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Experimental Study of Ultra Fine Fly Ash on Strength Properties of Concrete

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ABSTRACT:
Concrete is the most widely used material for construction. One of the most important ingredients of concrete which plays a major role in hydration process is cement. Due to increased population the need for construction has been increased. Cement is one of the important ingredients used for the construction process. During the production of cement, large amount of CO_2 have been emitted from the industry which affects the green environment. Alternative material for cement such as fly ash, a byproduct of thermal power station has been used in the place of cement now days. Fly ash is a fine powder which is a byproduct from burning pulverized coal in electric generation power plants. Fly ash is a pozzolan, a substance containing aluminous and siliceous material that forms cement in the presence of water. Typically, Class F fly ash is used at dosages of 15 to 25 percent by mass of cementitious material, and Class C fly ash at 15 to 40 percent. Class F fly ash, with particles covered in a kind of melted glass, greatly reduces the risk of expansion due to sulfate attack as may occur in fertilized soils or near coastal areas. Class F are generally low-calcium fly ashes with carbon contents less than 5 percent but sometimes as high as 10 percent. Class C fly ash is also resistant to expansion from chemical attack, has a higher percentage of calcium oxide, and is more commonly used for structural concrete. Class C fly ash is typically composed of high-calcium fly ashes with carbon content less than 2 percent. To refine the research, Ultra-fine fly ash from class F fly ash has been used to study the strength properties of concrete. In this study Ultra-fine fly ash have been replaced in the ratio of 5%, 10%, 15% and 20% by the weight of cement in concrete. Fresh concrete test like slump cone test have been done and hardened concrete tests like compressive strength test, splitting tensile strength test and flexural strength test have been studied. Sorptivity test also have been done to study the porous behavior of concrete. Research revealed that Ultra-fine fly ash shows the better strength property than conventional concrete and thus reducing the emission of $CO_2$and disposal problem of fly ash.

Keywords: Ultra-fine fly ash, Sorptivity test, Fresh concrete test and Hardened concrete test

1. INTRODUCTION

Concrete is the most widely used construction material in the industry for the infrastructural projects. Cement, fine aggregate, coarse aggregate and water are the key ingredients for the production of concrete. Among the key ingredients cement is the major component which plays an important role in hydration process. CO_2 is the major contributor to greenhouse effect and global warming, which is a major threat in present scenario. During the production of cement, large amount of CO_2 have been emitted from the industry which affects the green environment. In order to reduce the emission of CO_2 and make the environment green we have decided to replace cement by ultra-fine fly ash. Fly ash produced in small dark flecks by the burning of powdered coal or other materials and carried into the air. Two classes of fly ash as defined by ASTM C618 are Class C and Class F fly ash. The major difference between the classes of fly ash is that the amount of Calcium, silica, alumina and iron content in it. Ultra- fine fly ash is generally prepared from fine grinding of class F fly ash. [1] Studied the influence of mineral admixtures such as silica fume, fly ash and blast furnace slag on strength properties of concrete. Investigations revealed that these mineral admixtures develops a cementitious property when they come in contact with lime and improves the strength and durability properties. [2] Studied the effect of corrosion resisting characteristics of concrete. In this study cement is partially replaced by fly ash in the ratio of 0% and 20% by weight. Results revealed that fly ash addition is effective in inhibiting the corrosion of concrete. This superior performance is mainly due to densification of cement paste matrix due to the pozzolanic action in fly ash. [3] Studied the performance of ultra-fine fly ash in concrete. In this study, ultra-fine fly ash of size less than 4µm was prepared and used. Ultra-fine fly ash incorporation improves the mechanical properties, working performance and resistance to chloride and sulphate attack. [4] Studied the influence of ultra-fine ground fly ash on microstructure and properties of cementitious materials. Research revealed that combination of various mineral admixtures and ultra-fine fly ash provides the reaching of technological, technical and economic effects in concrete. Using of fly ash ultra-fine particles gives the possibility of manipulation and control of cementitious materials and design of high performance concrete.[5] Developed a high volume fly ash concrete using ultra-fine fly ash. In this study ultra-fine fly ash have been replaced 50% by weight of cement. Raw fly ash and ultra- fine fly ash with tap water and lime water as mixing water was used in this study. Research revealed that there is significant reduction in the amount of super plasticizer used in high volume fly ash concrete compared to conventional concrete. [6] Studied the effect of fly ash on properties of concrete. In this study he replaced the cement by fly ash in the ratio of 10%, 20% and 30%. Study revealed that concrete with 10% and 20% replacement by ultra-fine fly ash showed better results than conventional concrete. Compressive strength goes on decreasing with increase in w/c ratio. [7] Studied the effect of fly ash on fluidity of cement paste, mortar and concrete. This study investigates the effect of fineness and replacement levels of fly ash on fluidity property. In this study ultra-fine fly ash is replaced to 20%, 30% and 40% by weight of cement in concrete. Results revealed that ultra-fine fly ash increases the setting time of cement paste and reduces the slump loss in concrete. [8] Studied the effect of high performance concrete with high volume ultra-fine fly ash reinforced with basalt fibre. Fresh concrete tests and hardened concrete tests were carried to assess the strength property of concrete. Results reveled that ultra-fine fly ash concrete showed better results when compared to conventional concrete.

