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Effect of Partial Replacement of Cement by Fly Ash, Rice Husk Ash with Using Steel Fiber in Concrete

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Abstract: In the ancient period, construction work was mostly carried out with help of mudstone from industry. Fly ash is a by-product of burned coal from power station and rice husk ash is the by –product of burned rice husk at higher temperature from paper plant artificial fibers are commonly used nowadays in order to improve the mechanical properties of concrete. Especially Synthetic (Polypropylene, polyester etc.,) glass, nylon, asbestos, carbon and steel fibers used in concrete caused good results to improve numerous concrete properties. Considerable efforts are being taken worldwide to utilise natural waste and bye –product as supplementary cementing materials to improve the properties of cement concrete. Rice husk ash (RHA) and Fly ash (FA) with using Steel fiber is such materials. RHA is bye-product of paddy industry. Rice husk ash is a highly reactive pozzolanic material produced by controlled burning of rice husk. FA is finely divided produced by coal-fired power station. Fly ash possesses pozzolonic properties similar to naturally occurring pozzolonic material. The detailed experimental investigation is doing to study the effect of partial replacement of cement by FA, RHA with using Steel fiber in concrete. In this paper started proportion form 30% FA and 0% RHA mix together in concrete by replacement of cement ,last proportion taken 15% FA and 15% RHA, with gradual increase of RHA by 2.5% and simultaneously gradual decrease of FA by 2.5% and to improve the strength of concrete steel fibers were added and fiber volume fraction was 0%, 0.25%, 0.5%, 0.75% and 1.0% in volume basis in the proportion of 10% RHA and 20% FA. The purpose of this research is to study the effects of steel fibers on the workability, compressive strength, flexural tensile strength, splitting tensile strengths, Acid resistant test , durability study of fly ash and rice husk ash in concrete.

Keywords – Admixture, Cement, Concrete, Fly Ash, Rice husk Ash, Steel fiber

I. INTRODUCTION

CONCRETEas is well known is a heterogeneous mix of cement, water and aggregates. The admixtures may be added in concrete in order to enhance some of the properties desired specially. In its simplest form, concrete is a mixture of paste and aggregates. Various materials are added such as fly ash, rice husk, admixture and with using steel fiber to obtain concrete of desired property. The character of the concrete is determined by quality of the paste. The key to achieving a strong, durable concrete rests in the careful proportioning, mixing and compacting of the ingredients. The detailed experimental investigation is doing to study the effect of partial replacement of cement by FA and RHA with using Steel fiber in concrete. In this project I started proportion form 30% FA and 0% RHA mix together in concrete by replacement of cement with the gradual increase of RHA by 2.5% and simultaneously gradual decrease of FA BY 2.5% ,last proportion taken 15%FA and 15% RHA. Numerous tests are performed on wet concrete such as workability tests such as compaction factor test and slump test. The tests on hardened concrete are destructive test while the destructive test includes compressive test on concrete cube for size (150 x 150 x 150) mm, Flexural strength on concrete beam (500 x 100 x100) and split tensile strength on concrete cylinder (150 mm ø x 300mm) as per IS: 516 – 1959, IS: 5816 – 1999 and IS: 516 – 1959 respectively.In actual practice, test on workability of wet concrete are carried out to ensure uniform quality concrete only. Strength is not a measurable at that stage with the available technology. Therefore the concrete samples are to be cured for 28 days in normal method to arrive at the compressive strength and for necessary follow up action. It is not only difficult to dismantle the suspected portion of concrete at such a stage but also expensive in terms of time and money. Predicting the strength at the manufacturing stage, however, is yet to receive due attention of engineers. Hence, any new approach that is capable of predicting reliably the compressive strength of hardened concrete based on the properties of the ingredients and the wet concrete will be helpful to practicing engineers. Besides, such tests could be performed with the same ease as the workability tests. RHA has two roles in concrete manufacture, as a substitute for cement, reducing the cost and weight of concrete in the production of low cost building blocks. The workability of RHA concrete has been found to decrease but FA increases the workability of concrete so RHA and FA mix together in concrete to improve the workability of concrete. The work presented in thispaper reports an investigation on the behavior of concrete produced from blending cement with FA and RHA.

The objectives and scope of present study are.

- To find the optimum mix design with regards to the amount of water, RHA, FA, Steel fibre and cement ratio.
- To investigate the physical properties of the RHA and FA, steel fibre –strength (bending and compression)
- To study the relative strength development with age of (RHA + FA+ steel fibre) concrete with control concrete.
- Use of industrial waste in a useful manner.
- To conduct compression test on (RHA+FA+ steel fibre) and control concrete on standard IS specimen size (150 x 150 x 150) mm.
- To conduct Flexural test on (RHA+FA + steel fibre) and control concrete on standard IS specimen size (100 x 100 x 500) mm.
- To conduct split tensile test on (RHA+FA + steel fibre) and control concrete on standard IS specimen size (150 mm ø x 300mm) mm.
- To conduct acid resistant test.
- To provide economical construction material.
- Provide safeguard to the environment by utilizing waste properly.

