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Effect of Fly Ash as Supplementary Material in Portland Pozzolana Cement Concrete

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Abstract -- The era of infrastructure increased in recent year, so the advancement of concrete technology exaggerated day by day in life. Use of concrete exaggerated the consumption of natural resources and energy sources. In recent years inordinate measure of fly ash generated in thermal industries. The previous couple of years, some cement firms have started mistreatment ash in producing cement called hydraulic cement, however, the utilization of ash remains terribly low. There's intolerably opportunity for the fly ash in cement likewise as in concrete.
This work describes the use of Non-conventional artifact (Fly ash) that is definitely our there. During this work cement and fine aggregate has been partly replaced by fly ash consequently within the range of 0% (without fly ash), 10%, 20%, 30%, 40% and 60% by weight of cement for M-25 Mix Concrete mixtures were moulded, tested and compared in terms of compressive and split strength
Keywords– Cement, Fine Aggregate, Coarse Aggregate , Fly Ash, Water

I. INTRODUCTION

Fly ash is a finely divided residue resulting from the combustion of bituminous coal or lignite in a thermal power plant. Indian coals have on an average 45% ash content. The production of fly ash was 200 million ton by 2010 and now it is about 150 million per year. Research work of large number of agencies in the country and actual utilizations abroad has exhibited worth of fly ash. However, may be due to lack of local experience, utilization of fly ash did not pick up in India, till a few years ago. Fly Ash Mission, established by Government of India in 1994 is providing a focused thrust to develop local experiences and thus building up of confidence in techno-economic viability of fly ash utilizations as well as safe disposal of un-utilized ashes. Internationally fly ash is considered as a byproduct which can be used for many applications. Fly ash is one of the residues generated in combustion, and comprises the fine particles that rise with the flue gases. Fly ash consists of fine, powdery particles that are predominantly spherical in shape, either solid or hollow, and mostly glassy (amorphous) in nature. The carbonaceous material in fly ash is composed of angular particles. The particle size distribution of most bituminous coal fly ashes is generally similar to that of a silt (less than a 0.075 mm). Although sub-bituminous coal fly ashes are also silt-sized, they are generally slightly coarser than bituminous coal fly ashes. The specific gravity of fly ash usually ranges between 2.1 to 3.0, while its specific surface area (measured by the Blaine air permeability method) may range from 170 to 1000m2/kg. With fly ash accumulation emerging a big threat to environment, the State Government has made mandatory the use of fly ash bricks in all government buildings located within a radius of 100 m of fly ash generating units. Th notification issued by the Works Department on mandatory use of fly ash bricks would come into effect from September 1 next. Departments such as Housing and Urban, Water Resources, Forest and Environment, Industries, and Rural Development have been informed about it.

II. LITERATURE REVIEW

Maslehuddin et al (1989) carried out investigations to evaluate the compressive strength development and corrosion-resisting characteristics of concrete mixes in which fly ash was used as an admixture (equal quantity of sand replacement). Concrete mixtures were made with fly ash additions of 0%, 20%, and 30%, and water-cement ratios of 0.35, 0.40, 0.45, and 0.50. Based on the test results, they concluded that addition of fly ash as an admixture increases the early age compressive strength and long-term corrosion-resisting characteristics of concrete. The superior performance of these mixes compared to plain concrete mixes was attributed to the densification of the paste structure due to pozzolanic action between the fly ash and the calcium hydroxide liberated as a result of hydration of cement. Mukherjee et al (2013) reported that the zero slump concrete shows higher compressive strength compare to workable concrete with super plasticizer up to 60% replacement with fly ash. The strength gain with time is higher compared to the OPC concrete at all replacement level of cement by fly ash and the optimum strength gain was noted at 70% replacement at 28 days.

The objective of investigation is to study suitability of fly ash as cement and fine aggregate replacement in Portland Pozzolana

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Cement (PPC) concrete with the view to strength parameter, and cost analysis.

III. MATERIALS AND METHODS

A. Cement

In this work, Pozzolana Portland Cement PPC) of prism brand obtained from single batches throughout the investigation was used. The Portland cement content mainly two basic ingredients namely argillaceous and calcareous

B. Fine aggregate

The fine aggregate was locally available river sand which is passed through 4.75mm sieve. The specific gravity of fine aggregate is 2.3 and fineness modulus of fine aggregate is 2.524

C. Coarse aggregate

The coarse aggregate was locally available quarry having two different sizes, one fraction is passing through 20mm sieve and another fraction passing through 10mm sieve. The specific gravity of coarse aggregate is 2.66 for both fractions. . Proportion of 20mm and 10mm size aggregate was taken as 65% and 35%.