The Objectives of the study are stated below:

- To increase the strength properties of concrete by using ultra-fine fly ash
- To resolve the disposal problem of fly ash
- To study the porous behavior of ultra-fine fly ash concrete

2. MATERIALS USED

Cement: Ordinary Portland cement of 53 grade with standard consistency, setting time and soundness was used.

Fine aggregate: Aggregates passing through 4.75mm sieve with fineness modulus of 3.105 having specific gravity of 2.47 was used.

Coarse aggregate: Angular aggregates of 20mm size with fineness modulus of 7.42 and having specific gravity of 2.54 was used.

Ultra-fine Fly ash: Class F fly ash obtained from thoothukudi thermal power station was used. This kind of Class F fly ash has greater combination of silica, alumina and iron than class C fly ash. Specific gravity is 2.3. Size of the fly ash particle is less than 10µm. Ultra- fine fly ash is achieved by deval’s abrasion test. Fly ash is obtained from mettur thermal power station. Fly ash collected from thoothukudi thermal power station consist of 90.5% (SiO_2+Al_2O_3+Fe_2O_3), 58% (SiO_2), 3.6% (CaO), 1.8% (SO_3), 2% (Na_2O) and 1.91% (MgO).

3. METHODOLOGY

In this study, total of 78 specimens were casted in which it includes 52 number of cubes of size 150mm x 150mm x 150mm, 24 number of cylinders of size 150mm x 300mm and 24 number of prisms of size 500mm x 100mm x 100mm. Concrete mix design code IS 10262:2009 is usedfor mix design and water cement ratio

0.45 is adoptedwith the obtained mix ratio of 1:1.5:2.87. Ultra-fine fly ash is prepared by fine grinding of fly ash in Deval's abrasion testing machine.Based on the mix design obtained, required quantities of materials were taken and weighed. Before mixing, inner surface of the moulds were prepared and grease oil was applied uniformly over the inner surfaces of the moulds. The weighted quantities of materials were then uniformly mixed. Ultra-fine fly ash is then added in then proportion of 5%, 10%, 15% and 20% by weight of cement in concrete for each separate mixes. Then prepared concrete was uniformly poured into moulds in three layers and each layer is compacted for 25 blows using tamping rod. The top surface of the moulds are then levelled using trowel. Specimens are then allowed to set for 24 hours. After 24 hours, specimens were demoulded and cured for 7 and 28 days. After the desired time period, specimens were tested to review their fresh and hardened properties. The tests are conducted as per Indian Standards.

4. EXPERIMENTAL ANALYSIS

a. Slump Cone Test:

Slump cone test is done on the prepared concrete to determine the workability of the concrete. The achieved slump value is 108.3 mm.

Fig 4.1 Slump cone test

b. Compressive Strength Test:

Compressive strength results are presented in the Table 4.1. Compressive strength results were obtained for both raw fly ash concrete as well as Ultra-fine fly ash concrete. Test results shows that Ultra-fine fly ash shows better results compared to raw fly ash.

