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USE OF FLYASH AND RICE HUSK ASH AS PARTIAL REPLACEMENT OF CEMENT IN THE CONCRETE

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ABSTRACT
Concrete is one of the significant materials of the construction industry. These days because of expansion in a population, the demand of infrastructure is expanding day by day. This prompts the increment in production of cement. In the present scenario the overall cement production is about 4.1 billion metric tons worldwide. This huge amount of production prompts utilization of natural resources and it is very unsafe for environment. Enormous amount of waste by-products are delivered from the manufacturing enterprises, for example, mineral slag, fly ash, silica fumes, rice husk ash and so on. the rice husk ash is an agricultural by-product which is obtained from the rice mills ,the husk which is obtained from mill is of no use i.e it is not even be used for animals to eat. Hence it is used as a fuel in various big industries the burning temperature is very high hence they are obtained from that the RHA is very lightweight. The project work here deals with the partial replacement of cement with RHA and Fly ash in concrete at various percentage such as 0 % - 0%, 5% - 10%, 5% - 15%, 5% - 20%, 7.5% - 10%, 7.5% - 15%, 7.5%
- 20%, 10% - 10%, 10% - 15%, 10% - 20% by mass of cement. Various experimental investigations are carried out to find out the compressive strength, split tensile strength and of concrete samples cured for period of 7, 14 and 28 days. The results obtained from the experiments with satisfactory replacement of cement with rice husk ash and fly ash are presented in this project report.

Key words: RHA (rice husk ash), Fly ash, compressive strength, split tensile strength.

I.INTRODUCTION

1.1 General

Today concrete has become an unavoidable construction material in the construction industry. Cement is the main ingredient in concrete and its production increases global warming by releasing huge amount of carbon dioxide into the atmosphere which is one of the main threats to the environment. To address this problem, Supplementary Cementitious Materials (SCMs) are used in concrete to reduce the use of high amount of cement content. SCMs such as Fly Ash, Rice Husk Ash, Ground Granulated Blast Furnace Slag, Silica Fume and Metakaolin play a vital role in concrete industry. It has not only economic and environmental benefits but also enhanced concrete properties. Since most of the SCMs are by-product materials of industrial and agricultural sectors, their utilization in concrete has become an efficient alternative to disposal of the same.

Construction industry is connected either logically or collaterally with the cement industry. The industry appears to be bright from projections based on current trends in population growth, and increasing urbanization and industrialization. However, this optimism must be tempered with changing attitudes in the society on ecological issues for example, the preservation and careful management of the environment and of natural resources, concerned with the ecological effects of altering the environment and the disposal of their by-products and the economy which has been always area of interest to all. Now a days, the material which is mostly used in the building construction is cement and it construct every structure in the world including highways, mansions, bridge works, and other structures. Globally, the largest segment of the concrete market is proposed to exceed $200 billion in revenue by 2017. In concrete mix, it plays the role of most significant, versatile and energy consuming material. Hence, the substitute of the cement with some secondary cementitious or cheaper material SCM can directly impact the cost of concrete. So, among SCM, the fly ash, which is the burnt residue, has been replaced with cement in various percentages.

During the hydration of Portland cement, Calcium Silicate Hydrate (C-S-H) and Calcium Hydroxide (Ca (OH)2) are produced. The C-S-H gives strength to concrete whereas Ca (OH)2 in hydrated cement paste gives a negative effect to concrete quality. It is an undesirable material which reduces the strength of concrete. When SCMs are added to the Portland cement concrete, the amorphous silica present in SCMs reacts with more of Ca(OH)2 and converts them into C-S-H. This gives strength and reduces the permeability of concrete as well as improves the durability of the concrete. The addition of SCMs enhances the concrete properties due to pozzolanic effect and filler effect. Blending of SCMs in Portland cement concrete enhances the resultant concrete by making it stronger and more durable. Mineral admixtures have been incorporated into binary, ternary and quaternary concrete mixes (Shi et al. 2012). Many researchers prove that these materials improve the properties of blended cement concrete.

