Mechanical properties of Concrete by partial replacement of cement with RHA and flyash

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Abstract:

Concrete is the most widely used and versatile building material which is generally used to resist compressive forces. By addition of some pozzolanic materials, the various properties of concrete viz, workability, durability, strength, resistance to cracks and permeability can be improved. Many modern concrete mixes are modified with addition of admixtures, which improve the microstructure as well as decrease the calcium hydroxide concentration by consuming it through a pozzalonic reaction. In this work the concrete is replaced by the various percentages of rice husk ash. To study we have taken Rice husk ash, Fly ash as partial replacement of fine aggregate and cement, since the usage is common in the construction field. Using these constitutes M30 grade of concrete is designed with different mix proportions. These concretes shall be tested for finding compressive strength, split tensile strength for 7days, 14days and 28days using Indian Standard code books. These results were compared to M30 plane concrete and theoretical values.

- To study the effect of Rice husk and flyash on compressive strength ofconcrete for 7, 14, 28 days curing.
- To study the effect of Rice husk and flyash on split tensile strength ofconcrete for 7, 14, 28 days curing.

It is observed with the results obtained in compressive strength and split tensile strength that there is gradual increase in both the strengths with increase in rice husk simultaneously with fly. The optimum strength found in 4% rice husk+14% fly ash at 28days of curing.

1.Introduction:

Concrete is the most widely used and versatile building material which is generally used to resist compressive forces. By addition of some pozzolanic materials, the various properties of concrete viz, workability, durability, strength, resistance to cracks and permeability can be improved. Many modern concrete mixes are modified with addition of admixtures, which improve the microstructure as well as decrease the calcium hydroxide concentration by consuming it through a pozzalonic reaction. The subsequent modification of the microstructure of cement composites improves the mechanical properties, durability and increases the service-life properties.

The problem of disposing and managing solid waste materials in India and other industrial countries has become one of the major environmental, economical, and solid issues. A complete waste management system including source reduction, reuse, recycling, land-filling, and incineration needs to be implemented to control the increasing waste disposal problems. Of the above options, recycling is the most promising waste management process for the disposal of materials in the waste stream .The two main potential markets to utilize the recycled waste materials successfully are the transportation and construction industries. Special applications which would not require high strength concrete can be found in the transportation industry. Furthermore, the potential uses of most recyclables in the construction industry are almost endless.

Many virgin and waste materials are widely used in concrete composites as fiber reinforcement (e.g. steel, glass plastic, sisal and jute).For example it was believed that the presence of crushed glass in aggregates tends to produce unworkable concrete mixtures, and high alkali content of such aggregates would affect the long term durability and strength of the composite. Recently, using different types of waste materials (such as vegetables and plastic materials) in concrete composites as aggregates has been investigated. Results of such research showed the possibility of using these materials in concrete composites effectively.

What is rice husk?

The outermost layer of the paddy grain is the rice husk, also called rice hull. It is separated from the brown rice in rice milling.

Fig 1: Rice Husk

Importance of rice husk:

Around 20% of paddy weight is husk .In 2008 the world paddy production was 661 million tons and consequently 132 million tons of rice husk were also produced. While there are some uses for rice husk it is still often considered a waste product in the rice mill and therefore often either burned in the open or dumped on wasteland. Husk has a high calorific value and therefore can be used as a renewable fuel.

Properties of Rice Husk:

A. Chemical composition:

Proximate analysis,

PROPERTY	**RICE HUSK (%)**
Volatile matter	64.7
Fixed carbon	15.7
Ash	19.6

Table 1– Chemical composition of rice husk

Ultimate analysis,

PROPERTY	RICE HUSK (%)
Carbon	38.7
Hydrogen	5
Oxygen	36
Nitrogen	0.5

Table 2 – chemical composition of rice husk

B. Physical properties:

Bulk density, outer surface area, Porosity, Angle of repose Equilibrium moisture content, Thermal conductivity, Pressure drop of air in a rice husk bed and terminal velocity, Air velocity and pressure drop in rice husk bed.

Physical chemical characteristics of rice husk:

COMPOSITION	PERCENTAGE
Bulk density (g/m^3)	0.79
Solid density (g/m^3)	1.48
Moisture content (%)	5.98
Ash content (%)	48.81
Particle size (mesh)	200.4
Surface area (m^3/g)	320.9
Surface acidity (meq/g)	0.15
Surface basicity (meq/g)	0.53

Table 3: Physical chemical characteristics of rice husk:

1.1.1 FLY ASH:

- Fly ash, also known as "pulverised fuel ash" in the United Kingdom, is a coal combustion product composed of fine particles that are driven out of the boilers with the flue gases Ash that falls in the bottom of the boiler is called bottom ash.
- In modern coal-fired power plants, fly ash is generally captured by electrostatic precipitators or other particle filtration equipment before the flue gases reach the chimneys. Together with bottom ash removed from the bottom of the boiler, it is known as coal ash.
- Depending upon the source and makeup of the coal being burned, the components of the fly ash vary considerably, but all the fly ash includes the substantial amount of the silicon dioxide (SiO_2) which is both amorphous and crystalline in nature, aluminum oxides (Al2O_3) and calcium oxide (CaO), the main mineral compounds in coal-bearing rock strata.
- Fly ash particles are generally spherical in shape and range in size from 0.5 µm to 300 µm.

OXIDES	**PERCENTAGE (%)**
SiO_2	60.54
Al_2O_3	26.20
Fe_2O_3	5.87
CaO	1.91
MgO	0.38
K_2O+Na_2O	1.02
SO_3	0.23
Loss of ignition	2.0

Table 4 - chemical composition of fly

fig 2: fly ash

1.2. SCOPE OF THE WORK

To study we have taken Rice husk ash, Fly ash as partial replacement of fine aggregate and cement, since the usage is common in the construction field. Using these constitutes M30 grade of concrete is designed with different mix proportions. These concretes shall be tested for finding compressive strength, split tensile strength for 7days, 14days and 28days using Indian Standard code books. These results were compared to M30 plane concrete and theoretical values.

1.3. OBJECTIVE OF THE WORK

- To study the effect of RICE HUSK AND FLY ASH on compressive strength of concrete for 7, 14, 28 days curing.
- To study the effect of RICE HUSK AND FLY ASH on split tensile strength of concrete for 7, 14, 28 days curing.