Table 4. 1 Compressive Strength results at 7 and 28 days

S. No	Replacement (%)	7 Days		28 Days	
		RFA	UFFA	RFA	UFFA
1	5	20.43	21.62	34.27	36.08
2	10	22.76	24.51	38.15	41.17
3	15	24.93	26.89	41.63	44.20
4	20	25.32	27.40	42.48	45.94

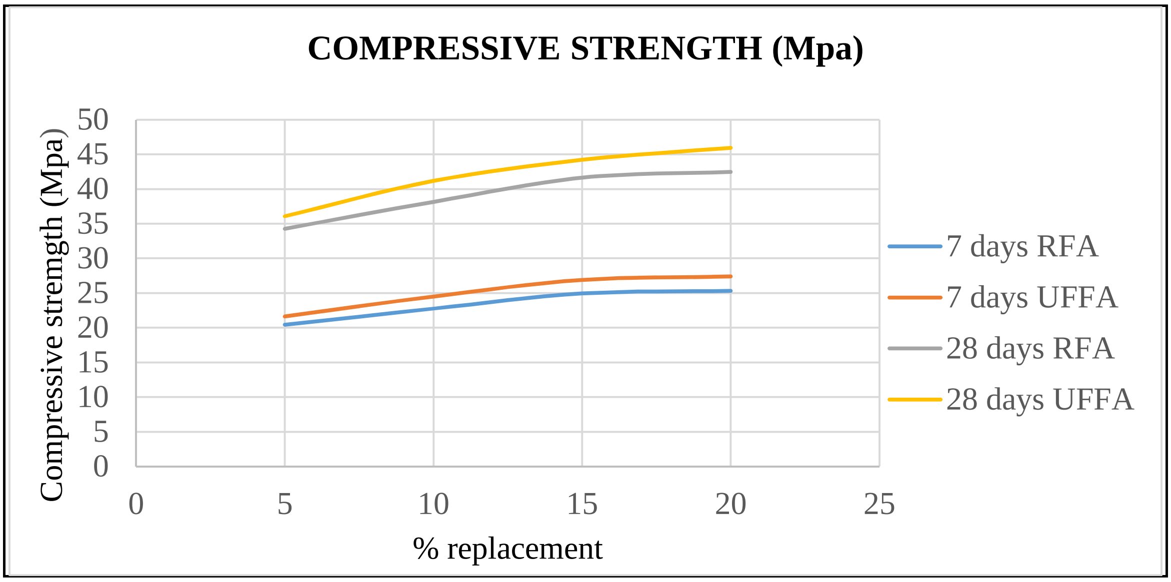

Fig 4.2 Compressive strength chart at 7 and 28 days

c. Split Tensile Strength Test:

Split Tensile strength results are presented in the Table 4.2. Split tensile strength results were obtained for both raw fly ash concrete as well as Ultra-fine fly ash concrete. Test results shows that Ultra-fine fly ash shows better results compared to raw fly ash.

Table 4. 2 Split tensile strength results at 7 and 28 days.

S. No	Replacement (%)	7 Days		28 Days	
		RFA	UFFA	RFA	UFFA
1	5	2.14	2.41	3.32	3.68
2	10	2.31	2.53	3.51	3.87
3	15	2.48	2.68	3.62	4.05
4	20	2.53	2.79	3.69	4.13