2. MATERIALS AND METHODS

The work presented in this paper reports an investigation on the behaviour of concrete produced from blending cement with RHA and FA. The physical and chemical properties of RHA, FA and OPC were first investigated. Mixture proportioning was performed to produce high workability concrete (200- 240 mm slump) with target strength of 32.1 Mpa (M25) for the control mixture. The effect of RHA on concrete properties was studied by means of the fresh properties of concrete and the mechanical properties. I.e. Compressive strength, tensile splitting strength, flexural test was studied as the time dependent property.

2.1Cement

The cement used was Ordinary Portland cement (43 Grade) with a specific gravity of 3.15. Initial and final setting time of the cement was 50 min and 365 min, respectively. Its chemical composition is given in Table 1.

Table 1: Following are the Chemical properties of cement (OPC), Fly ash and Rice husk ash

Materials	SiO2	Al2O3	Fe2O3	CaO	MgO	LOI	SO3	K2O	Na2O3
Cement	19.71	5.20	3.73	62.91	2.54	0.96	2.72	0.90	0.25
Fly ash	40	25	6	20	3.71	3.0	1.74	0.80	0.96
Rice husk ash	78.21	(SiO2+ Al2O3+ Fe2O3) =82.64		0.99	4.89	--------	------	-------	-------

2.2 Rice Husk Ash

Rice husk ash used was obtained from Ellora Paper Plant located in TumsarBhandara .The Specific gravity of rice husk ash is 2.10 and bulk density is 0.781 g/cc RHA, produced after burning of Rice husk (RH) has high reactivity and pozzolanic property. Indian Standard code of practice for plain and reinforced concrete, IS 456- 2000, recommends use of RHA in concrete but does not specify quantities. Chemical compositions of RHA are affected due to burning process and temperature. Silica content in the ash increases with higher the burning temperature. As per study by Houston, D. F. (1972) RHA produced by burning rice husk between 600 and 700°C temperatures for 2 hours, contains 90-95% SiO2, 1-3% K2O and < 5% unburnt carbon. Under controlled burning condition in industrial furnace, Studies have shown that RHA resulting from the burning of rice husks at control temperatures have physical and chemical properties that meet ASTM (American Society for Testing and Materials).Standard C 618-94a. Studies have shown that to obtain the required particle size, the RHA needs to be grown to size 45 µm – 10 µm.

2.3 Fly Ash

Fly ash used was obtained Koradi Power Plant Nagpur. Fly ash is one of the residues generated in the combustion of coal. Fly ash is generally captured from the chimneys of power generation facilities, whereas bottom ash is, as the name suggests, removed from the bottom of the furnace. In the past, fly ash was generally released into the atmosphere via the smoke stack, but pollution control equipment mandated in recent decades now require that it be captured prior to release. It is generally stored on site at most US electric power generation facilities. Depending upon the source and makeup of the coal being burned, the components of the fly ash produced vary considerably, but

all fly ash includes substantial amounts of silica (silicon dioxide, SiO2) (both amorphous and crystalline) and lime (calcium oxide, (CaO). Fly ash is commonly used to supplement Portland cement in concrete production, where it can bring both technological and economic benefits, and is increasingly finding use in synthesis of geopolymers and zeolites.

2.4 Fibers

Steel fiber having low carbon and its both end were hooked were used. The steel fibers have a length of 30 mm, diameter of 0.60 mm, aspect ratio of 50, and density of 7.85 g/cm3. Collect from Stewols Pvt. Ltd. Nagpur.

2.5 Aggregate

Good quality river sand was used as a fine aggregate. The fineness modulus, specific gravity and dry density are 2.32, 2.68 and 1690 kg/m3. Coarse aggregate passing through 20mm and retained 10mm sieve was used.Its specific gravity and dry density was 2.7 and 1550 kg/m3.

2.6 Chemical Admixture

A commercial AC- Green Slump-GS-02B black cat Chemical Limited plasticizer From Nagpur was used to maintain the workability of fresh concrete. The dosage of hyper plasticizer was 1% to 1.5% by weight of cement of the binder content of concrete. The aim of keeping the amount of plasticizer constant is to neglect, if any, the influence of plasticizer on the properties of hardened concrete.

3. EXPERIMENTAL PROGRAMME

Experimental programme comprises of test on cement, RHA,FA, cement concrete with partial replacement of cement withRHA and FA.

