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Experimental Investigation on Durability Properties of Concrete using Hybrid material (Nano Rice Husk Ash and Nano Fly Ash) as a partial replacement of OPC

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Abstract- *Durability is defined as the capability of concrete to resist weathering action, chemical attack and abrasion while maintaining its desired engineering properties. It normally refers to the duration or life span of trouble-free performance. Different concretes require different degrees of durability depending on the exposure environment and properties desired. Ordinary Portland Cement (OPC) is one of the main ingredients used in the production of concrete. Large scale production of cement is causing environmental problems on one hand and depletion of natural resources on other hand. This threat to ecology has led researchers to use industrial by products as supplementary cementitious material in making concrete such as Fly ash and rice Husk ash due to its huge production and also they causes environmental pollution.*

In this study, concrete of grade M_{25} with partial replacement of cement by nano rice husk ash (5, 10 and 15%) and nano fly ash (20, 30, 40 and 50%) and their combinations are prepared at a constant water/binder ratio of 0.5. A detailed experimental study on Compressive strength and Durability tests including Chloride permeability, Acid attack, Alkaline attack and Sulphate attack at age of 28, 60 and 90 days are investigated experimentally and compared with Conventional concrete and combination of 20% nano FA and 5% Nano RHA proved to be optimum.

Keywords- *Durability, Hybrid material, Fly ash, Rice husk ash, Compressive strength, Chloride permeability, Acid attack, Alkaline, Sulphate.*

I. INTRODUCTION

Concrete's versatility, durability, sustainability, and economy have made it the world's most widely used construction material. The production of one ton of cement consumes about 1.5 tons of raw materials, 80 units of electric power apart from one ton of CO_2 released into the atmosphere. Out of the total CO_2 emissions (from various sources) worldwide, cement industry contributes about 7% of CO_2 emissions. Annual cement production rate is increasing very much year by year. Pozzolans decrease capillary porosity, reduce micro cracking and density the interfacial transition zone in concrete. There are both technical advantages and social benefits in using rice husk ash and fly ash in concrete. Because RHA contains large amount of silica which is assimilated into the structure by absorption from the soil during the growth of rice plant and fly ash is a pozzolonic material which behaves like cement in the presence of lime and water. In order to make the concrete more eco-friendly to use Nano RHA and Nano FA in concrete. After the selection of supplementary cementing materials for making concrete, the other ingredients such as aggregates were collected from the nearby quarries, 53 Grade OPC was used in all concrete mixtures. The Durability properties of the concrete were examined by replacement of OPC with Nano FA and Nano RHA.

II. LITERATURE REVIEW

M. Nili (2010) et al : The highest compressive strength at the ages of 7 and 28 days was attained when the mixtures contain 6% microsilica and 1.5% nanosilica. A considerable increase in electric resistant of nano-micro silica specimens was observed compare to reference ones and the highest value was corresponding to the specimens which contain totally 7.5% nano and micro silica. The capillary absorption rate decreased to a lowest level, when 3% microsilica and 1.5% nano silica were used in the mixtures.

Prince Arulraj. G (2011) et al : Since the nano sized particles are most active, the strength of concrete with nano-materials was found to be higher than that of Normal Cement Concrete. The 28th day strength of concrete with 10% of nano-fly ash was found to be 17 to 46% higher than that of Normal Cement Concrete. M20 concrete had the highest increase in strength where as M50 concrete had the least increase in strength. The 28th day strength of concrete with 20% of nano- fly ash was

found to be 19 to 56% higher than that of Normal Cement Concrete. The 28th day strength of concrete with 30% of nano- fly ash was found to be 21 to 60% higher than that of Normal Cement Concrete. The workability of the concrete with nano- fly ash was found to be 90 to 140% higher than that of Normal Cement Concrete.