D. Concrete

The concrete mix design is done in accordance with IS 10262(2009). The cement content used in the mix design is taken as 380 kg/m3 which satisfies minimum requirement of 300 kg./m3 in order to avoid the balling affect. Good stone aggregate and Natural River sand of Zone-II were used as coarse and fine aggregate respectively. Size of coarse aggregate was 20mm and 10mm. A sieve analysis conforming to IS 383-1970 was carried out for both the fine and coarse aggregates.

E. Water

Potable water is used for mixing and curing. The water cement ratio (w/c) of 0.46 has been used.

F. Fly ash

In the present work the fly ash is obtained from the NTPC. Unchahar, Raebareli U.P.

Physical Properties		
	PPC	**Fly Ash**
Specific gravity	2.67	2.30
Mean grain size (µm)	21.5	20
Specific area (cm2/gm)	2770	2680
Colour	Grey	Grey to black

IV. EXPERIMENTAL STUDY

Compressive and split tensile strength of cubes and cylinders have been determined as per IS 516-1959 at a loading rate of about 140 kg/cm2/min (about 30 tones per minute) on 2000 tons compression testing machine. Two dial gauges in diametrically opposite directions were cast for testing are:-

- The cubes size 150mm for compressive strength.
- The cylinder size 300mm height and dia. 150mm for split tensile strength.
- The details of cubes and cylinders given below.

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TABLE 1: Cubes, Cement partially replaced with fly ash for compressive strength

S.No.	Cube designation	Size (mm)	Fly ash %age
1	A1	150x150x150	0
2	A2	150x150x150	10
3	A3	150x150x150	20
4	A4	150x150x150	30
5	A5	150x150x150	40
6	A6	150x150x150	50
7	A7	150x150x150	60

TABLE 2: Cubes fine aggregate partially replaced with fly ash for compressive strength

S.No.	Cube designation	Size (mm)	Fly ash %age
1	B1	150x150x150	0
2	B2	150x150x150	10
3	B3	150x150x150	20
4	B4	150x150x150	30
5	B5	150x150x150	40
6	B6	150x150x150	50

TABLE- 3: Cylinders, cement replaced partially with fly ash for split tensile test

S.No.	Cylinder designation	Size (mm) Radium x Height	Fly ash %age
1	C1	150x150x150	0
2	C2	150x150x150	10
3	C3	150x150x150	20
4	C4	150x150x150	30
5	C5	150x150x150	40
6	C6	150x150x150	50
7	C7	150x150x150	60

V. RESULTS AND DISCUSSION

When cement replaced by Fly ash: The compressive strength of referral concrete at 7, 28 and 56 days are given in Table 4. It is evident from this table that the strength increases with the addition of fly ash. Strength increases up to 30% fly ash content and after that it decreases. However increase in strength is more prominent at 20% replacement level. The variation of compressive strength with different percentage of fly ash is shown in fig 1. These figure shows that the compressive strength of concrete with and without as function of curing time. The compressive strength of PPC is 22.7 N/mm2, 31.8 N/mm2 and 35.59 N/mm2 when water/cement ratio is 0.46 at 7, 28 and 56 days respectively.

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Table 4 Compressive strength of Fly ash concrete

S.No.	Cube designation	Compressive strength (N/mm2)			%age of fly ash
		7 days	28 days	56 days	
1	A1	22.7	31.8	35.90	0
2	A2	20	33.3	38.4	10
3	A3	20.6	33	38.9	20
4	A4	17.7	28.8	37.3	30
5	A5	14.2	20.7	28.5	40
6	A6	12.9	19.1	24	50
7	A7	7.4	14.9	17.3	60

When fine aggregate replaced by Fly ash : The compressive strength of referral concrete at 7, 28 and 56 days are given in table 5. It is evident from this table that the strength increases with the addition of fly ash. Strength increases continuously increases percentage of fly ash content. The variation of compressive strength with different percentage of fly ash is shown in fig 2.The compressive strength of fly ash concrete when fine aggregate partially replaced with fly ash at 50% replacement level increase in strength is 15.4% & 18% at 28 & 56 days with the reference of referral concrete cubes.