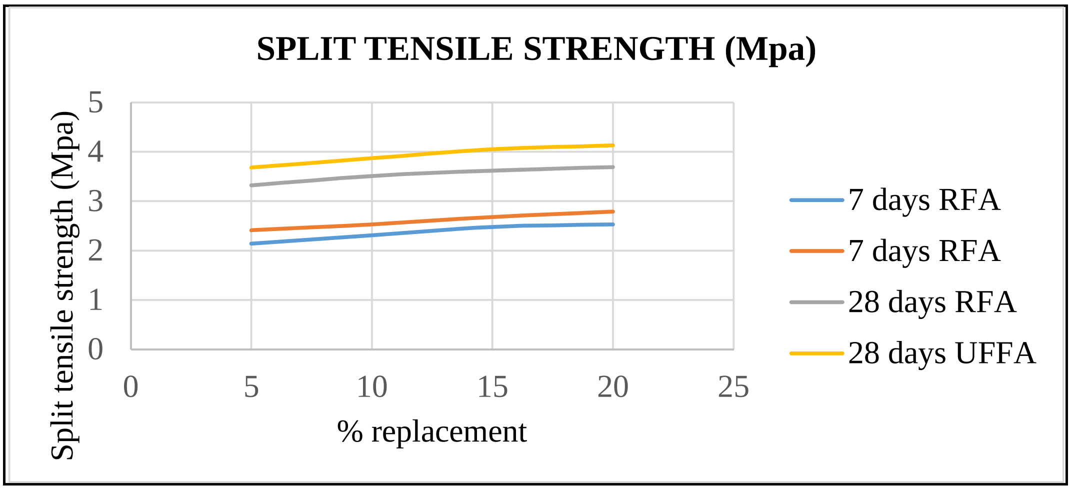

Fig 4.3 Split tensile strength chart at 7 and 28 days

d. Flexural strength Test:

Flexural strength test results are presented in the Table 4.4. Flexural strength test results were obtained for both raw fly ash concrete as well as Ultra-fine fly ash concrete. Test results show that Ultra-fine fly ash shows better results compared to raw fly ash.

Table 4.4 Flexural strength results at 7 and 28 days

S. No	Replacement (%)	7 Days		28 Days	
		RFA	UFFA	RFA	UFFA
1	5	2.74	2.99	4.17	4.46
2	10	2.81	3.08	4.20	4.53
3	15	2.89	3.13	4.33	4.67
4	20	2.97	3.19	4.41	4.79

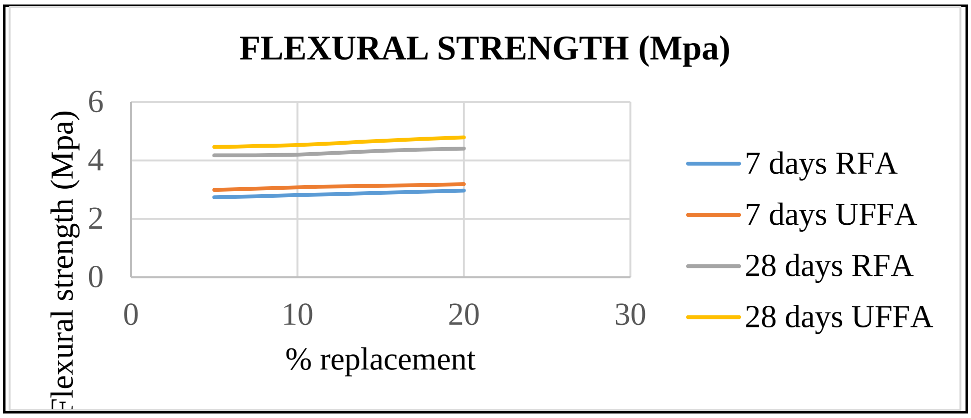

Fig 4.4 Flexural strength chart at 7 and 28 days

e. Sorptivity test:

Sorptivity is the rate of entry of water through the concrete. In this study sorptivity test have been done for raw fly ash concrete and concrete containing ultra-fine fly ash at 20% replacement level and results are presented in Table 4.5. Test results shows that there is no much variation in rate of entry of water for both raw fly ash and ultra-fine fly ash concrete.

Table 4.5 Sorptivity test results

S. No	Time	Sorptivity Co-Efficient (Raw Fly Ash)	Sorptivity Co-Efficient (20% UFFA)
1	15	0.00052	0.00052
2	30	0.00036	0.00035
3	45	0.00030	0.00029
4	60	0.00026	0.00025
5	75	0.00023	0.00022
6	90	0.00021	0.00020
7	105	0.00020	0.00019
8	120	0.00018	0.00018
9	135	0.00017	0.00017
10	150	0.00016	0.00016
11	165	0.00016	0.00015
12	180	0.00015	0.00014