Er. Magudeaswaran. P (2013) et al : According to the test results, it can be conclude that structural grade concrete can be produced by partial replacement (25%&12.5%, 30%& 15%, 35%&17.5%) of cement by fly ash and silica fume. The strength of the concrete and durability characteristics of the concrete is increased by using admixtures. Compression strength is increased by 31.6% for 35% & 17.5% replacement of fly ash and silica fume. Flexural strength of concrete is increased by 24.46% for 35% & 17.5% replacement of fly ash and silica fume. Spilt tensile strength of the concrete is increased. The pH value of the concrete decreases by 5.47%. The rate of absorption of the concrete is reduced by 0.24%. However, an acceptable strength and durability characteristics can be achieved by using a fly ash and silica fume.

III. MATERIALS

3.1. CEMENT

Cement is the most important material in concrete and it acts as a binding material. Ordinary Portland cement 53 grade manufactured by Ultratech Cement Company confirming to IS 12269-1987 is used in this investigation. The physical properties of cement are presented in table 1.

Table no1 – Physical properties of cement

S.NO	PARTICULARS	RESULTS
1	Specific Gravity	3.15
2	Initial setting time	41 min
3	Final setting time	650 min
4	Fineness	225 m^2/kg

3.2. AGGREGATE

After cement, Aggregate is the basic material used in any concrete to constitute the body of concrete to reduce the cementitious material quantity, and to reduce the consequent volume change of concrete

3.2.1. FINE AGGREGATE:

The amount of the fine aggregate usage is important to fill the voids present in coarse aggregate. In this investigation natural sand was used as fine aggregate. The specific gravity of sand is found to be 2.65.The physical properties of fine aggregate are shown in table no 2. Sand was obtained from Bahuda River near Nandaluru in YSR Kadapa district.

Table no 2- Properties of the fine aggregate

S.NO	PARTICULARS	RESULTS
1	Type	Normal sand
2	Specific gravity	2.67
3	Grading size	4.75mm – 0.075mm
4	Bulking of Sand	6%
5	Fineness modulus	2.28
6	Bulk density in Loose state Compacted state	1378.82 kg/m^3 1544.67 kg/m^3

3.2.2. COARSE AGGREGATE

In the present investigation crushed granite aggregate of 20mm size was used. The specific gravity of coarse aggregate is 2.7. The physical properties of coarse aggregate are shown in table no 3. Fineness modulus is obtained by using sieve analysis.

Table no 3 – Physical Properties of coarse aggregate

S.NO	PARTICULARS	RESULTS
1	Type	Crushed stone
2	Specific gravity	2.70
3	Maximum size	20mm
4	Water absorption	0.8%
5	Fineness modulus	4.30
6	Bulk density in Loose state Compacted state	1688 kg/m^3 1766 kg/m^3

3.3. WATER

Water is used for mixing and curing of concrete. In the present investigation, tap water available in the campus was used for both mixing and curing of concrete. P_H value of 7.1.

3.4. NANO RICE HUSK ASH:

In the present experiment cement is partially replaced by Nano RHA, Nano RHA is made with rice husk ash material in which particle size range is from 1 Nano meter to 100 micro meter. The particle size of Nano RHA is calculated by using X-Ray Diffraction (XRD) analysis. X-Ray Diffraction (XRD) analysis gives not only grain size but also the crystalline structure, lattice parameters, strain and phase composition.

Table no 4 - Physical properties of Nano rice husk ash

SL.NO	PARTICULARS	PROPERTIES
1	Color	Gray
2	Specific gravity	2.2
3	Mineralogy	Crystallite size
4	Particle size	26.8nm

3.5. NANO FLY ASH:

The other supplementary cementing material used in this investigation is Nano FA. Fly ash used in this study contains more silica content and less calcium. The details of chemical compounds present in the fly ash are furnished in table 5. The material is obtained from RTTP, Muddanur.