Table 5 Compressive strength of Fly ash concrete

S.No.	Cube designation	Compressive strength (N/mm2)			%age of fly ash
		7 days	28 days	56 days	
1	B1	22.7	31.8	35.90	0
2	B2	24.5	32.88	36.78	10
3	B3	25.11	32.97	37.28	20
4	B4	25.97	35.31	40	30
5	B5	26.51	35.4	40.4	40
6	B6	27	36.8	42.47	50

Split Tensile Strength of Fly Ash Concrete (Cement Partially Replaced With Fly Ash): The split tensile strength of referral concrete as well as fly ash concrete at 7, 28 and 56 days are given in table 6. It is evident from this table that the strength increases with the addition of fly ash. Strength increases up to 20% fly ash content and after that it decreases. However, increase in strength is more prominent at 10% replacement level. The variation of tensile strength with different percentage of fly ash is shown in fig. 3. These figure shows that the tensile strength of concrete with and without as function of curing time. The tensile strength of PPC is 4.5 N/mm2, 6.9 N/mm2 and 7.9 N/mm2 when water/cement ratio is 0.46 at 7, 28 and 56 days respectively.

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Table 6. Split tensile strength of fly ash concrete

S. No.	Cube designation	Compressive strength (N/mm2)			%age of fly ash
		7 days	28 days	56 days	
1	C1	4.5	6.9	7.9	0
2	C2	6.0	7.8	9.9	10
3	C3	5.5	8.0	8.5	20
4	C4	3.0	5.3	6.3	30
5	C5	2.8	5.0	5.4	40
6	C6	2.3	3.7	5.3	50
7	C7	1.9	2.8	4.2	60

VI. CONCLUSIONS

From the above study following conclusions are drawn:

A. Compressive Strength (when cement replaced with fly ash)

1) The compressive strength of fly ash concrete up to 30% replacement level is slightly equal to referral concrete at 28 and 56 days.

2) Optimum replacement level of fly ash is 20%, at 20% replacement level increase in strength at 28 and 56 days is 1.9% & 3.2%.

B. Compressive strength (when fine aggregate replaced with fly ash)

3) The compressive strength of fly ash concrete at 50% replacement level increased in strength with referral concrete is 15.4% and 18% at 28 & 56 days.

C. Splitting tensile test (when cement replaced with fly ash)

4) The split tensile strength of fly ash concrete up to 20% replacement level is more than referral concrete at 7, 28 and 56 days.

5) Optimum replacement level of fly ash is 20%

6) , at 20% replacement level increase in tensile strength at 7, 28 and 56 days is 13%, 5.63% and 19.0%.

D. Cost analysis

7) By using Fly ash at 30% in concrete as cement replacement material, the material cost may decrease up to 23.34%.

8) It is observed that in PPC gains strength after the 56 days curing.

9) Increase in strength after 56 days curing showed because of slow hydration process of Fly Ash PPC concrete, Since Fly ash is a slow reactive Pozzolanic material.

VII. ACKNOWLEDGMENT

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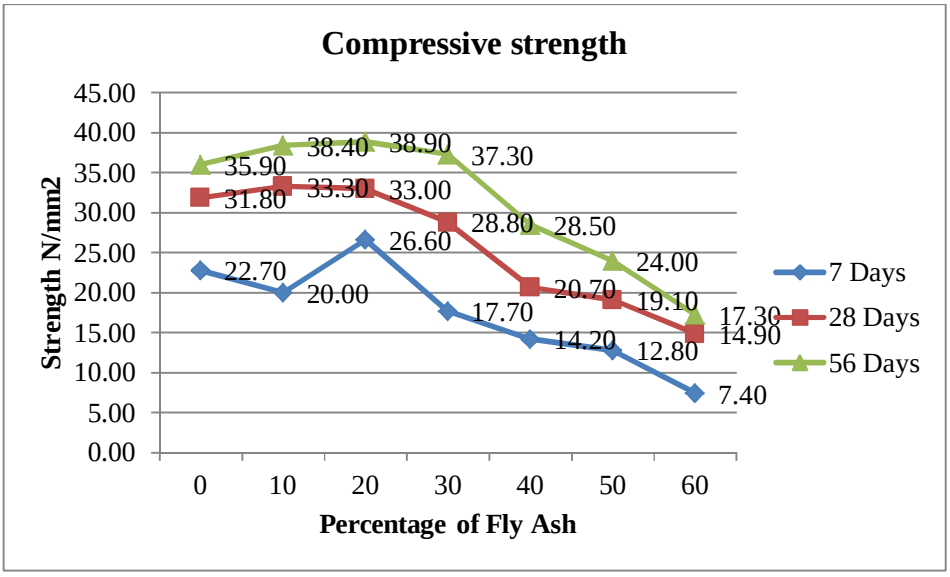