Fly ash is generated due to the combustion of pulverized coal which deliberately cause or initiates a major problem to the environment because of its dumping. It is a burnt and a powdery form of inorganic mineral. Utilization of Fly ash by replacing with the cement will definitely solve the problem of its dumping and on the other way it will decrease the costing of concrete. Probably, it the most commonly used SCM in the field of concrete industry. SCMs are the secondary cementitious material, which is used in the concrete by replacing cement. It impart strength to the concrete as well as it makes the concrete more compact and durable. The use of Fly-ash has great beneficial effect on the concrete because it works as 2 filler. Fly-ash, is the totally fundamental element of the blend like aggregate (CA+FA), cement(C), water and expansion of FA blend in this present reality of ebb and flow concrete like FRC. It is significant among the used reproduced pozzolans like Metakaoline, Rice Husk, Blast Furnace Slag and surkhi etc. It is the mostly used pozzolanic material all through the world and vigourly added substance in the present use of cement in current world. The absolute necessary ingredient of the mixture are coarse aggregate (CA), fine aggregate (FA), cement(C), water and chemical mixture. It is utilized pozzolans such as Metakaoline, Rice Husk, Blast Furnace Slag and surkhi and so forth. It is the most generally utilized pozzolanic material all through the world. Addition of chemical is in practice in the real world of modern concrete.

In this modern world aerated concrete is used as an innovative construction material. This aerated concrete is lightweight as compared to conventional concrete because of large number of voids present in it. The volume of pores present in concrete is 50% to 60% of the total volume of concrete. Size of these pores will affect the properties such as strength, durability, density, and water absorption etc. in concrete. Due to the pore space in concrete, it also provides good thermal insulation and acoustic insulation.

II.LITERATURE REVIEW

Saand et.al., (2019) studied the effect of partial replacement of cement with rice husk ash at different percentage i.e., 0%,2.5%,5%,7.5%,10%,12.5% and 15%. It was found that up to 10% replacement of cement with rice husk ash the compressive strength and split tensile strength will get increased but further increase in the percentage of rice husk ash beyond 10% the strength starts decreasing. The maximum value of compressive strength and split tensile strength for 10% of cement replacement with RHA obtained is 4.4MPa and 0.53MPa respectively.

He et.al., (2019) used recycled wood fibre and rubber powder in AAC. Researchers used the different percentage of recycled wood fibre and rubber powder in AAC to improve its performance and reduce the negative environmental impact. It is found that 0.4% is optimal wood fibre content for the strength of AAC blocks. No effect is seen at 0.5% and 1% of rubber powder content. At 1% of rubber powder content and 0.4% of wood fibre, high-performance AAC can be obtained.

Sukmana et.al., (2019) used the phosphogypsum in NAAC to study the effect on compressive strength. Taguchi method is used for experimental design. The result shows that the best composition for NAAC is Portland cement with a content of 34%, phosphogypsum 35% and quicklime 10% to achieve the best strength value 20.93 kg/cm2 having density 806 kg/m3.

III.OBJECTIVE AND METHODOLOGY

3.1 Objective

- Comparative study on the properties of nominal concrete and concrete containing rice husk ash and fly ash.
- Study on the workability of nominal concrete and Fly ash – RHA based concrete.
- Determine its mechanical properties such as compressive strength, tensile strength with the replacement of cement with Fly ash and RHA.

3.2 Methodology

- Collect the RHA and fly ash and sieve with 75microns.
- Physical properties tests on basic materials fly ash, RHA, coarse aggregate, fine aggregate, cement.
- Mix design for M20 and its proportions. Find out the individual proportions for partial replacement of cement with fly ash and rice husk ash.
- Find out the fresh properties of concrete by slump cone test.
- Prepare the Cubes (150 x 150 x 150 mm) and Cylinders (150mm dia & 300mm height).
- Find out the Harden properties of concrete by Cube Compressive strength and Cylinder tensile strength.