Table no 5-Properties of fly ash

Major element	% by weight in the fly ash of RTTP Muddanur	Requirement as per IS:3812-2003
SiO_2	58.80%	>35%
Al_2O_3	24.10%	-
Fe_2O_3	5.18%	-
TiO_2	6.14%	-
CaO	1.00%	-
MgO	0.38%	<5.0%
Na_2O	0.66%	<1.50%
K_2O	0.62%	<1.50%
P_2O_5	0.60%	-
SO_3	0.25%	<2.75%
Loss on ignition	6.25%	<12.00%

IV. EXPERIMENTAL STUDY

4.1. MIX PROPORTIONS

In the present investigation M_{25} grade concrete is used with a constant W/C ratio of 0.5. Concrete mix is prepared by varying the percentage replacement of cement with Nano RHA (5%, 10%, and 15%) and Nano FA (20%, 30%, 40% and 50%) and their combinations (i.e., 5% of Nano RHA with 20, 30, 40 and 50% of Nano FA replacement in cement, 10% of Nano RHA with 20, 30, 40 and 50% of Nano FA replacement in cement and 15% of Nano RHA with 20, 30, 40 and 50% of Nano FA replacement in cement).

Table no 6- Mix Proportions

Mix Proportion	Proportions of Supplementary materials
A0	100% Cement
A1	20% Nano Fly Ash, 5% Nano RHA and 75% Cement
A2	30% Nano Fly Ash, 5% Nano RHA and 65% Cement
A3	40% Nano Fly Ash, 5% Nano RHA and 55% Cement
A4	50% Nano Fly Ash, 5% Nano RHA and 45% Cement
A5	20% Nano Fly Ash, 10% Nano RHA and 70% Cement
A6	30% Nano Fly Ash, 10% Nano RHA and 60% Cement
A7	40% Nano Fly Ash, 10% Nano RHA and 50% Cement
A8	50% Nano Fly Ash, 10% Nano RHA and 60% Cement
A9	20% Nano Fly Ash, 15% Nano RHA and 65% Cement
A10	30% Nano Fly Ash, 15% Nano RHA and 55% Cement
A11	40% Nano Fly Ash, 15% Nano RHA and 44% Cement
A12	50% Nano Fly Ash, 15% Nano RHA and 35% Cement

4.2. MIXING OF CONCRETE

The ingredients of concrete in the required quantities were charged into the capacity laboratory concrete mixer. After through mixing i.e., having achieved uniform color, workable consistency to concrete, the concrete was delivered into the pan for casting the specimens.

4.3. CASTING OF SPECIMENS

For casting specimens the concrete has been placed in the standard metallic moulds in three layers and compacted with tamping rod by giving 25 blows. Before placing the concrete in the moulds a thin coat of oil was applied for the walls of the mould inside for easy removal. After thorough compaction the top surface of specimens were finished smoothly.

4.4. CURING OF SPECIMENS

The concrete specimens were air dried for 24 hours and then the specimens were demoulded and then kept for curing. Marking was done on the specimens to identify the percentage of Nano RHA and Nano FA combinations. And then some specimens were placed in water tank for curing and some specimens were placed in Acid, Alkaline and Sulphate solutions . All the specimens have been cured for desired age and then tested for Compressive Strength.

4.5. TESTING OF SPECIMEN

For testing of specimens compressive strength, Compression Testing Machine is used and tested for 28, 60 and 90 days and for testing of chloride permeability, RCPT Machine is used and tested for 60 days and finally the results are tabulated.

V. EXPERIMENTAL RESULTS

5.1. COMPRESSIVE STRENGTH

Table no 7- Compressive strength

Mix Proportions	Compressive strength N/mm^2		
	28 days	60 days	90 days
A0	27.4	29.3	30.4
A1	32.8	33.5	34.2
A2	25.6	27.1	27.5
A3	24	26.5	27.1
A4	19.7	22.4	23.0
A5	26.4	28.6	29.1
A6	22.48	23.2	23.9
A7	20.2	21.5	22.4
A8	18.6	20.08	20.7
A9	21.4	24.5	25.6
A10	18.3	19.9	20.6
A11	16.1	16.8	17.4
A12	13.4	15.2	16.2