2.LITERATURE REVIEW

I. **chatterjee, (2011):** reported that about 50% of fly ash generated is utilized with present efforts. he also reported that, one may achieve up to 70% replacement of cement with fly ash when high strength cement and very high reactive fly ash is used along with the sulphonated naphthalene formaldehyde super plasticizer. he reported improvement in fly ash properly could be achieved by grinding and getting particles in sub microcrystalline range.

II. **rao, (2004):** discussed the need to use about 650kg/cu.m of the material to make self compacting concrete. this also requires fine aggregates more than 50% of total aggregate so that coarse aggregate can float in the fine material. this requirement of fine materials can be easily fulfilled by use of fly ash.

III. **subramaniam, gromotka, shah, obla& hill, (2005):** investigated the influence of ultrafine fly ash on the early age properly development, shrinkage and shrinkage cracking potential of concrete. in addition, the performance of ultrafine fly ash as cement replacement was compared with that of silica fume. the mechanisms responsible for an increase of the early age stress due to restrained shrinkage were assessed; free shrinkage and elastic modulus were measured from an early age. in addition, the materials resistance to tensile fracture and increase in strength were also determined as a function of age. comparing all the test results authors indicated the benefits of using ultrafine fly ash in reducing shrinkage strains and decreasing the potential for restrained shrinkage cracking.

IV. **Hwang, noguchi & tomosawa, (2004)**: based on their experimental results concerning the compressive strength development of concrete containing fly ash, the authors concluded that the pores in concrete reduce by addition of fly ash as

3.TESTS ON MATERIALS

3.1TESTS ON RICE HUSK:

3.1.1 SPECIFIC GRAVITY:

Sl.no	Details	weight in gm
1	Wt. of empty pycnometer(w1)	225
2	Wt. of pycnometer + rice husk +water (w2)	764.4
3	Wt. of pycnometer+ water(w3)	756.4
4	Wt. of rice husk taken (w4)	25
5	Wt. of pycnometer + rice husk (w5)	250

Table 5 – Specific gravity of rice husk

3.1.2WATER ABSOPRTION:

Wt. of wet rice husk = 62gm

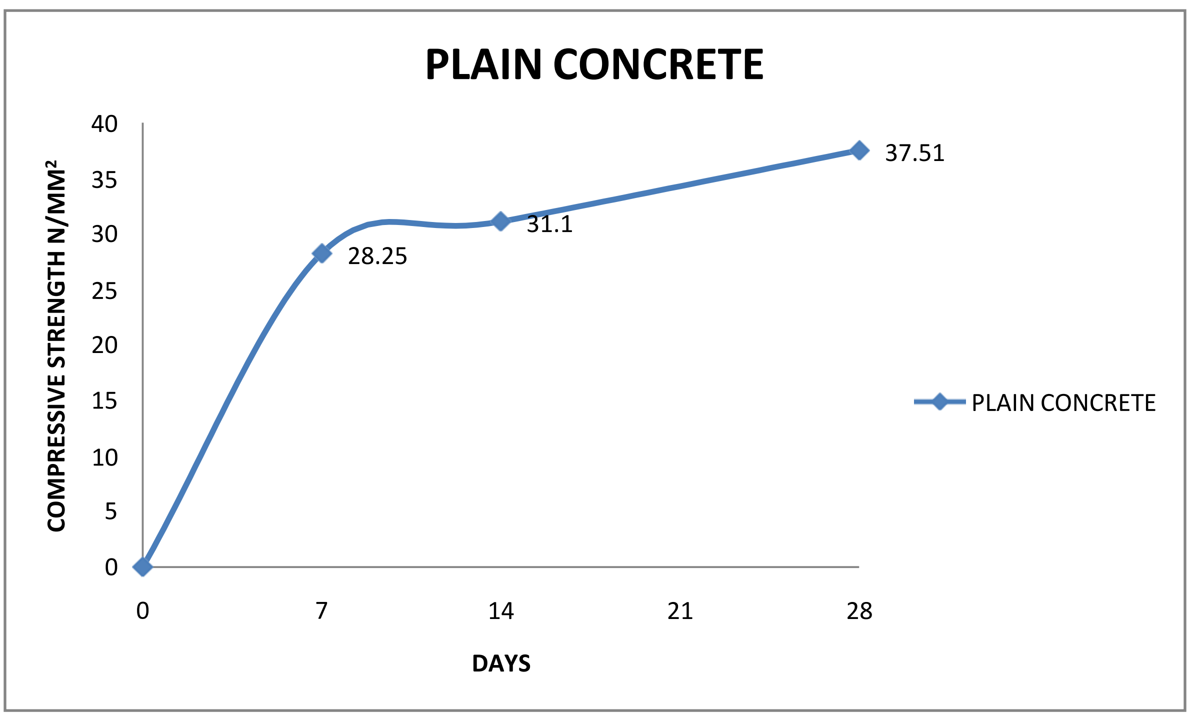
Wt. of oven dry rice husk =25gm

Water absorption =37ml for 25gm

Water absorption capacity of rice husk = $\frac{37}{250} X100 = 14.8\%$

PLAIN CONCRETE				
DAYS	SPECIMEN	LOAD IN KN	COMPRESSIVE STRENGTH IN N/mm^2	AVERAGE
7 DAYS	A	700	31.1	28.25
	B	550	24.44	
	C	590	29.22	
14 DAYS	A	650	28.88	31.10
	B	750	33.33	
	C	700	31.11	
28 DAYS	A	950	42.22	37.51
	B	890	39.5	
	C	680	31.11	