IV.EXPERIMENTAL INVESTIGATIONS

4.1 Materials used

The materials used for this study are Fine aggregate, Coarse aggregate, Cement, Water, Fly ash and Rice husk ash. The physical properties of concrete mentioned in below:

Cement

Chemical bond is vital primarily in light of the fact that its impacts the rate of advancement of compressive quality of cement. The decision of the sort of bond relies on the necessities of execution. There are different types of cement, but ordinary Portland cement is the most widely used binders. The concrete compressive strength depends upon the variation of the cement quality more than any other single material. An Ordinary Portland Cement of various evaluations OPC-33, OPC-43 and OPC-53 are accessible in the market and are for the most part utilized for delivering fly ash blended cement. The bond utilized as a part of this trial examination is Ordinary Portland Cement Grade 43. All properties of concrete are being tested by utilizing IS 12269 - 1987 for 43 grades Ordinary Portland Cement. The physical properties of Portland concrete is shown below in table 4.1.

Fig. 1: Cement

Table 4.1 Physical Properties of Cement

Physical properties	Test result	Requirement as per IS 12269 (1987)
Specific gravity	3.14	-
Fineness (%)	3	Max 10%
Normal consistency	31%	-
Initial setting time (min)	92	Min. 30 min
Final setting time (min)	325	Max. 600 min

Aggregates

The aggregates suitable for plain concrete can be suitably used in fly ash fiber reinforced concrete. The totals reasonable for plain cement can be appropriately utilized as a part of fly fiery debris fiber strengthened cement. In the concrete, to give great nature of solid total is utilized as a part of two size gatherings i.e. fine and coarse aggregates. Fine aggregate (sand) includes minimal exact or balanced grains of silica. Sand is generally utilized as the fine aggregate in concrete. Fine total ordinarily comprises of normal, squashed, or produced sand. Common fine aggregates have been customarily utilized as a part of cement. It is the typical segment for ordinary weight concrete. Be that as it may, made FA (MFA) then show up as an appealing other option to characteristic FA for bond mortars and cement.

Fig. 2: Fine aggregate

Table 4.2 Properties of Fine Aggregate

S.No	PARTICULARS	RESULTS	BIS SPECIFICATIONS (IS 2386-2013
1	Specific gravity	2.83	2.4 – 2.6
2	Fineness modulus	2.95	5 – 8
3	Water absorption	0.5%	<2%

Coarse aggregates (CA) make strong and hard mass of concrete with cement and sand. CA can be regular weight, light weight, or substantial weight in nature. Typical weight totals are gotten by pulverized stone, rock and broken blocks. Lightweight coarse totals are for the most part made by extended mud, (as pumice, shale).The physical characteristics of coarse aggregate is shown in table 4.3.

Fig. 3: Coarse aggregate

Table 4.3 Properties of coarse Aggregate

S.No	PARTICULARS	RESULTS	BIS SPECIFICATIONS (IS 2386-2013
1	Specific gravity	2.83	2.4 – 2.6
2	Fineness modulus	3.28	5 – 8
3	Flakiness index	13%	<40%
4	Elongation index	10%	<40%
5	Crushing value	12%	<45%
6	Impact value	14%	<45%
7	Water absorption	0.4%	<2%

Fly ash

FA is the most comprehensively used pozzolanic material all through the world. FA blazing garbage is finely isolated store coming to fruition as a result of the consuming of powder coal and changed by the vent gasses and accumulated by electrostatic precipitator. Its structure contrasts with the sort of separator, load on evaporator and kind of fuel devoured, et cetera. FA is considered superior to Portland cement and includes round sparkly particles from 1 to 150 micron in estimation. Flyash is the best known, and a super material among the most conventionally used pozzolans available. Dependent upon the source and expending of the coal, the section of fly searing flotsam and jetsam change altogether, yet all the fly ash fuses impressive measure of silicon dioxide (SiO2), (both amorphous and crystalline) and calcium oxide and iron (CaO and

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Fe2O3). Flyash material solidifies while suspended in the vapour gasses and is accumulated by electrostatic precipitators. The flyash has been set up and is extensively used as mineral admixture or supplementary setting material in bond to import specific properties to concrete for field applications.