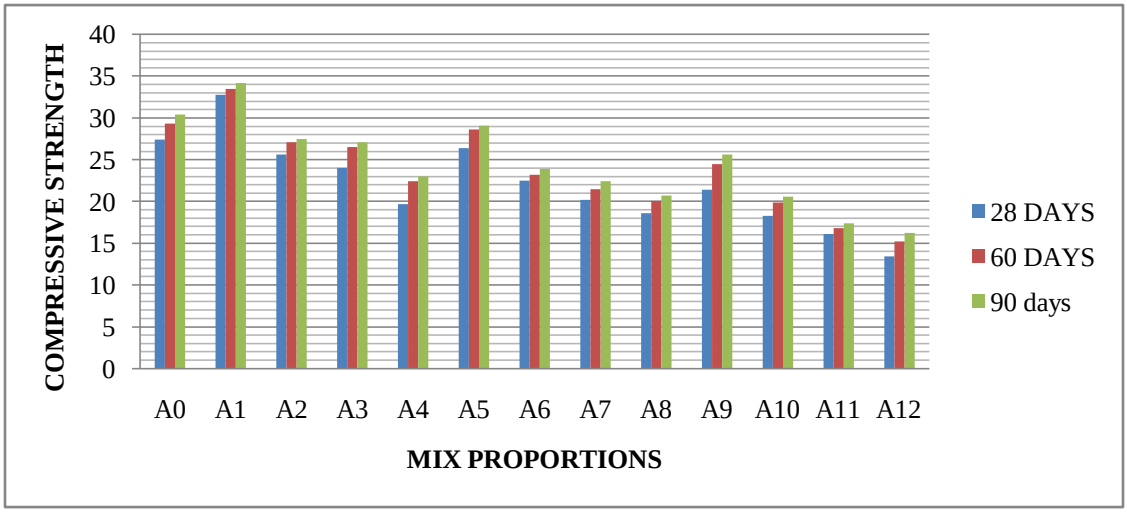

Fig 1- Compressive strength

5.2. ACID ATTACK TEST

The specimen are casted and cured in mould for 24 hours, after 24 hours, all the specimen are demoulded and the specimens are weighed and immersed in sulphuric acid (H_2SO_4) solution for 60-days. The pH value of the acidic media was at 1. The pH value was periodically checked and maintained at 1.

Table no 8- Acid Attack Test

Mix Proportions	Compressive Strength N/mm^2	
	28 days	60 days
A0	25	23.8
A1	29.9	27.5
A2	23.05	22.7
A3	22.2	20.8
A4	17.2	15.4
A5	23.5	21.3
A6	20.94	19.5
A7	18.1	16.2
A8	16.2	13
A9	19.9	17.2
A10	15.6	12.3
A11	14.1	11
A12	11.2	9.8

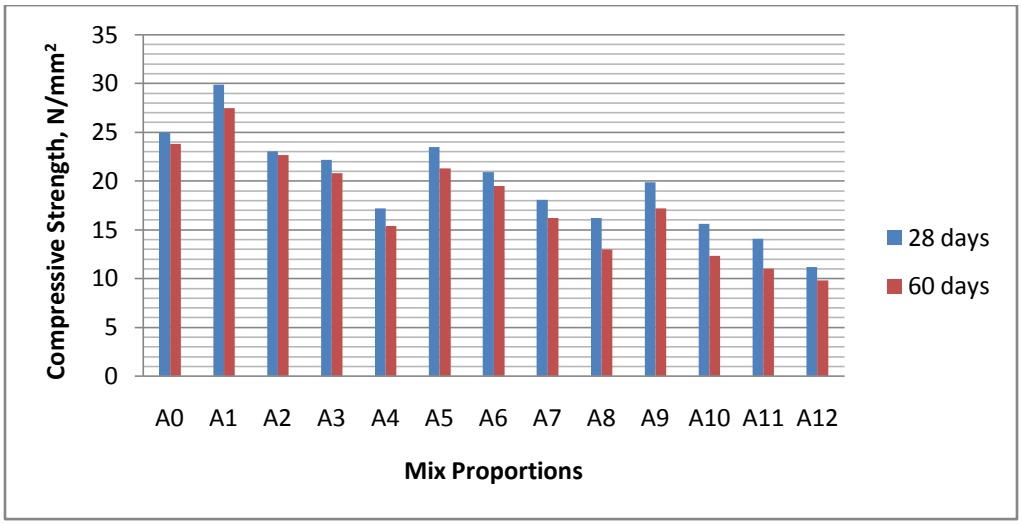

Fig 2- Acid Attack Test

5.3. ALKALINE ATTACK TEST

The specimen are casted and cured in mould for 24 hours, after 24 hours, all the specimen are demoulded and the specimens are weighed and immersed in Sodium Hydroxide (NaOH) solution for 60-days. The pH value of the alkaline media was at 12. The pH value was periodically checked and maintained at 12.