3.1 Rice Husk Ash

1) Normal Consistency = 17%
2) Initial and Final Setting time = 195min.
and 265min.
3) Compressive Strength = 11 N/mm2
4) Specific Gravity = 2.09

3.2 Ordinary Portland Cement

OPC 43 grade cement is used for this whole experimental study. The physical test results on OPC are as follows.
1) Normal consistency = 22%
2) Initial Setting time = 30 min.
3) Final Setting Time = 10 hrs.
4) Specific Gravity = 3.15

3.4 Test on Concrete

An M25 mix is designed as per guidelines in IS 10262, 1982 based on the preliminary studies conducted in the constituentmaterials. Tests on fresh concrete are obtained as follows.
1) Slump Test=65mm
2) Vee-Bee = 15sec.
3) Compaction factor =0.95
4) Flow Test =79 %.

3.5 Mixture Proportioning

The mixture proportioning was done according the Indian Standard Recommended Method IS 10262- 1982.The target mean strength was 32.1 Mpa for the OPC control mixture, the total binder content was 435.45 kg/m ,fine aggregate is taken 476kg/m and if any, the influence of plasticizer on the properties of hardened concrete. coarse aggregate is taken 1242.62kg/m the water to binder ratio was kept constant as 0.44, the Superplasticizer content was varied to maintain a slump of (200-240 mm) for all mixtures. The total mixing time was 5 minutes, the samples were then casted and left for 24 hrs before demoulding They were then placed in the curing tank until the day of testing Cement, sand, Fly ash, Rice husk ash and fine and coarse aggregate were properly mixed together in accordance with British Standard Code of Practice (BS 8110)19 in the ratio 1:1.1:2.85 by weight before water was added and was properly mixed together to achieve homogenous material. Water absorption capacity and moisture content were taken into consideration and appropriately subtracted from the water/cement ratio used for mixing reported the blending of rice husk ash (RHA) in cement is recommended in most international building codes now. Hence, cement was replaced in 30% with rice huskash and fly ash and 150 × 150 × 150mm3, Beam and Cylinder moulds were used for casting. Compaction of concrete in three layers with 25 strokes of 16 mm rod was carried out for each layer. The concrete was left in the mould and allowed to set for 24 hours before the cubes were de moulded and placed in curing tank. The concrete cubes were cured in the tank for 7, 14, 28, 56 and 90 days.

3.6 Testing methods

Testing is done as per following IS code. The testing done for compressive strength of cubes were measured 7,14, 28,56 and 90 days as per IS : 516 – 1959 ,the testing done for flexural strength of beam were measured 28 days as per IS : 5816 - 1999 and the testing done for split tensile strength of cylinder were measured 28 days as per IS : 516 – 1959.

3.7 Durability study

The durability of concrete with the optimum percentage replacement of cement by Fly ash and RHA90µ is study by the following test

3.8 Acid Resistant Test

In this study concrete cubes of control mix and maximum compressive strength with replacement of cement by FA and RHA and maximum compressive strength with using 0.75% of steel fiber are weighted after 28 days of curing and immersed in diluted 1% of sulphuricacidsolution for 30 days. Then the cubes are taken out and before testing each specimen is removed from the bath& brushed with the soft