Figure. 4 Low calcium Fly ash ASTM Class F

According to Indian Standards IS3812-2003 requirements of Fly ash are given below:

Table 4.4 Chemical composition of Fly ash ASTM class F

Parameters	Experimental value (%)	Requirements as per IS3812-2003
Silica	64.11	SiO_2 >35%
Aluminium oxide	18.58	Total - >70%
Iron oxide	4.32	
Calcium oxide	1.21	---
Sodium oxide	0.21	<1.5%
Potassium oxide	1.02	
Magnesium oxide	0.24	<5%
Loss of ignition	0.64	<12%

Rice husk ash

Rice husk can be burnt into ash that fulfills the physical characteristics and chemical composition of mineral admixtures. Pozzolanic activity of rice husk ash (RHA) depends on (i) silica content, (ii) silica crystallization phase, and (iii) size and surface area of ash particles. In addition, ash must contain only a small amount of carbon.The optimized RHA, by controlled burn and/or grinding, has been used as a pozzolanic material in cement and concrete. Using it provides several advantages, such as improved strength and durability properties, and environmental benefits related to the disposal of waste materials and to reduced carbon dioxide emissions.

Rice husk is an agricultural residue widely available in major rice producing countries. The husk surrounds the paddy grain. During milling process of paddy grains about 78 % of weight is obtained as rice, broken rice and bran. Remaining 22 % of the weight of paddy is obtained as husk. This husk is used as fuel in the various mills to generate steam for the parboiling process. This husk contains about 75 % organic volatile matter and the rest 25 % of the weight of this husk is converted into ash during the firing process, this Ash is known as rice husk ash. This RHA contains around 85 % - 90% amorphous silica. Rice husk is generated from the rice processing industries as a major agricultural by product in many parts of the world especially in developing countries. About 500 million tons of paddies are produced in the world annually after incineration only about 20% of rice husk is transformed to RHA. Still now there is no useful application of RHA and is usually dumped into water streams or as landfills causing environmental pollution of air, water and soil. RHA consists of non-crystalline silicon dioxide with high specific Surface area and high pozzolanic reactivity, thus due to growing environmental concern and the need to conserve energy and resources, utilization of industrial and biogenic waste as supplementary cementing material has become an integral part of concrete construction. Pozzolonas improve strength because they are smaller than the cement particles, and can pack in between the cement particles and provide a finer pore structure. RHA has two roles in concrete manufacture, as a substitute for Portland cement, reducing the cost of concrete in the production of low cost building blocks, and as an admixture in the production of high strength concrete.

Table 4.5 Chemical composition of RHA

Parameters	Experimental values(%)
Sio_2	2.36
Fe_2O_3	19.72
Al_2O_3	39.05
Cao	34.27
K_2O	0.06
MgO	1.02
Chloride	0.023
Loss Of Ignition	0.88

Figure.5 Rice Husk Ash

Water

The water utilized as a part of cement has an imperative impact in the blending, laying compaction setting and solidifying of cement. It is required for hydration of bond. Water works as a binder for the ingredients and makes the mix workable. The quality of cement specifically relies on the amount and nature of water that is utilized as a part of the blend. An increase in water cement proportion prompts a decrease in compressive strength. Water utilized for blending and curing should be spotless and free from damaging sum if oils, acids, soluble bases, salts, sugar and natural materials. Versatile water is for the most part viewed as acceptable for blending concrete. Here the potable water used for the experiment work.

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Table 4.6: Individual weight of materials M20 grade fly ash – RHA based concrete

For Cubes						
RHA % - FLYASH %	Cement	RHA	Fly ash	FA	CA	Water
0 - 0	1496.88	0	0	2494.8	5613.3	748.44
5 – 10	1272.34	74.84	149.7			
5 – 15	1197.508		224.532			
5 – 20	1122.04		300			
7.5 - 10	1234.92	112.26	149.7			
7.5 – 15	1160.08		224.532			
7.5 – 20	1084.62		300			
10 - 10	1197.48	149.7	149.7			
10 – 15	1122.648		224.532			
10 – 20	1047.18		300			
For Cylinders						
0 - 0	2351	0	0	3918	8817	1175
5 - 10	2010.11	117.55	223.34			
5 – 15	1898.43		335.017			
5 – 20	1786.75		446.7			
7.5 - 10	1957.22	176.32	217.46			
7.5 – 15	1848.48		326.2			
7.5 – 20	1739.78		434.9			
10 - 10	1904.4	235.1	211.6			
10 – 15	1798.6		317.4			
10 – 20	1692.8		423.2			

4.2Preparation of Fly ash – RHA based concrete

All the required quantities of cement, fine aggregate and coarse aggregates weighed separately and mixed in dry condition. The obtained proportion of water is added to the composite mixture and mix thoroughly until a uniform mixture is formed. The same procedure is repeated for different mixes which includes the replacement of cement with RHA and Fly ash. The complete mixing is done by hand mixing. The mixing of the concrete is shown in the Fig.5.1.