Fig 1: Compressive Strength of Fly Ash Concrete (Line chart)

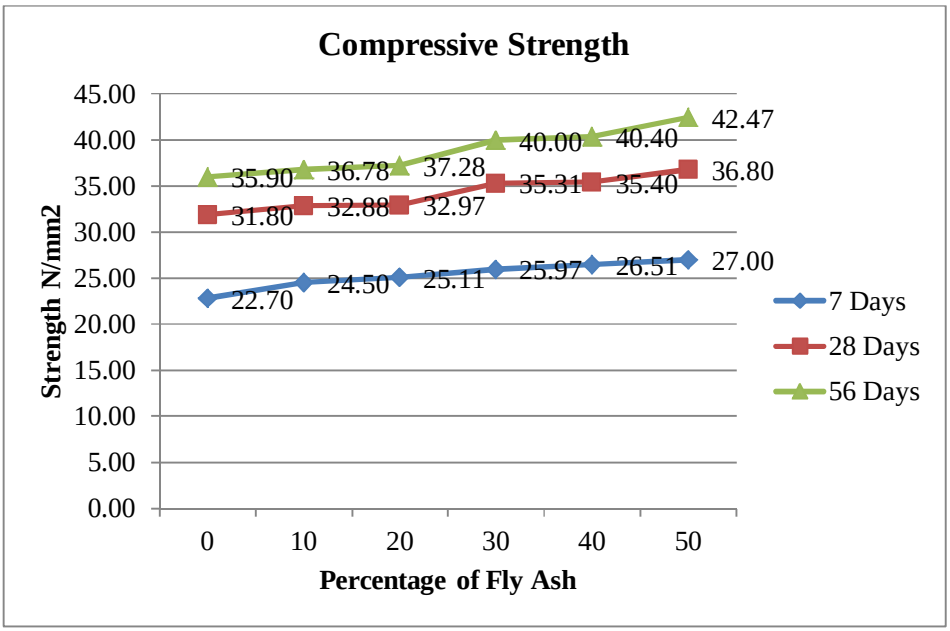

Fig2: Compressive strength of Fly Ash Concrete (Line Chart)