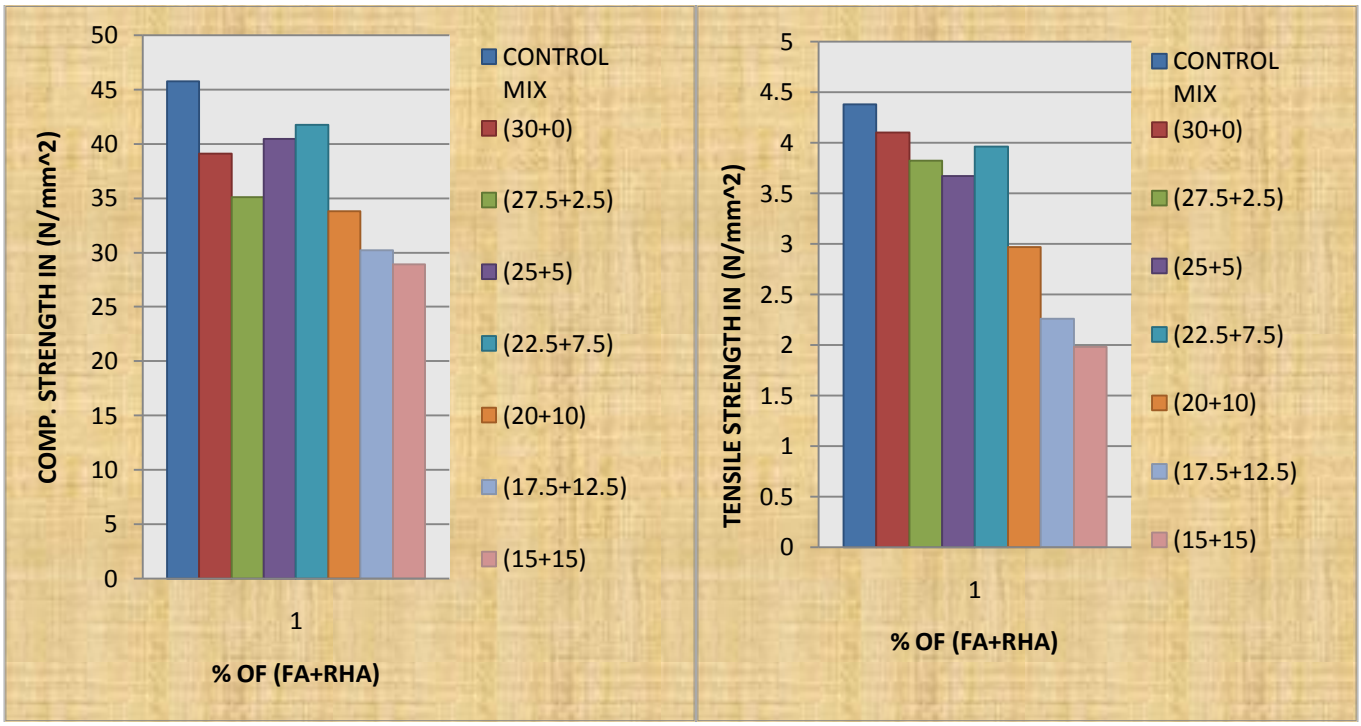
nylon brush and rinsed in a tap water and weighed. The percentage loss in weight and percentage reduction in compressive strength are calculated and compared with that of mix.

3.9 Chloride Attack Test

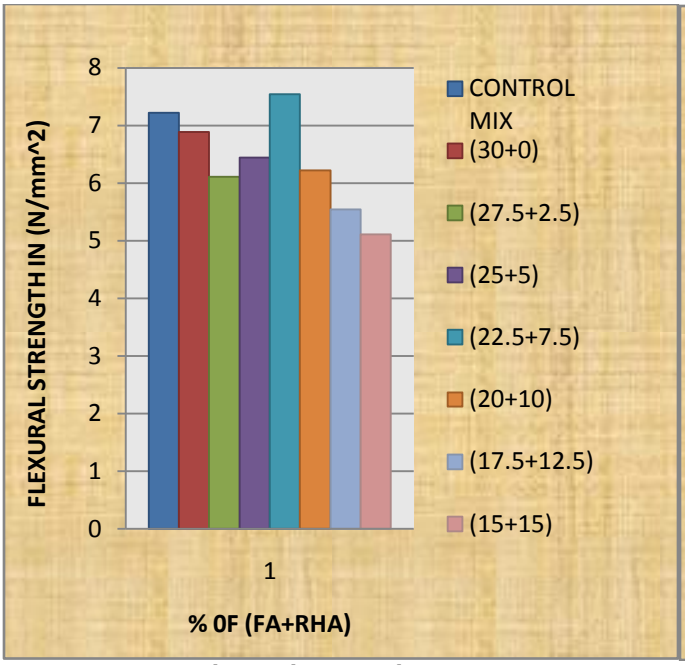
Chloride attack is one of the most important aspect to be considered while dealing with the durability of concretebecause it primarily causes corrosion of reinforcement. Concrete cubes of control mix and maximum compressive strength with replacement of cement by FA and RHA and maximum compressive strength with using 0.75% of steel fiber are weighted after 28 days of curing and immersed in a solution of 3% sodium chloride by weight of water for 30 days. Then the cubes are taken out and weighed and the percentage loss in weight and percentage reduction in compressive strength are calculated

Table 2 Compressive strength, Flexural strength, Split tensile strength.