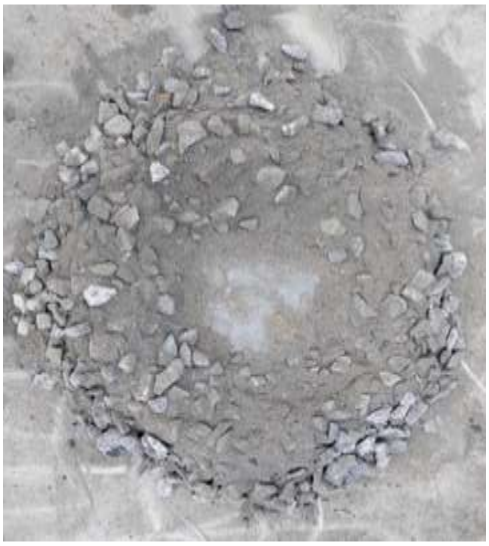

Fig. 6: Mixing of ingredients

Fig. 7: Mixing of Concrete

After the concrete is mixed, the fresh concrete tests are to be carried out to measure the workability. The detailed explanation of the slump test is reported below.

Slump test

Slump cone test is most simple and common test conducted to determine the workability of concrete mix. According to the IS 1199-1959, Slump test is carried out for every batch of mix. The apparatus is shown in the Table 4.7 and Fig.4.7.

Table 4.7 Apparatus for slump test

S.No	Name of the apparatus	Size of the apparatus
1	Slump cone – Frustum	h = 30 cm, Bottom dia = 20 cm and top dia= 10 cm.
2	Tamping rod with one end round	16 mm dia and 60cm long

Fig8.: Slump cone apparatus

Fig. 9: Slump cone test

A sample of prepared concrete mix is taken for the test. The internal surface of the frustum of cone is cleaned and greased to avoid the adhesion of concrete. A non-porous base plate is placed on a uniform surface and the slump cone mould is fixed on it. Concrete mix is filled in three equal layers in the mould. The excess concrete is removed and levelled. Now, the cone is lifted in upward direction and the concrete slumps down. The slump (Vertical settlement) is measured in mm.

Casting and Curing

In the present work cubes and disc specimens were cast to conduct various tests.

Casting of cubes

Totally 90 cubes were cast for conducting various tests. For the preparation of cube specimens, the mixed concrete is poured into the cube moulds made of steel of dimensions of 150 X 150 X 150 mm. The moulds are cleaned and greased to avoid sticking of concrete to the moulds and tighten the bolts to prevent leakage of concrete. The concrete is put in 3 layers (each layer more than 35 blows) into the moulds till the surface and levelled. The specimens are allowed to dry up for 24hrs.

Fig. 10: Casting of cube

4.3.2.1 Casting of cylinders

Totally 90 cylinders were cast for conducting various tests. For the preparation of cube specimens, the mixed concrete is poured into the cylinder moulds made of steel of dimensions of 150mm diameter and 300mm height. The moulds are cleaned and greased to avoid sticking of concrete to the moulds and tighten the bolts to prevent leakage of concrete. The concrete is put in 3 layers (each layer 35 blows) into the moulds till the surface and levelled. The specimens are allowed to dry up for 24hrs.

Fig. 11: Casting of cylinder

Curing

The next stage is curing of the specimens. It is an important phase as the water for hydration is to be maintained in the specimens. Proper curing gives good strength to the concrete. So, after removing from the moulds the specimens are transferred to the curing tank containing water free from impurities and cured for 28 days. The specimens in the curing tank are shown in the Fig 4.10.

Fig. 12 Specimens in Curing Tank

V.RESULTS AND DISCUSSIONS

As per experimental programme results for different experiments were obtained. They are shown in table format and graph format, which is to be presented in this chapter.

