability of the pozolan, fixation of the calcium hidroxide, generated during the cement hydrate reactions. All degrees of replacement RHA increased the compressive strength. For a 5% ORS, 25% of the increase is verified by comparison with the mixture D.

Mixture	7 days	28 days
D	45.9	48.1
E	52.9	60.4
F	45.8	54.2



Result of compressive strength

METHODOLOGY

The main objective of this work is to study the suitability of the rice husk ash as a pozzolanic material for cement replacement in concrete. However it is expected that the use of rice husk ash in concrete improve the strength properties of concrete.

Also it is an attempt made to develop the concrete using rice husk ash as a source material for partial replacement of cement, which satisfies the various structural properties of concrete like compressive strength and Flexural strength.

It is also expected that the final outcome of the project will have an overall beneficial effect on the utility of rice husk ash Concrete in the field of civil engineering construction work.

Following parameters influences behavior of the rice husk ash concrete, so these parameters are kept constant for the experimental work:

- Percentage replacement of cement by rice husk ash
- Fineness of rice husk ash
- Chemical composition of rice husk ash
- Water to cementitious material ratio (w/b ratio)

Design of Concrete Mix

The compressive strength is said to be the index of quality of concrete. Therefore the design mix should be prepared keeping in view compressive strength of concrete with adequate workability so that the fresh concrete can be properly mixed, placed and compacted. The proportions for the mix were calculated adopting the requirements of water as specified in IS: 10262-2009. The following three steps must be followed for proportioning of concrete mixes.

1. Selection of suitable ingredients-cement, supplementary cementing materials, aggregates, and water and chemical admixtures (if required).
2. Determination of the relative quantities of components to have economical concrete, that has desired rheological properties i.e. strength and durability.
3. Careful quality control of every phase of the concrete making process.

PREPARATION OF MIX DESIGN

In this project we are using the M40 grade of Concrete mix design for testing purpose.

Mix Design Proportions are given in the Table below

MIX	CEMENT	SAND	COARSE AGGREGATE	WATER
RATIO	1	1.632	2.353	0.40
QUANTITY	442 Kg/m3	734.9 Kg/m3	1048.53Kg/m3	176.5 Kg/m3

CASTING OF SPECIMENS

All the specimens were casted referring to the mix proportions mentioned in table. For these mix proportions, required quantities were weighed. Under this article, casting of specimens for different properties. Specimens for Compressive Strength 150x150x150 mm sized cube specimens were prepared for compressive strength. The materials required were weighed according to the mix proportion. Cement, fly ash, fine aggregates and coarse aggregates were dry mixed first to have a uniform colour.

After that 50% of the total water required was added to the mix to have thorough mixing for 3-4 minutes. Then 40% of the water was added with addition to the mix. Remaining 10% of water was sprinkled on the above mix and it was thoroughly mixed in the mixer. The oiled samples were then filled with the mix prepared and then filled moulds were put on the vibrating table for their proper mixing. Immediately after casting cubes, the specimens were covered with gunny bags to prevent water evaporation. Six identical cubes were casted. Out of six, three were tested after 7 days and rest after 28 days of curing.

Compressive Strength

Specimens were demoulded after 24 hours of casting. Then they were poured in curing tank for the predefined time. At the age of testing, specimens were taken out of the tank and allowed surface drying for 10-15 minutes. Specimens were tested in Compression Testing Machine (CTM) at the load rate of 5 kN/sec specified as per IS: 516-1959. CTM has the capacity of 5000kN. The failure load was then evaluated.

Universal testing Machine (UTM)

Split Tensile Strength

Specimens were demoulded after 24 hours of casting. Then they were poured in curing tank for the predefined time. At the age of testing, specimens were taken out of the tank and allowed surface drying for 10-15 minutes. Specimens were tested in Universal testing machine (UTM) at the load rate of 70 kN/min. UTM has the load capacity of 1000kN. The failure load was then evaluated. The formula used is

$$\text{Split tensile strength} = \frac{0.5187XP}{S^2}$$

P = Failure load, in N
S = Side of cube, in mm

DETERMINATION OF FLEXURE STRENGTH TEST ON CONCRETE BEAMS

$F_b = PL/ bd^2$

Where b= width in cm of specimen
d= depth in cm of specimen at point of failure
L= length in cm of specimen on which specimen was supported