Table 7 – Compressive strength of plain concrete

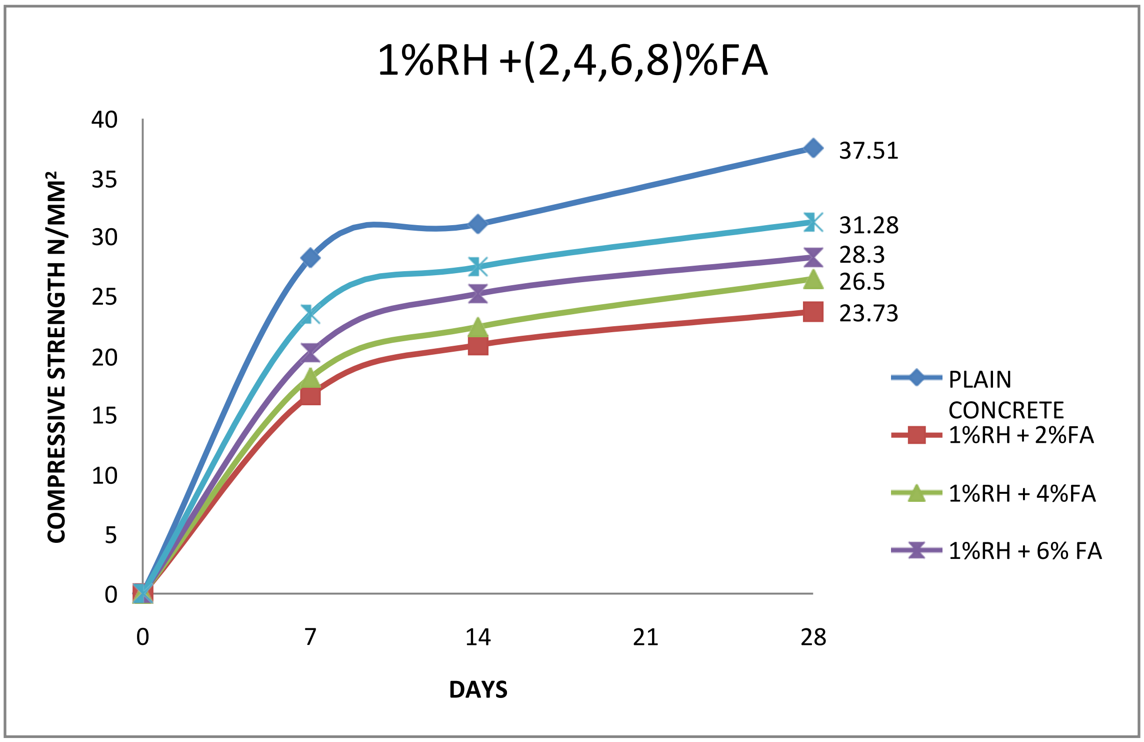


Graph 1: Compressive Strength of Plain Concrete

1% RH + (2,4,6,8) % FA				
DAYS	COMPRESSIVE STRENGTH IN N/mm^2			
	1%RH + 2%FA	1%RH + 4%FA	1%RH + 6%FA	1%RH + 8%FA
7 DAYS	16.736	18.20	20.28	23.55
14 DAYS	20.92	22.45	25.24	27.50
28 DAYS	23.73	26.50	28.30	31.28

Table 8 – Compressive strength of 1% RH + (2, 4, 6, 8) % FA

GRAPH:

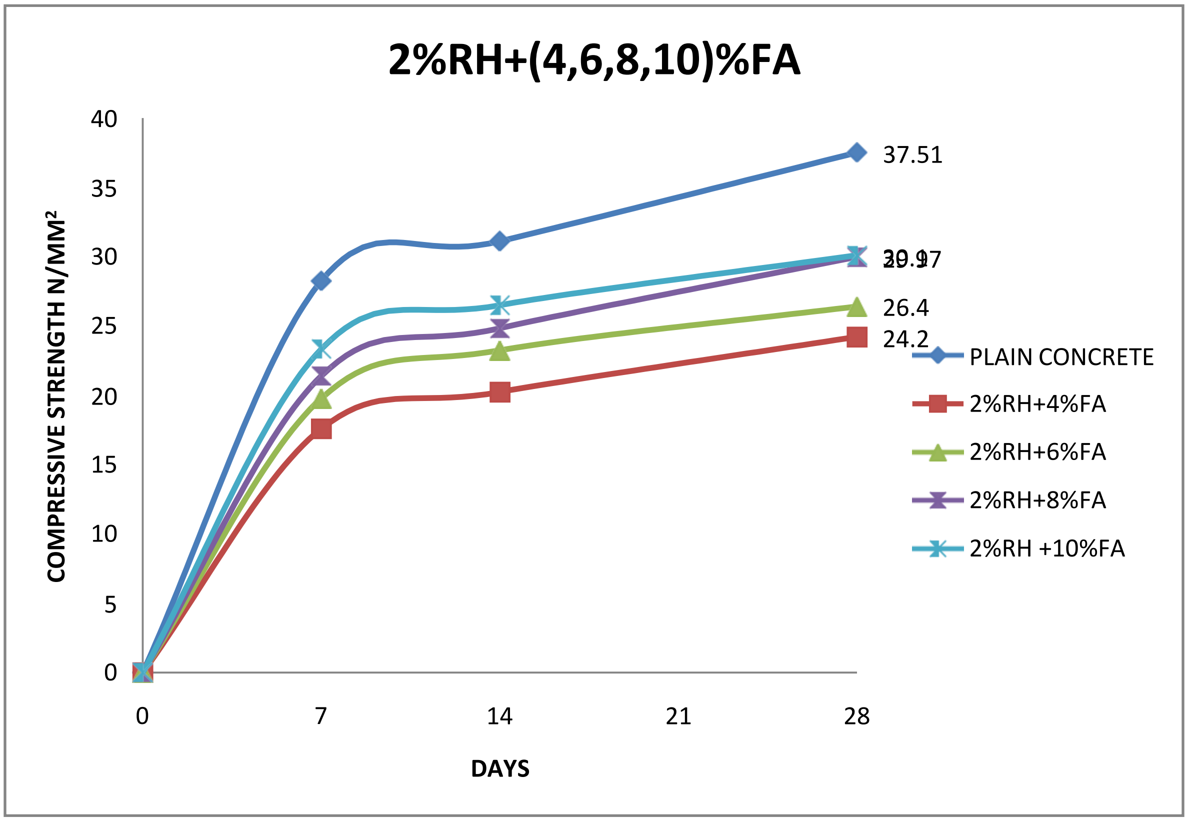


Graph 2: Compressive Strength of 1% RH + (2, 4, 6, 8) % FA

2% RH + (4,6,8,10) % FA				
DAYS	COMPRESSIVE STRENGTH IN N/mm^2			
	2%RH + 4%FA	2%RH + 6%FA	2%RH + 8%FA	2%RH + 10%FA
7 DAYS	17.59	19.78	21.40	23.34
14 DAYS	20.23	23.24	24.82	26.49
28 DAYS	24.20	26.40	29.97	30.10