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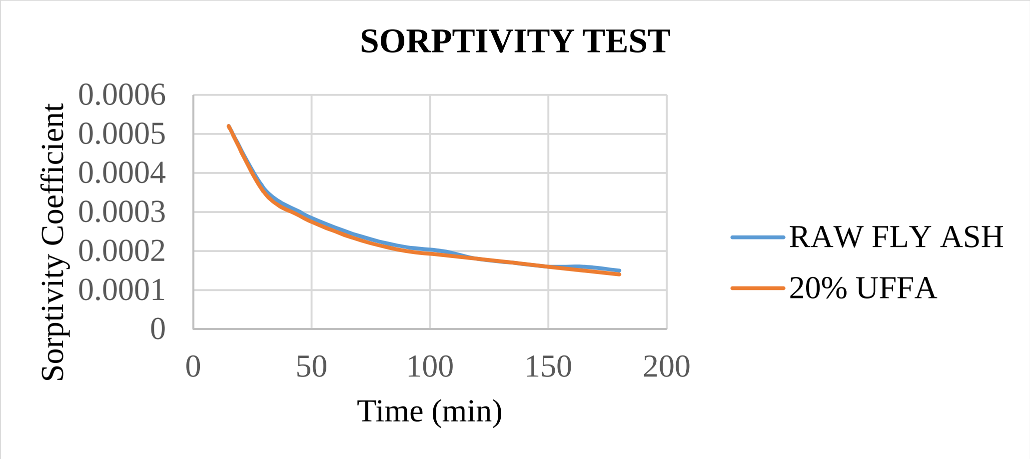

Fig 4.5 Sorptivity test results

5. Conclusion:

From the study on replacing cement by ultra-fine fly ash in concrete, the following conclusions were made:

- Strength properties of the concrete go on increasing by increasing the percentage the ultra-fine fly ash. This is because the ultra-fineness of fly ash which fills the voids between the particles.
- From the test results it could be inferred that UFFA shows 41.6% increase in strength and 44.5% increase compared to conventional concrete and RFA concrete from compressive strength test.
- From the test results it could be inferred that UFFA shows 35.8% increase in strength and 42.11% increase compared to conventional concrete and RFA concrete from split tensile strength test.
- From the test results it could be inferred that UFFA shows 27.5% increase in strength and 32% increase compared to conventional concrete and RFA concrete from flexural strength test.
- Sorptivity analysis shows that porosity behavior of raw fly ash and ultra-fine fly ash does not vary much
- Slump loss of the concrete increases with increase in water to cement ratio

REFERENCES

1. Xiaofeng, 1992, “Influence of mineral admixtures on strength properties of concrete
2. Mohammed Maslehuddin, Huseyin Saricimen, and Abdulazizi Al-Mani., 1987, “Effect of Fly Ash Addition on the Corrosion Resisting Characteristics of Concrete”.
3. H. Li, D.L.Xu, Y. Shao, M.L. Cao and J. Zhao, 2015,“Performance of ultra-fine fly ash in concrete”.
4. Myroslav SANYTSKY, Bohdan RUSYN, Jacek HALBINIAK, Joanna SZYMAŃSKA, 2013. “Influence of ultrafine ground fly ash on the microstructure and properties of cementitious materials”.
5. Himabindu Myadaraboina, Mochamad Soliki, Indubhushan Patnaikuni and Sujeeva Setunge, 2014, “Development of high volume fly ash concrete using ultra-fine fly ash”.
6. P. R. Wankhede, V. A. Fulari, 2014 “Effect of fly ash on properties of concrete”.
7. Mochamad Solikin, 2012, “High performance concrete with high volume ultra-fine fly ash reinforced with basalt fibre”,
8. J. Babu Rao, P. Narayanaswami & K. Siva Prasad. “Thermal stability of Nano Structured fly ash synthesized by high energy ball milling”.
9. Indian Standard Code for concrete mix proportioning guidelines, IS – 10262: 2009, Bureau of Indian Standards, July 2009, New Delhi.
10. Indian Standard Code for plain and Reinforcement Concrete IS: 456-2000, Bureau of Indian Standards, July 2000, New Delhi.
11. Indian Standard Code for specification for fine and coarse aggregate IS – 383:1970, Bureau of Indian Standards, April 1971, New Delhi.