5.1 Fresh properties of concrete (Workability Test)

Slump Test

The Slump test was performed on the Rice husk ash – Fly ash concrete to check the workability of it at different replacements viz. 0 % - 0%, 5% - 10%, 5% - 15%, 5% -
20%, 7.5% - 10%, 7.5% - 15%, 7.5% - 20%, 10% - 10%, 10% - 15%, 10% - 20% and the
following results were obtained, according to which it can be concluded that with the increase in % of Rice husk ash – Fly ash from M1 to M10 , workability increases. The results obtained for Slump test are shown

below in Table 5.1.

Table 5.1: Results of Slump test

Mix No	RHA % - FLYASH %	Slump (mm)
M1	0 - 0	90
M2	5 - 10	95
M3	5 – 15	97
M4	5 – 20	100
M5	7.5 - 10	101
M6	7.5 – 15	102
M7	7.5 – 20	105
M8	10 - 10	108
M9	10 – 15	110
M10	10 – 20	112

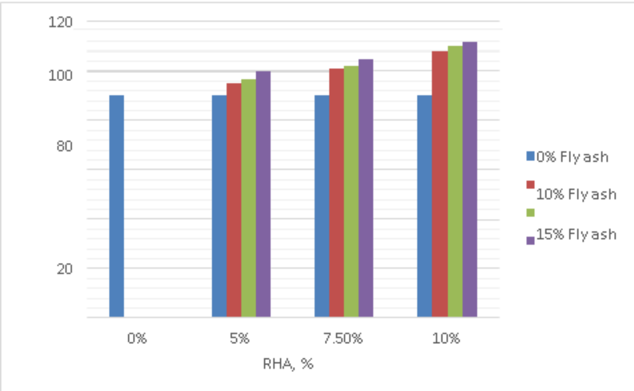

Fig 13: Slump test results

The above figure 5.1 shows the slump results. It was observed that, the slumps increased from M1 to M10 mix with increased RHA – Fly ash in the mix. It was varied from Medium Workability to High workability.

5.2 Harden properties of concrete

Compressive Strength Test

The compressive strength test was performed on the cubes of size 15 cm x 15 cm x 15 cm to check the compressive strength of RHA -Fly ash based concrete and the results obtained are given in Table 5.2.

Table 5.2: Results of compressive strength test

Mix No	RHA % - FLYASH %	Compressive strength of cubes (N/mm^2)		
		7 days	14 days	28 days
M1	0 - 0	15.6	21.4	25
M2	5 - 10	18	24.8	28
M3	5 – 15	19.2	27	30.4
M4	5 – 20	15.6	23.5	26.1
M5	7.5 - 10	21.35	31.5	35
M6	7.5 – 15	25	37	40.2
M7	7.5 – 20	23	34.68	37.7
M8	10 - 10	19	29	32
M9	10 – 15	18.2	26.5	33.3
M10	10 – 20	16	24.3	27