Table 9 – Compressive strength of 2% RH + (4, 6, 8, 10) % FA

GRAPH:

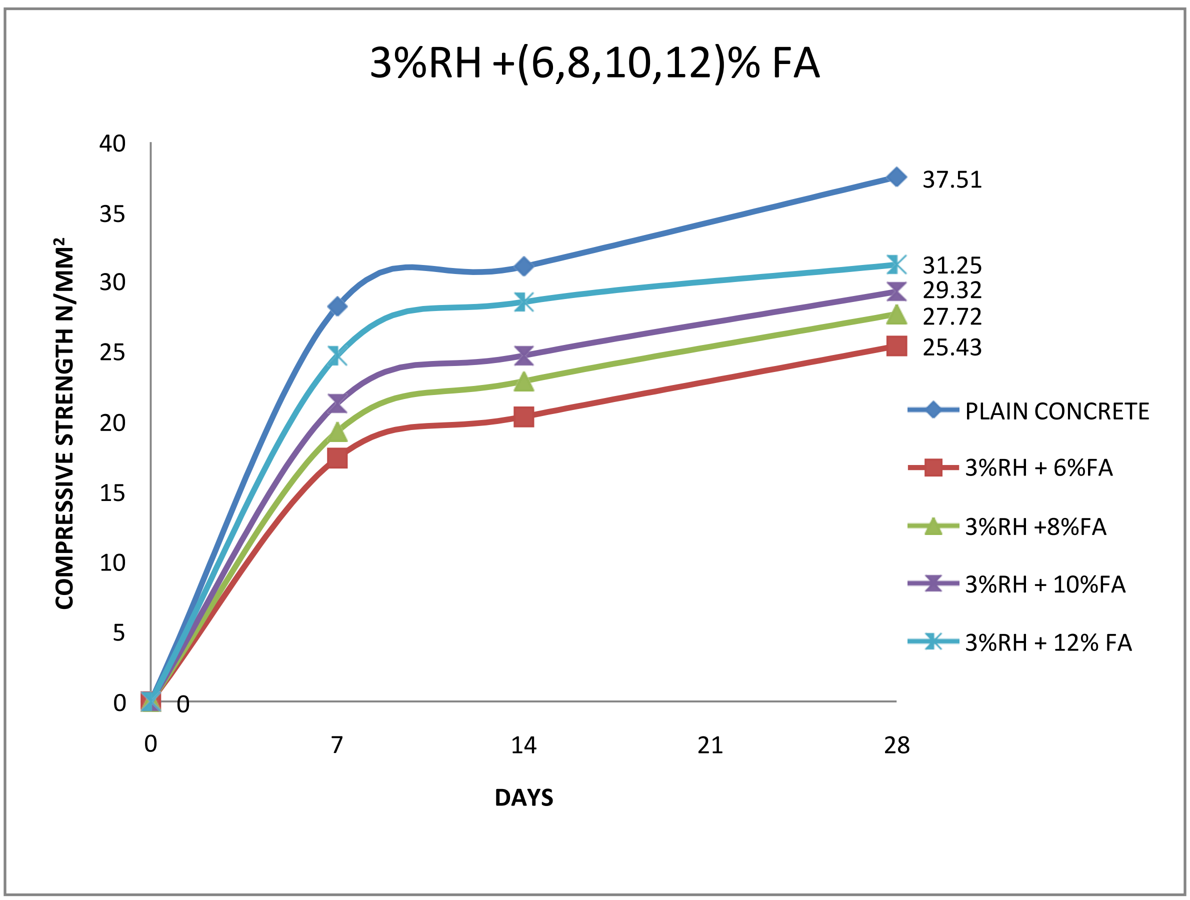


Graph 3: Compressive Strength of 2% RH + (4, 6, 8, 10) % FA

3% RH + (6,8,10,12) % FA				
DAYS	COMPRESSIVE STRENGTH IN N/mm^2			
	3%RH + 6%FA	3%RH + 8%FA	3%RH + 10%FA	3%RH + 12%FA
7 DAYS	17.40	19.30	21.32	24.73
14 DAYS	20.36	22.91	24.73	28.57
28 DAYS	25.43	27.72	29.32	31.25

Table10 – Compressive strength of 3% RH + (6, 8, 10, 12) % FA

GRAPH:

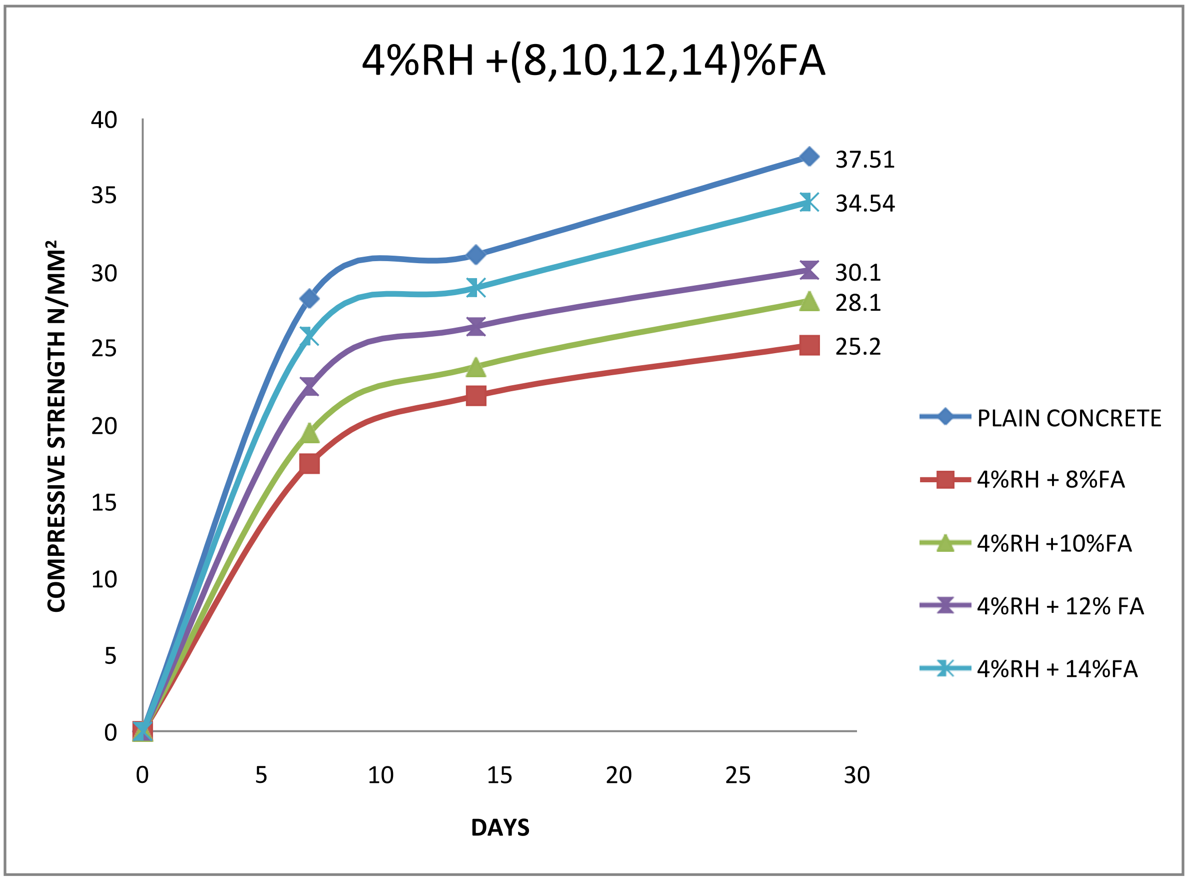


Graph 4: Compressive strength of 3%RH + (6, 8, 10, 12) % FA

4% RH + (8,10,12,14) % FA				
DAYS	COMPRESSIVE STRENGTH IN N/mm^2			
	4%RH + 8%FA	4%RH + 10%FA	4%RH + 12%FA	4%RH + 14%FA
7 DAYS	17.47	19.50	22.50	25.78
14 DAYS	21.90	23.80	26.41	28.95
28 DAYS	25.20	28.10	30.10	34.54

Table 12 – Compressive strength of 2% RH + (6, 8, 10, 12) % FA

GRAPH:



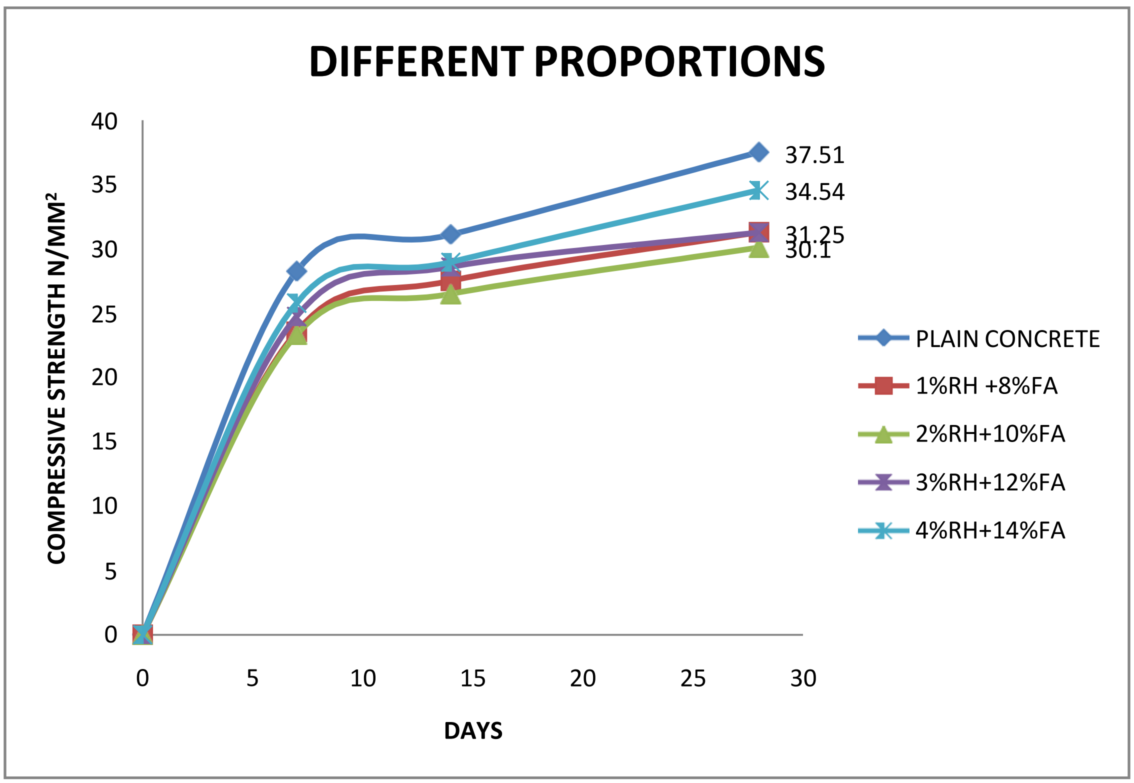
Graph 5: Compressive Strength of 4%RH + (8, 10, 12, 14) %FA

COMPRESSIVE STRENGTH:

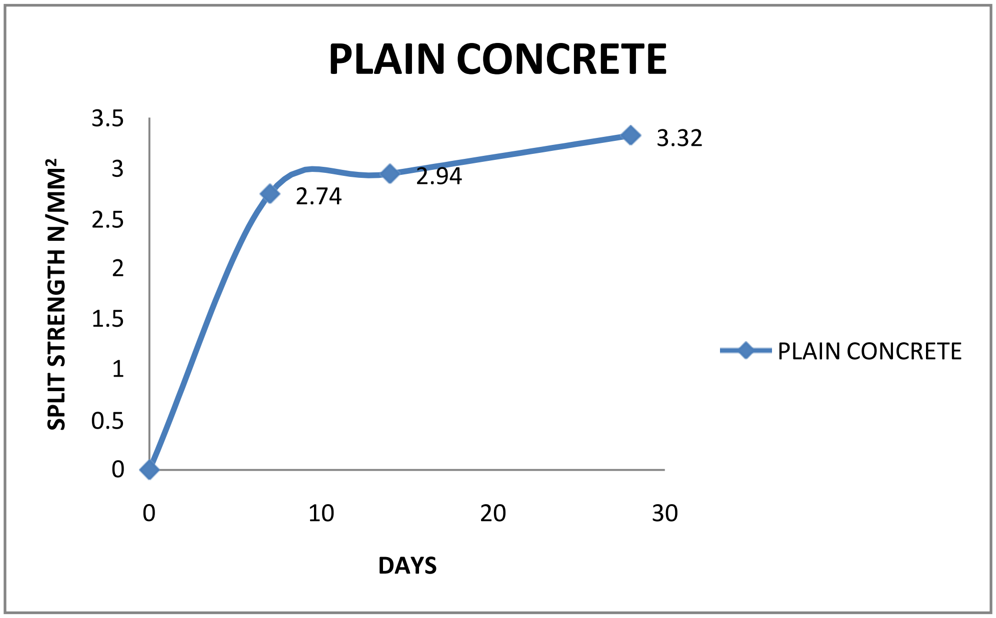
DIFFERENT PROPORTIONS				
DAYS	COMPRESSIVE STRENGTH IN N/mm^2			
	1%RH + 8%FA	2%RH +10%FA	3%RH + ,12%FA	4%RH + 14%FA
7 DAYS	23.55	23.34	24.73	25.78
14 DAYS	27.50	26.49	28.57	28.95
28 DAYS	31.28	30.10	31.25	34.54

Table 13 – compressive strength for different proportions

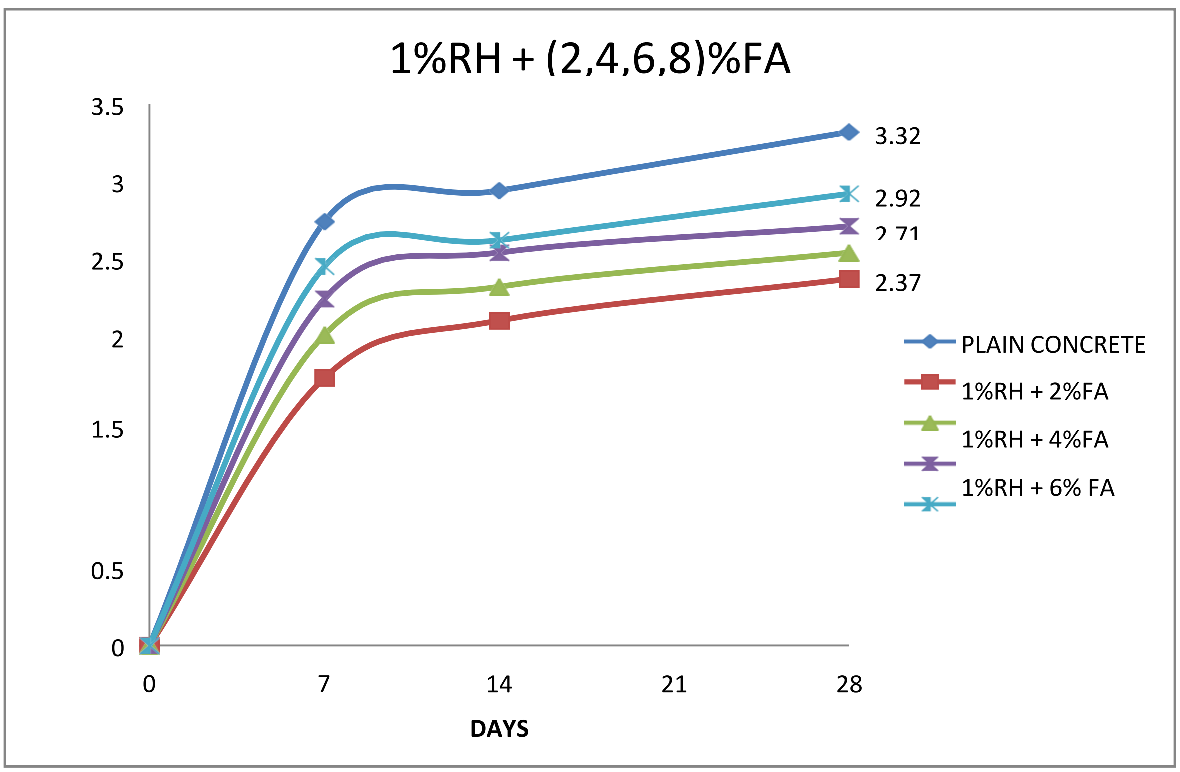
GRAPH:



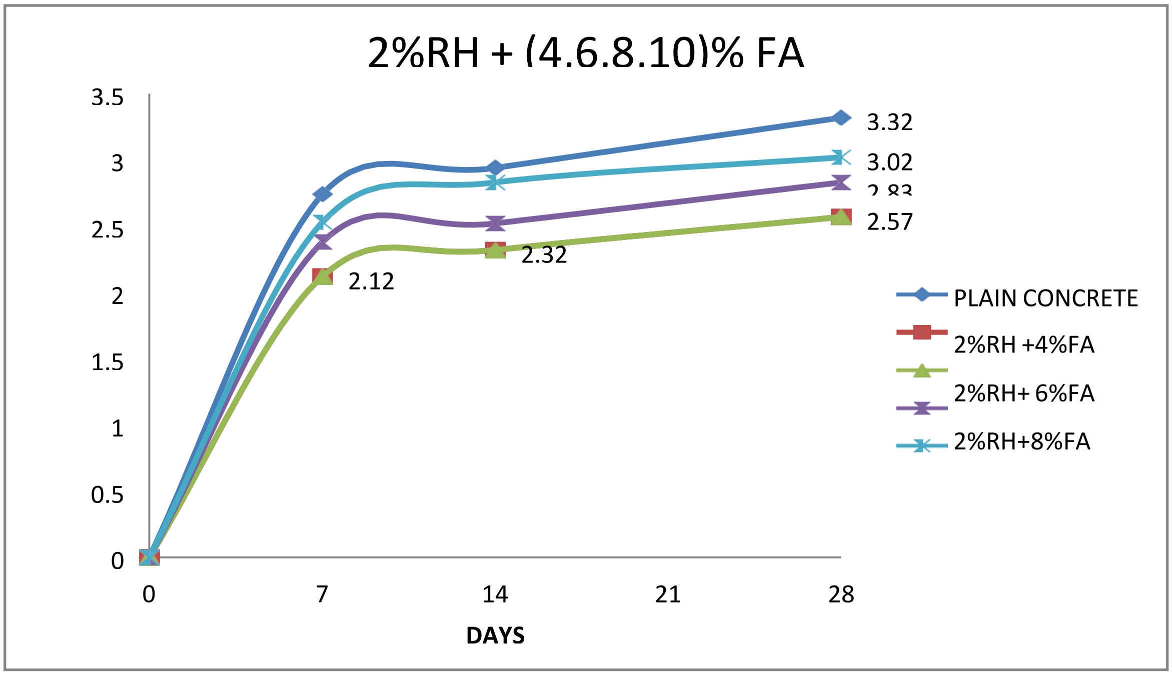
Graph 6: Compressive Strength for Different Proportions