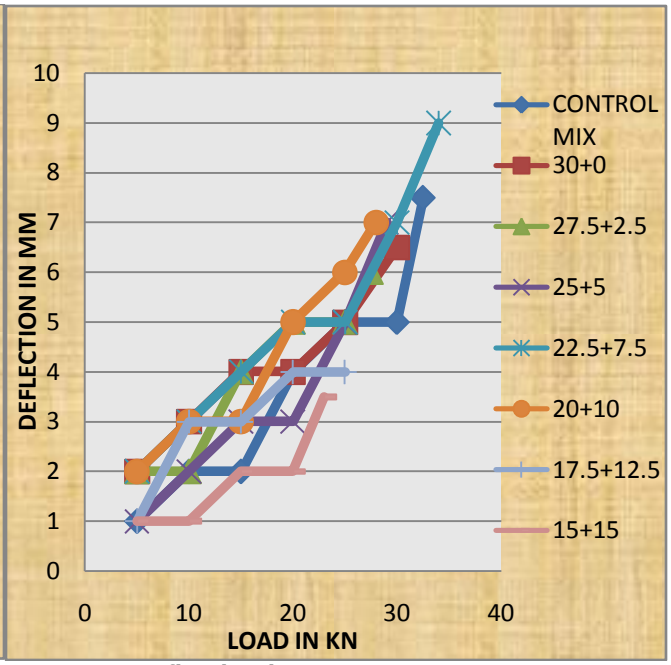
Mix			Strength after curing in days in N/mm2						
Sr. No.	Mix Proportion		7 Days	14 Days	28 Days	56 Days	90 Days	Flexural strength	Split tensile strength
	FA by% of cement	RHA by% of cement							
1	Control Mix		35.56	39.11	45.78	48	49.78	7.22	4.38
2	30	0	32.89	33.33	39.11	42.22	44.89	6.89	4.10
3	27.5	2.5	31.11	31.33	35.11	37.33	39.56	6.11	3.82
4	25	5	31.56	32.44	40.44	43.11	45.78	6.44	3.67
5	22.5	7.5	22.67	34.67	41.78	44.89	46.67	7.55	3.96
6	20	10	22.22	26.22	33.78	35.11	37.78	6.22	2.97
7	17.5	12.5	18.22	24.89	30.22	32	34.67	5.55	2.26
8	15	15	17.78	24	28.89	30.67	33.78	5.55	1.98



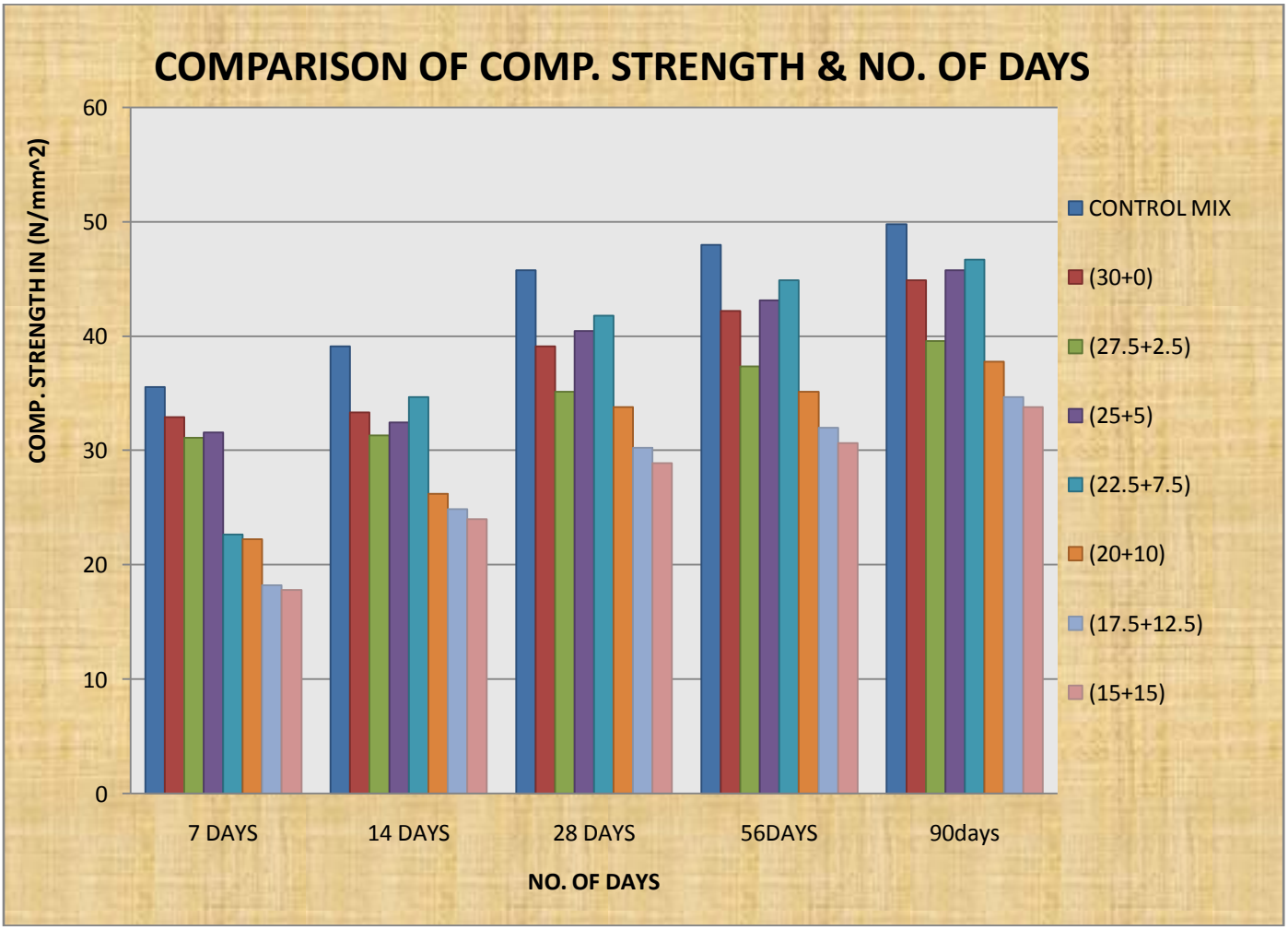
GRAPH 1: 28 Days Compressive strength GRAPH 2: 28 Days Tensile strength