DETERMINATION OF SPLIT TENSILE STRENGTH TEST

The split tensile strength of the specimen calculated from the following formula

$T_{sp} = (2P/ (\pi dL))$

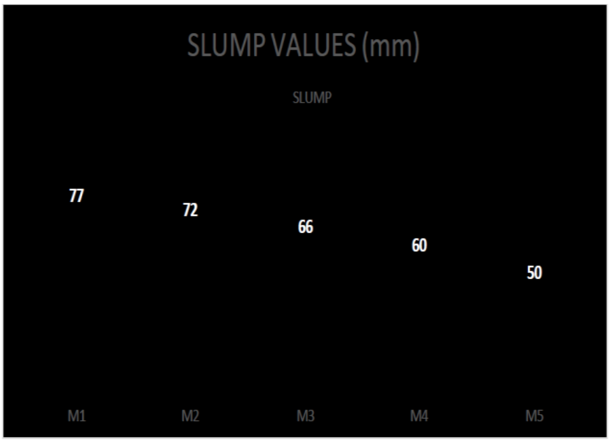
Where P= maximum load in tonne

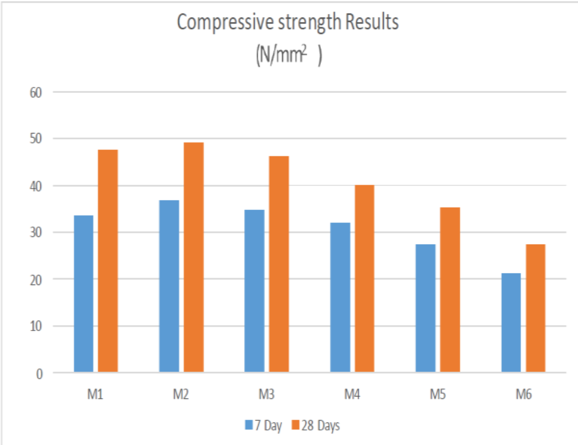
L= length of the specimen

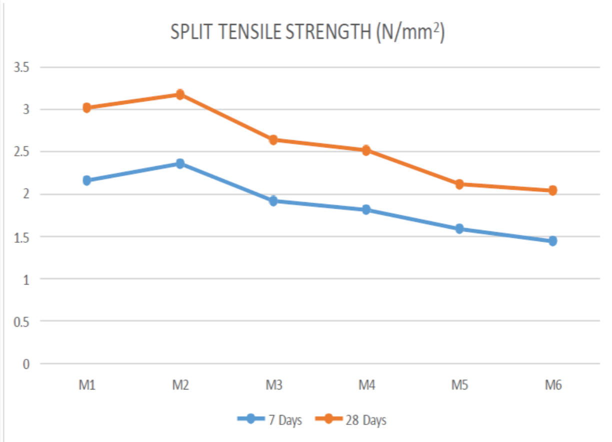
d= diameter of width of the specimen

RESULTS OF SLUMP TEST

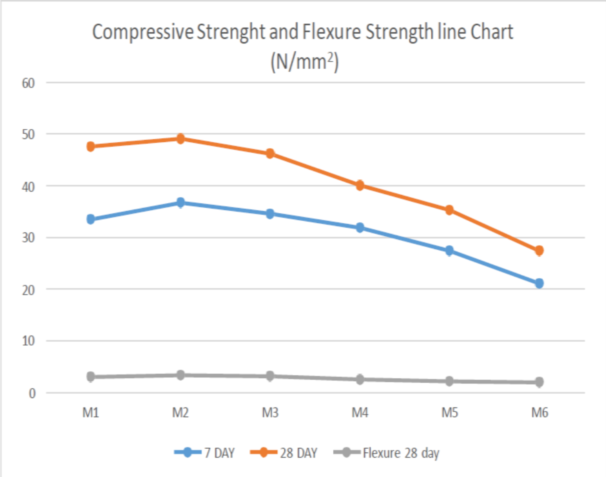
MIX	RHA Replacement	Slump Value (mm)
M1	0%	77
M2	5%	72
M3	10%	66
M4	15%	60
M5	20%	50

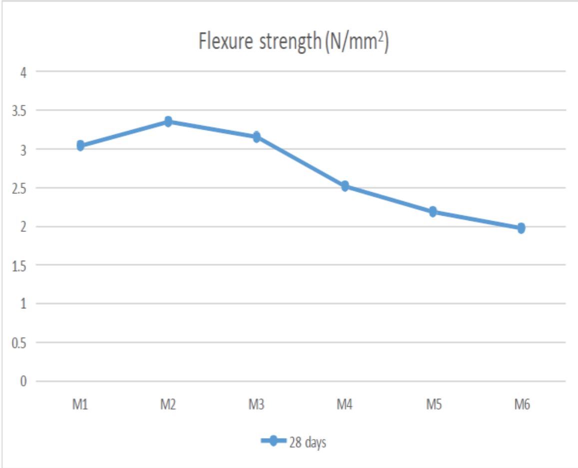






MIX	RHA REPLACEMENT	COMPRESSIVE STRENGTH (N/mm^2)		FLEXURE STRENGTH
		7 DAYS	28 DAYS	28 DAYS (N/mm^2)
M1	0%	33.5	47.6	3.037
M2	5%	36.7	49.1	3.350
M3	10%	34.6	46.2	3.151
M4	15%	31.9	40.1	2.516
M5	20%	27.4	35.3	2.185
M6	25%	21.1	27.4	1.975





CONCLUSION

- After doing this project following conclusions are made :
- Rice Husk Ash is a highly reactive pozzolanic material and can be used as a supplementary cementing material to produce high-performance concrete.
- The compressive strength of the concrete containing up to 15 percent of the RHA was higher than that of the control Portland cement concrete. The strength of the concrete increased with decreasing *w*/(*c* + RHA).
- Due to the high specific surface of the RHA, the concrete incorporating RHA required
- The RHA concrete had slightly longer setting times than those of the control and the silica fume concretes. The bleeding of the concrete incorporating RHA was negligible.
- The RHA concrete had higher compressive strengths at ages up to 180 days compared.
- The flexural and splitting tensile strengths, modulus of elasticity, and drying shrinkage of the control concrete and the concrete incorporating RHA or silica fume were comparable higher dosages of the super-plasticizer and the air-entraining admixture than the control Portland cement and silica fume concretes to achieve the same slump and air content.
- with that of the control concrete, but lower values than those of the silica fume concrete.

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