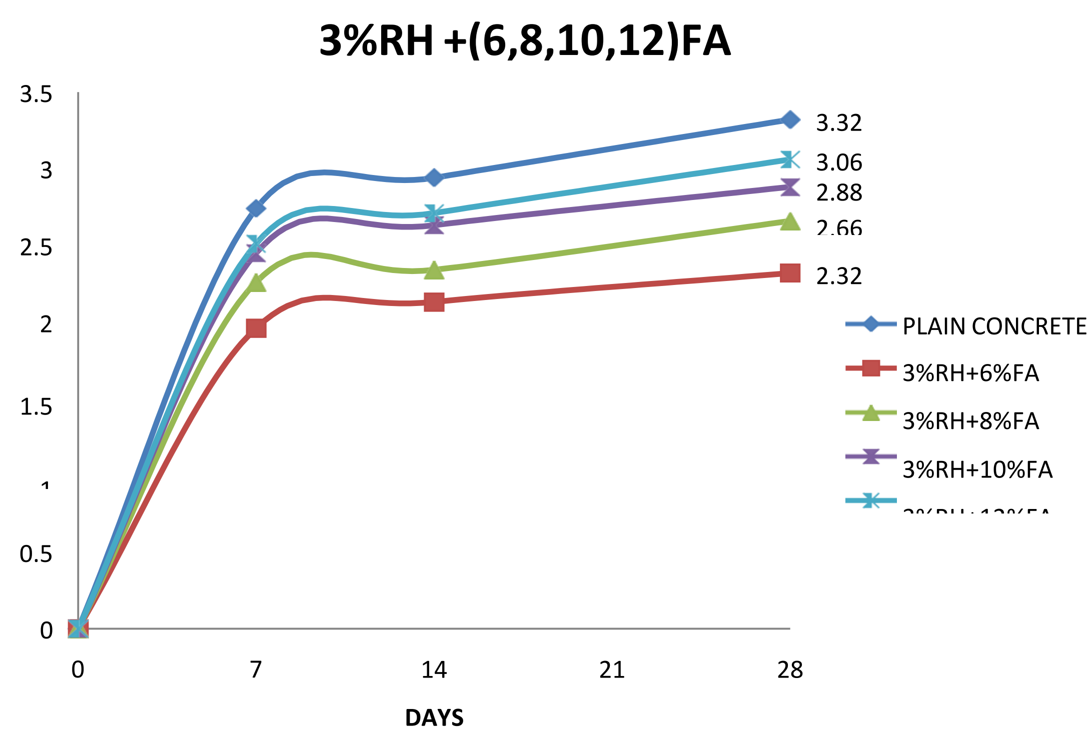
Graph 7: Splitting Tensile Strength Plain Concrete



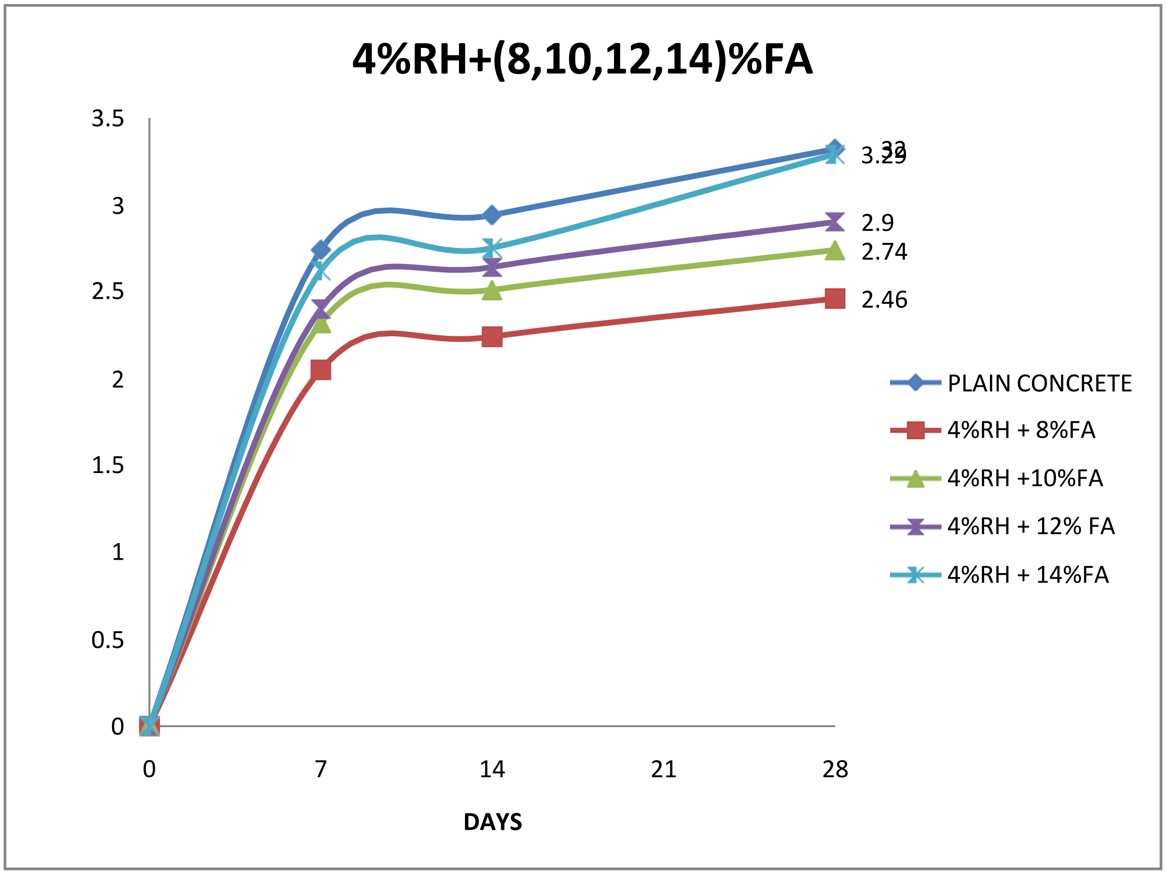
Graph 8: Splitting Tensile Strength 1%RH + (2, 4, 6