GRAPH 3: 28 Days Flexural strength



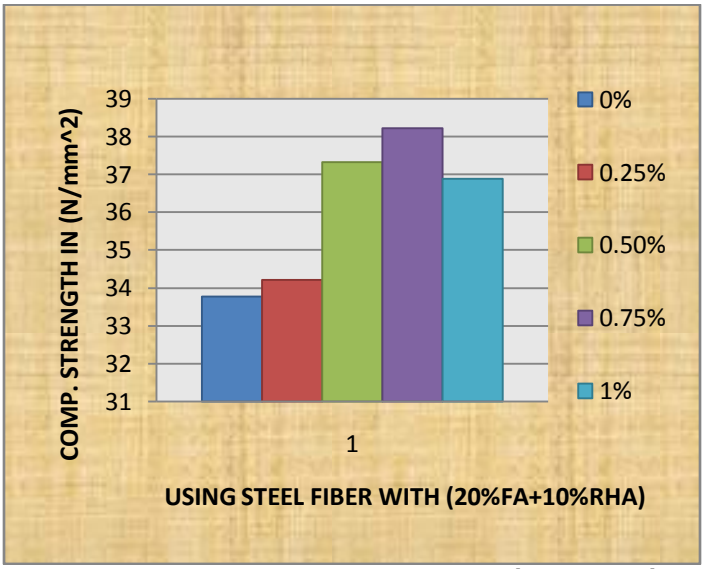
GRAPH 4: Deflection in Beam



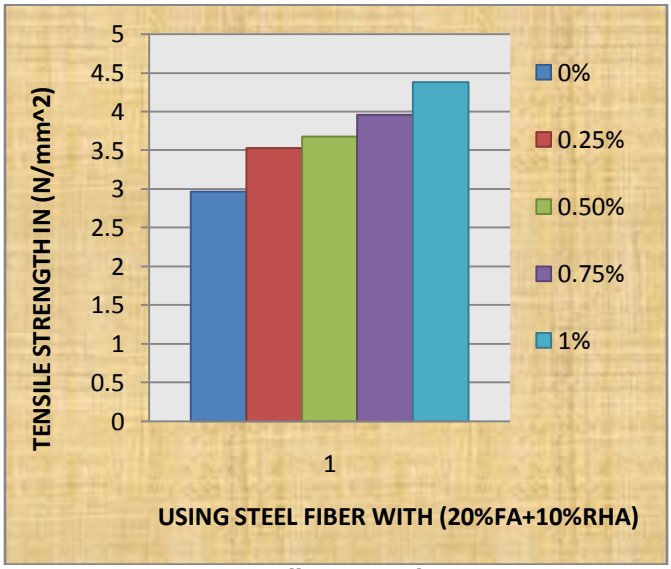
GRAPH 5: Study of Comparision of Compressive strength in No. of Days

Table 3 Compressive strength, Flexural strength, Split tensile strength with using steel fiber by replacement of cement of 20%fly ash and 10% rice husk ash .