Table no 9- Alkaline Attack Test

Mix Proportions	Compressive Strength N/mm^2	
	28 days	60 days
A0	25.4	24.2
A1	29.4	28.1
A2	24.6	23.7
A3	22.1	20.6
A4	17.7	16.5
A5	25.1	21.3
A6	19.6	18.6
A7	18.7	16
A8	17.2	15.3
A9	19.5	17.8
A10	16	15.2
A11	14.8	12.3
A12	11.9	10.8

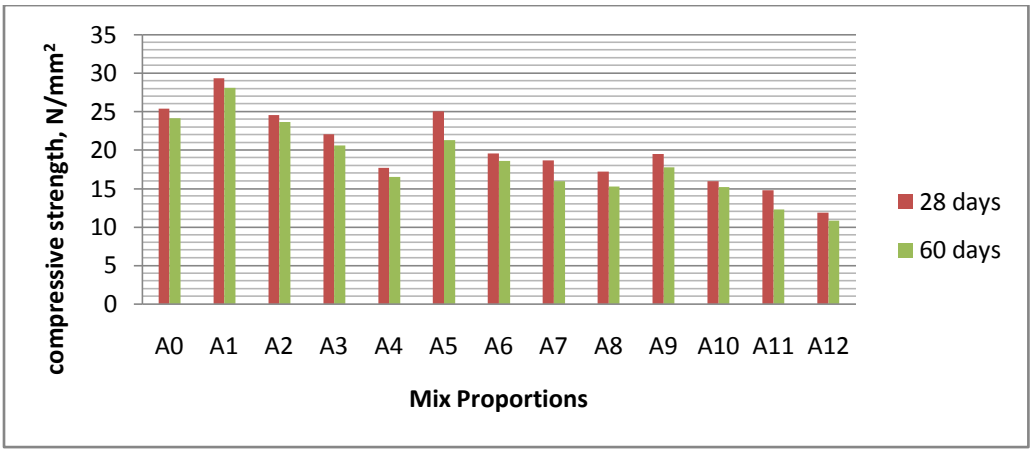

Fig 3- Alkaline Attack test

5.4. SULPHATE ATTACK TEST

The specimen are casted and cured in mould for 24 hours, after 24 hours, all the specimen are demoulded and the specimens are weighed and immersed in Magnesium Sulphate and Sodium Hydroxide (MgSO4+NaOH) solution for 60-days. The pH value of the alkaline media was at 7. The pH value was periodically checked and maintained.

Table no 10- Sulphate Attack Test

Mix Proportions	Compressive Strength N/mm^2	
	28 days	60 days
A0	25.3	23.44
A1	29.6	27.9
A2	22.4	20.8
A3	20.1	18.9
A4	16.2	15.2
A5	23.8	20.9
A6	19.9	16.8
A7	16.2	14.8
A8	15.8	13.5
A9	18.4	16.0
A10	15.2	11.9
A11	12.2	10.1
A12	10.8	8.6