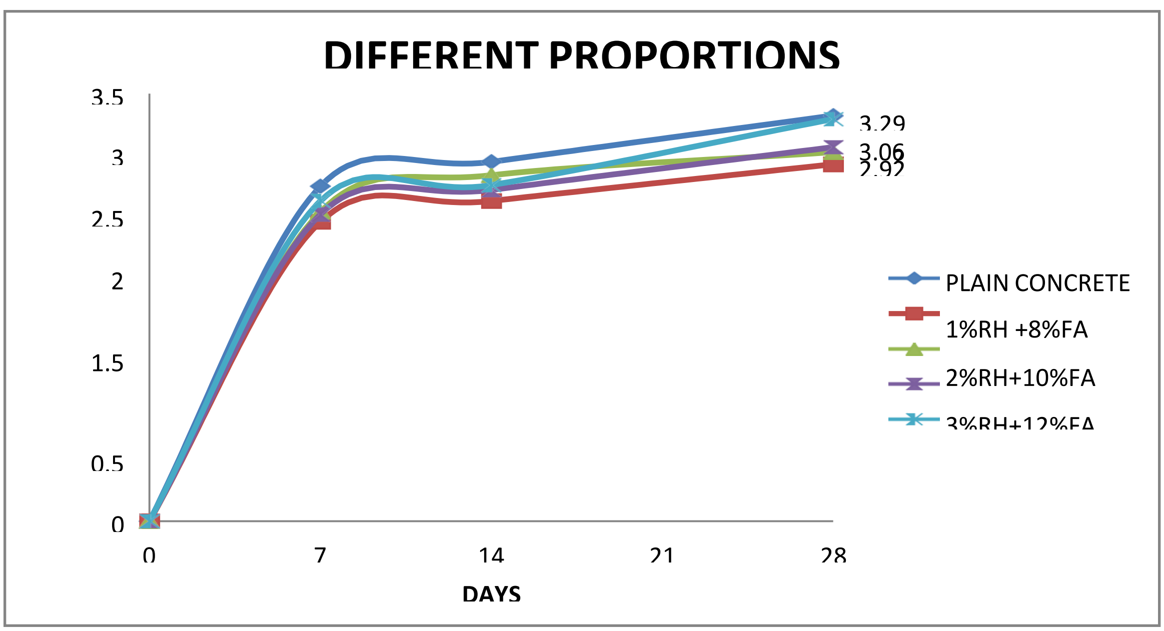
Graph 9: Splitting Tensile Strength 2% RH + (4, 6, 8, 10) % FA



Graph 10: Splitting Tensile Strength 3% RH + (6, 8, 10, 12) % FA



Graph 11: Splitting Tensile Strength 4% RH +(8,10,12,14)% FA



Graph 12: Splitting Tensile Strength for Different Proportion

5. CONCLUSION

It is observed with the results obtained in compressive stress that general increase in rice husk simultaneously with fly ash there is gradual rise in compressive strength. The strength found in 4% rice husk+14% fly ash at 28days curing to be 34.54N/mm^2 which is found to be highest of all other replacements, which is found to be 92.08% than that of the specimen tested without any replacement i.e., 37.5N/mm^2.Though the strength arrived is 92%,yet on cost analysis replacement of 4%fine aggregate with rice husk and 14% replacement of cement by fly ash leads to considerable economical as such mixes will beused to the works which are subjected to average loading.

It is observed with the results obtained in split tensile strength that gradual increase inrice husk along with increase in replacement of fly ash that the values of tensile stresses are also gradually increased. The maximum value of tensile strength observed in 4% replacementwith rice husk and 14% replacement with fly ash is 3.29N/mm^2.Where as for the specimen without any replacement of various ingredients is observed to be 3.32N/mm^2.

On overall the specimen tested with 4% rice husk and 14% fly ash replacement shown satisfactory results but in compression and tension when compared with other replacements of fine aggregate and cement.

8. REFERENCES

1. Chatterjee, A.K. (2011) Indian Fly Ashes: Their Characteristics and Potential for Mechanochemical Acivation for Enhanced Usability. Journal of Materials in Civil Engineering, 23, 783-788
2. Rao, M. Kanta, and Naga Satish Kumar Ch. "Evaluation of Strength Properties of the Concrete Prepared from Class F Fly Ash." *IOP Conference Series: Earth and Environmental Science*. Vol. 982. No. 1. IOP Publishing, 2022.
3. IS 10262. (2009). Concrete Mix Design. New Delhi: BIS.
4. Anjan Chatterjee, K. Indian Fly Ashes: Their Characteristics and Potential for Mechanochemical Activation for Enhanced Usability, Journal of Materials in Civil Engineering, Vol. 23, No. 6, pp. 783-788, 2011.
5. ASTM C150/C150-11, Standard Specification for Portland Cement.
6. IS 456: Indian Standard Code for Plain and Reinforced Concrete, Code of practice, 4th Revision, BIS, New Delhi, 2000.
7. IS 516: Method of Test for Strength of Concrete, Reaffirmed 2004, Bureau of Indian Standards, New Delhi, 1959.