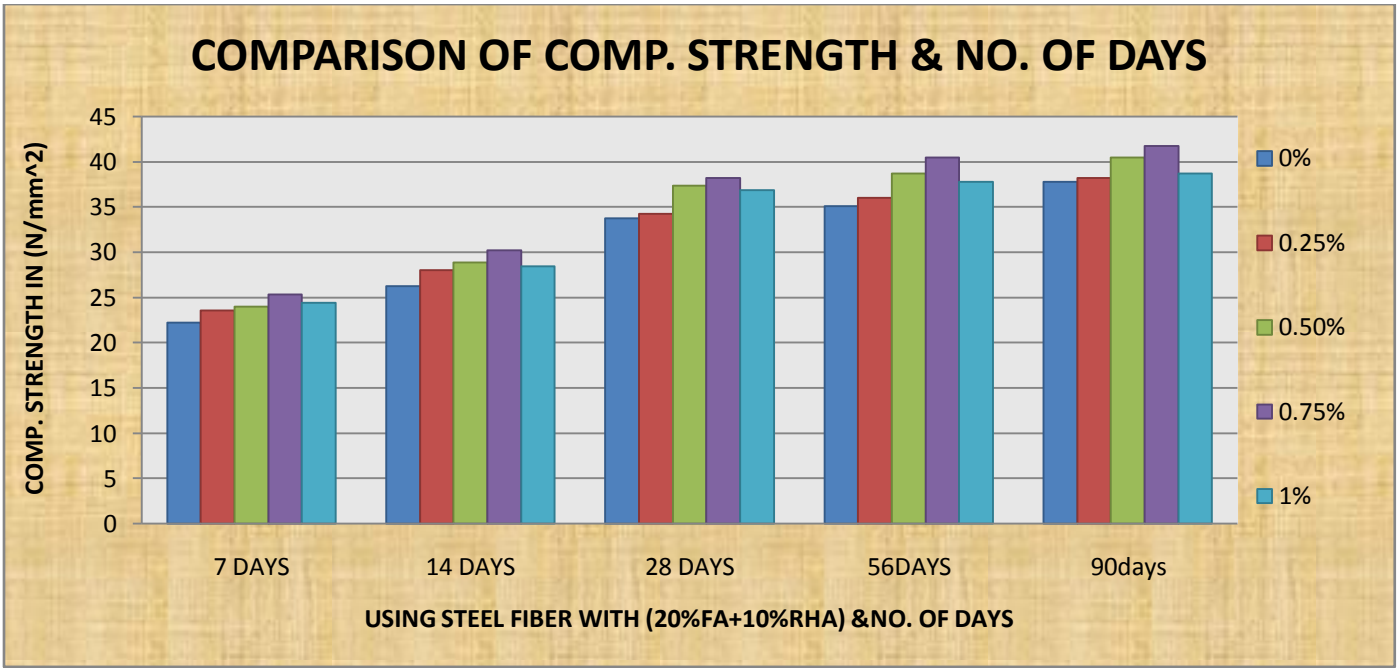
Sr.No.	Aspect ratio of fibers	% of steel fiber	Strength after curing in N/mm2						
			7 Days	14 Days	28Days	56Days	90 Days	Flexural strength	Split tensile strength
1	50	0%	22.22	26.22	33.78	35.11	37.78	6.22	2.97
2	50	0.25%	23.56	28	34.22	36	37.33	3.33	3.53
3	50	0.50%	24	28.89	37.33	38.67	40.44	6.67	3.68
4	50	0.75%	25.33	30.22	38.22	40.44	41.78	7.78	3.96
5	50	1%	24.44	28.44	36.89	37.78	38.67	8.33	4.38