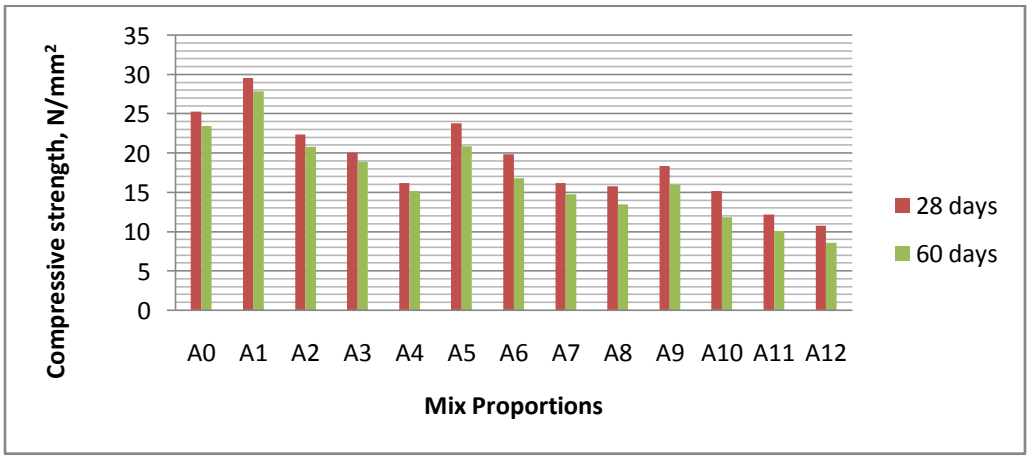

Fig 4- Sulphate Attack test

5.5. RAPID CHLORIDE PERMEABILITY TEST

Table no 11- Rapid chloride permeability Test

Mix Proportion	Chloride permeability in coloumbs
	60 days
A0	2438
A1	1656
A2	1224
A3	1025
A4	785
A5	1748
A6	1366
A7	1124
A8	988
A9	1790
A10	1286
A11	1081
A12	856

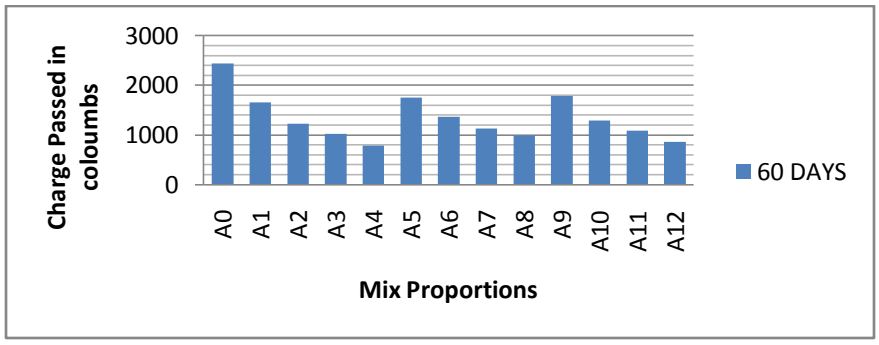

Fig 5- Rapid chloride permeability test

VI. CONCLUSION

1.The Compressive Strength of concrete increased by 19.7% at 28 days, 14.3% at 60 days and 12.5% at 90 days when cement is replaced by combination of 20% Nano FA and 5% Nano RHA compared with conventional concrete is proved to be optimum.

2.In Acid Attack, Compressive Strength of conventional concrete is reduced by 14.67% at 28 days and 21.7% at 60 days. When the cement is replaced by combination of 20% Nano FA and 5% Nano RHA reduced by 10.7% at 28 days and 19.6% at 60 days when compared with normal curing of same proportion.

3.In Alkaline Attack, Compressive Strength of conventional concrete is reduced by 13.3% at 28 days and 20.4% at 60 days. When the cement is replaced by combination of 20% Nano FA and 5% Nano RHA reduced by 12.2% at 28 days and 17.8% at 60 days when compared with normal curing of same proportion.

4.In Sulphate Attack, Compressive Strength of conventional concrete is reduced by 13.7% at 28 days and 22.9% at 60 days. When the cement is replaced by combination of 20% Nano FA and 5% Nano RHA reduced by 11.6% at 28 days and 18.4% at 60 days when compared with normal curing of same proportion.

5. In Rapid Chloride Permeability Test, while replacing 20% Nano FA and 5% Nano RHA reduces 32.07% and replacing 50% Nano FA and 5% Nano RHA reduces 67.8% Permeability when compared with conventional concrete.

6. The addition of Fly ash in cement decreases the chloride ion attack on mortar shows the very low ion attack on OPC.

7.With increasing the percentage of RHA, water cement ratio affects and also workability decreases.

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