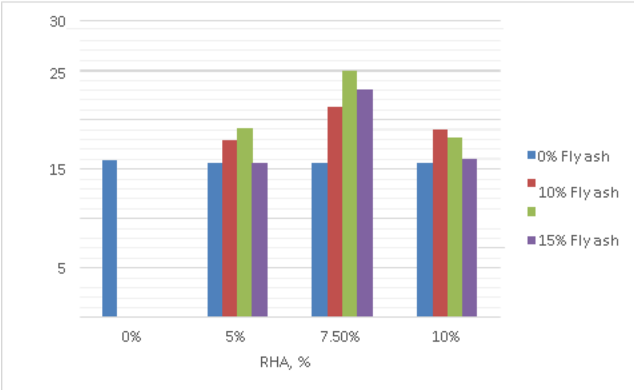

Fig 14: 7days Compressive strength test result graph

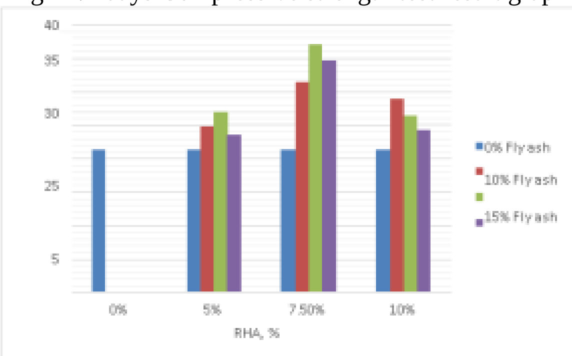

Fig 15: 14days Compressive strength test result graph

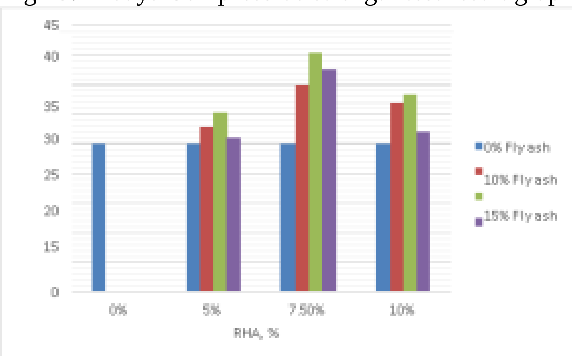

Fig 16: 28days Compressive strength test result graph

From the above results it was observed that with the increase in percentage of RHA – fly ash from M2 to M10 in concrete the compressive strength more than control mix M1. The highest compressive strength gained for 7.5% RHA – 15% Fly ash replacing with cement in the preparation of concrete. The optimum dosage suggested from this study was 7.5% RHA – 15% Fly ash.

Tensile Strength Test

The Tensile test was performed on the beams of size 300mm height x 150 diameter mm to check the Tensile strength of the concrete and the results obtained while performing the Tensile test on CTM are given in Table 5.3.

Table 5.3: Result of Tensile strength

Mix No	RHA % - FLYASH %	Tensile Strength for 28 days (N/mm^2)
M1	0 - 0	2.92
M2	5 - 10	3.27
M3	5 – 15	3.56
M4	5 – 20	3.05
M5	7.5 - 10	4
M6	7.5 – 15	4.7
M7	7.5 – 20	4.42
M8	10 - 10	3.71
M9	10 – 15	3.85
M10	10 – 20	3.12

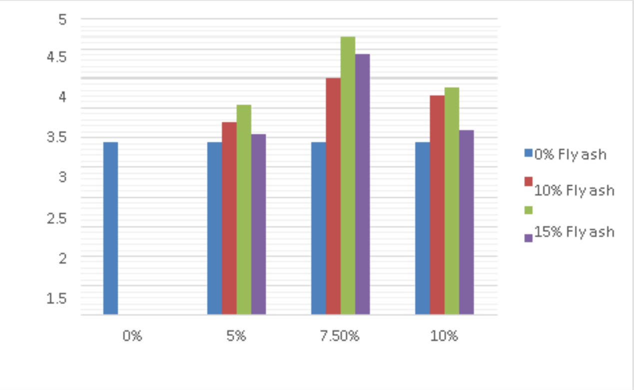

Fig 17: Tensile strength graph

From the above results it was observed that with the increase in percentage of RHA – Fly ash from M2 to M10 in concrete the tensile strength more than the control mix M1. The highest tensile strength gained for 7.5% RHA – 15% Fly ash replacing with cement in the preparation of concrete. The optimum dosage suggested from this study was 7.5% RHA – 15% Fly ash.

VI.CONCLUSIONS

In this experimental investigation, the effect of rice husk ash and fly ash blended in control concrete with respect to tensile behaviour of the concrete cylinders and compressive behaviour of the concrete cubes have been investigated. The experimental results have been compared with the control mix concrete. The following conclusions are drawn from the present experimental investigation.

1. Workability increases with increasing in the fly ash and rice husk replacement in the concrete.
2. The compressive and tensile strength highest gains for 7.5% rice husk ash with various fly ash contents (10%, 15%, 20%).
3. The maximum strength gained for 7.5% rice husk ash with 15% fly ash replacing with cement in the preparation of concrete. The compressive and tensile strength increased by 60.8% and 60.96% as compare to the conventional concrete.
4. By replacing Supplementary Cementitious Materials (SCMs) such as fly ash and rice husk ash, the cost of construction decreases and disposable problem of agricultural and industrial wastes reduces.

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