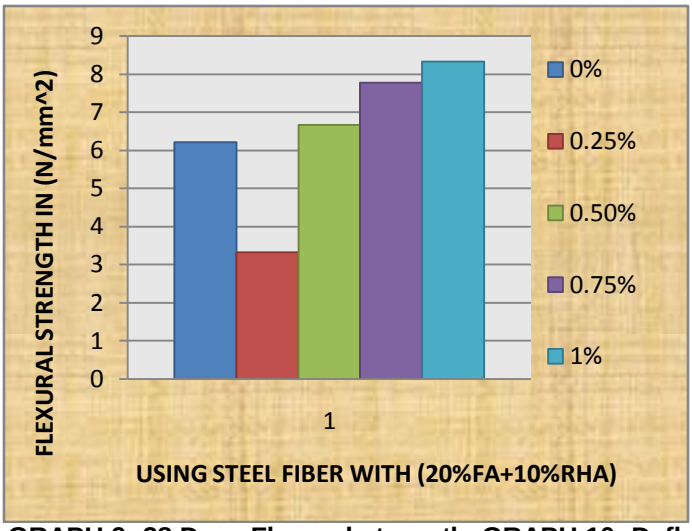
GRAPH 6: 28 Days Compressive strength

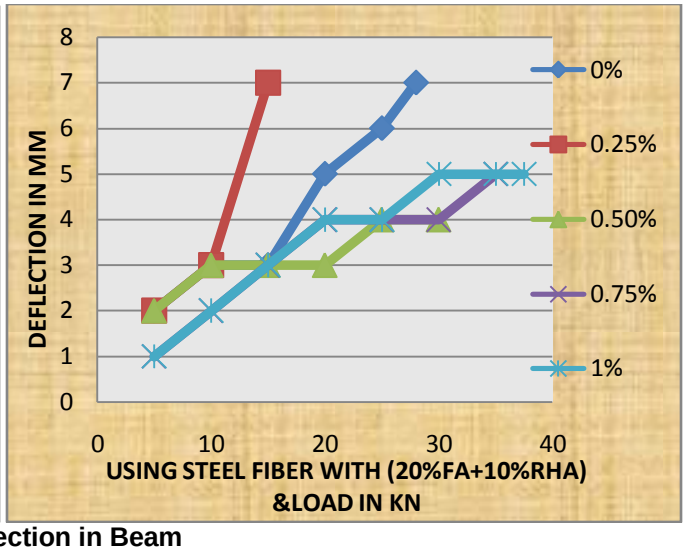


GRAPH 7: 28 Days Tensile strength



GRAPH 8: Study of Comparision of Compressive strength in No. of Days





GRAPH 9: 28 Days Flexural strength GRAPH 10: Deflection in Beam

Table 4 Reduction in weight and compressive strength of concrete cubes immersed in 1% sulphuric acid solution.

Sr. No.	Mix designation	Average weight of cubes before immersion in kg	Average weight of cubes after immersion in kg	Reduction in weight %	Average compressive strength before immersion, N/mm^2	Average compressive strength after immersion, N/mm^2	Reduction in compressive strength %
1	Control mix	8.82	8.73	1.02	45.78	43.55	4.87
2	22.5%FA+7.5%RHA by%of cement	8.56	8.52	0.47	41.78	40.0	4.26
3	20%FA+10%RHA by% of cement with using 0.75% steel fiber	8.73	8.69	0.46	38.22	37.33	2.32

Table 5 Reduction in weight and compressive strength of concrete cubes immersed in 3% sodium chloride solution.

Sr. No.	Mix designation	Average weight of cubes before immersion in kg	Average weight of cubes after immersion in kg	Reduction in weight %	Average compressive strength before immersion, N/mm^2	Average compressive strength after immersion, N/mm^2	Reduction in compressive strength %
1	Control mix	8.76	8.62	1.60	45.78	44.0	3.89
2	22.5%FA+7.5%RHA by%of cement	8.48	8.40	0.94	41.78	40.89	2.13
3	20%FA+10%RHA by% of cement with using 0.75% steel fiber	8.90	8.88	0.22	38.22	37.78	1.15

4 CONCLUSIONS

Based on the results presented above, the following conclusions can be drawn:

1 Compressive strength increases with the increase in the percentage of Fly ash and Rice Husk Ash up to replacement (22.5%FA and 7.5% RHA) of Cement in Concrete for different mix proportions.

2 The maximum 28 days split tensile strength was obtained with 22.5% fly ash 7.5% rice husk ash mix.

3 The maximum 28 days flexural strength was obtained again with 22.5% fly ash and 7.5% rice husk ash mix.

4 The percentage of water cement ratio is reliant on quantity of RHA used in concrete. Because RHA is a highly porous material

5 The workability of concrete had been found to be decrease with increase RHA in concrete .

6 As the rice husk is burned out at 600^{o} to 800^{o} c. It is observed that the 80 % silica was produced due to this it gives a excellent thermal insulation.

7 Through Rice husk ash is harmful for human being and the cost of rice husk ash is zero and thus we preferred RHA use in concrete as compare to silica fumes and it is also economical.

8 The workability of RHA concrete was found to decreased but the FA increases the workability of concrete.

9 Rice Husk Ash can be used with admixtures, plasticizers, and super plasticizers, for increasing the workability and strength of concrete with partial replacement of cement.

10 The mechanical properties in terms of flexural and tensile strength have been significantly improved with the addition of RHA.

11 The unit weight of concrete increased uniformly with the increase in fiber content and decreased with the increase of rice husk ash content.

12 The inclusion of steel fiber reduces the workability with increasing fiber content.

13 It is found that the addition of steel fibers into concrete the small increase in compressive strength with increase in fiber content after7,14 ,28,56 and 90 days of curing.

14 It is observed that the addition of steel fibers did not improve the compressive strength in concrete.

15 Steel fibers have showed more significant effects on flexural and tensile strength at 0.75% by volume fractions.

16 Durability studies carried out in the investigation through acid attack test and chloride test with 1% H2SO4 and 3% NaCl revealed that 22.5%FA+7.5%RHA concrete is more durable in terms of durability factors than control concrete.

17 It is observed that rice husk ash concrete will have higher life compared to control concrete.

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