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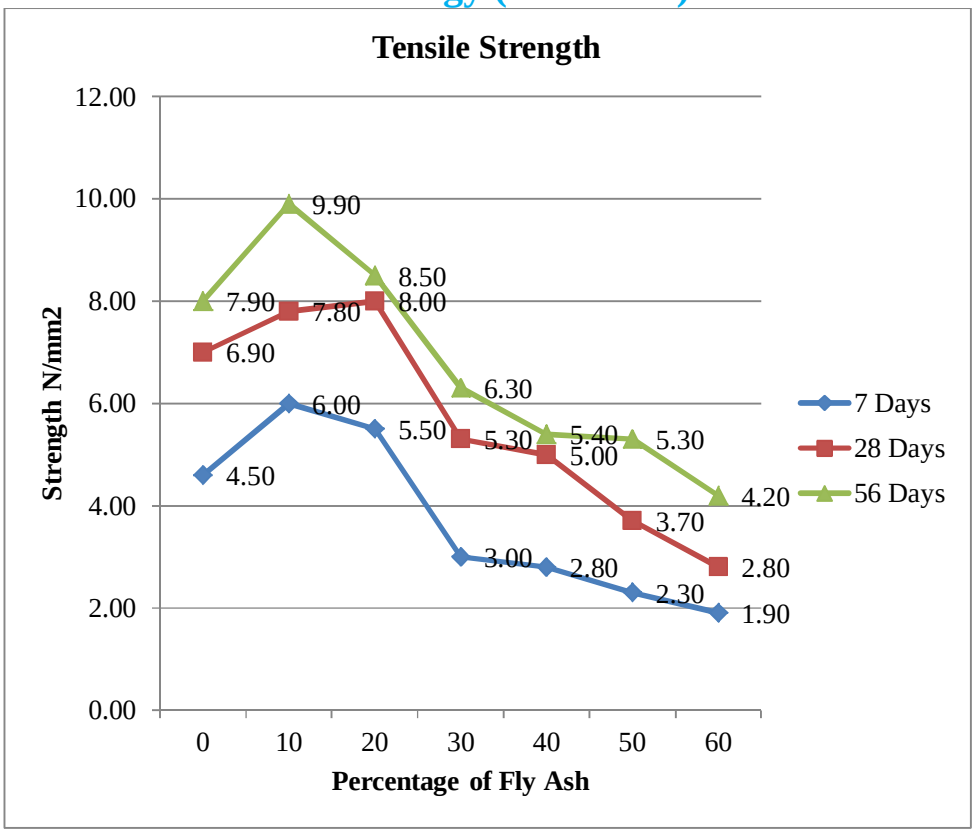
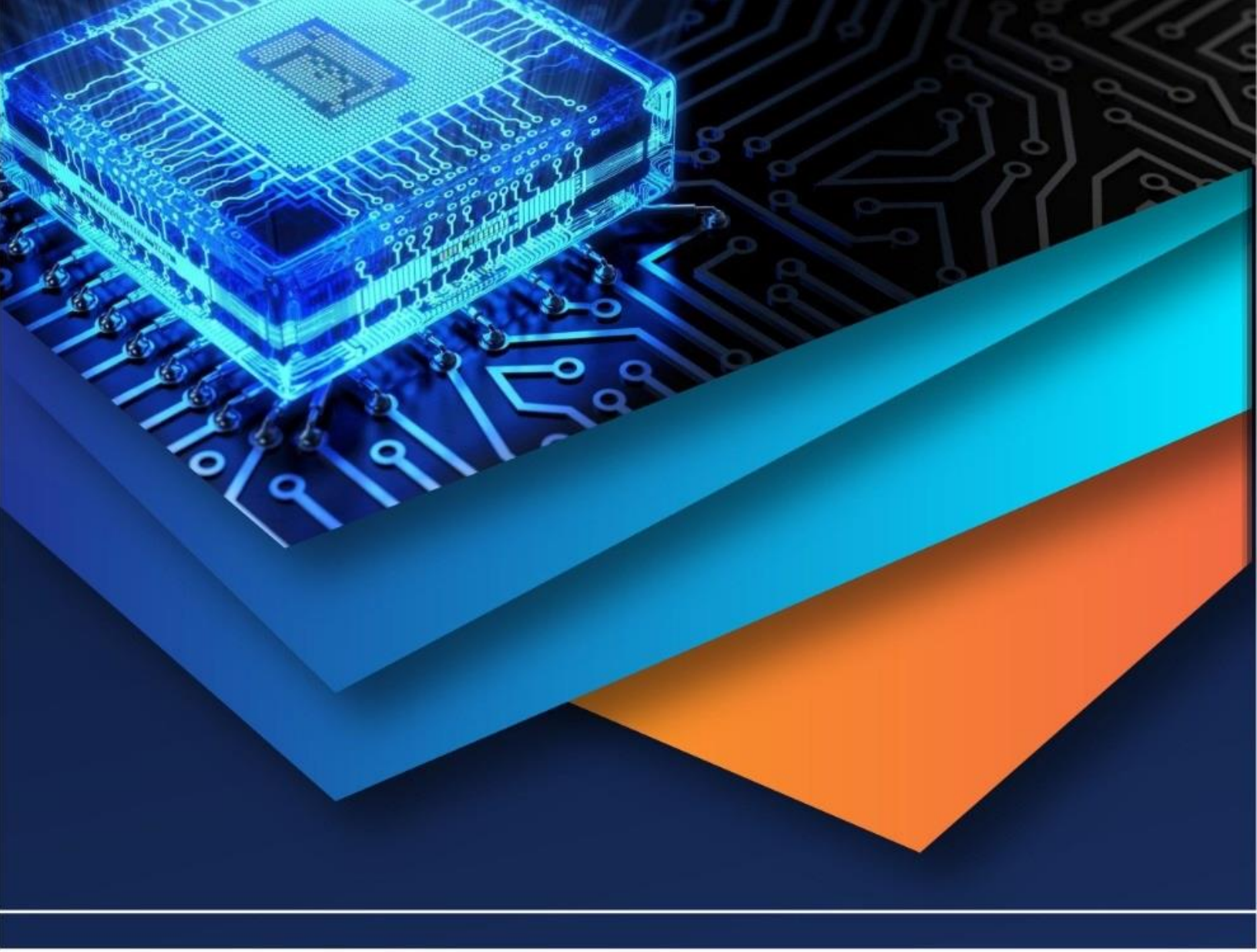


Fig 3: Split Tensile Strength of Fly Ash Concrete (Line Chart)



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