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Effect of Fly Ash on Strength and Durability Parameters of Concrete

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Abstract: ***Ordinary Portland cement (OPC) is one of the main ingredients used for the production of concrete and no alternative in the civil construction industry, and is a versatile and relatively high cost material. Large scale production of cement is causing environmental problems on one hand and depletion of natural resources on other hand. This threat to ecology has led to researchers to use industrial by products as supplementary cementations material in making concrete. The main parameter investigated in this study is M20 grade concrete with partial replacement of cement by fly ash by 0, 5, 10,15and by 20%. This paper presents a detailed experimental study on Compressive strength, split tensile strength, at age of 7 and 28 day. Durability study on acid attack was also studied and percentage of weight loss is compared with normal concrete. Test results indicate that use of fly ash in concrete has improved the performance of concrete in strength as well as in durability aspect.***

Keywords: Fly ash, durability, Compressive strength, Split tensile strength, Acid resistance.

1. Introduction

Concrete is a widely used construction material for various types of structures due to its structural stability and strength. The usage, behaviour as well as the durability of concrete structures, built during the last first half of the century with Ordinary Portland Cement (OPC) and plain round bars of mild steel, the ease of procuring the constituent materials (whatever may be their qualities) of concrete and the knowledge that almost any combination of the constituents leads to a mass of concrete have bred contempt. Strength was stressed without a thought on the durability of structures. The Ordinary Portland Cement (OPC) is one of the main ingredients used for the production of concrete and has no alternative in the civil construction industry. Unfortunately, production of cement involves emission of large amounts of carbon-dioxide gas into the atmosphere, a major contributor for green house effect and the global warming, hence it is inevitable either to search for another material or partly replace it by some other material. The search for any such material, which can be used as an alternative or as a supplementary for cement should lead to global sustainable development and lowest possible environmental impact. Substantial energy and cost savings can result when industrial by products are used as a partial replacement of cement. Fly ash, Ground Granulated Blast furnace Slag, Rice husk ash, High Reactive Metakaolin, silica fume are some of the pozzolanic materials which can be used in concrete as partial replacement of cement. A number of studies are going on in India as well as abroad to study the impact of use of these pozzolanic materials as cement replacements and the results are encouraging. Addition of fly ash to concrete has many advantages like high strength, durability and reduction in cement production. The optimum fly ash replacement percentage for obtaining maximum 28- day's strength of concrete ranged from 5% to 20%. Cement replacement up to 20% with fly ash leads to increase in compressive strength, for M20 grade of concrete. When pozzolanic materials are incorporated to concrete, the silica present in these materials react with the calcium hydroxide released during the hydration of cement and forms additional calcium silicate hydrate (C – S – H), which improve durability and the mechanical properties of concrete. In this paper suitability of fly ash has been discussed by replacing cement with fly ash at varying percentage and the strength parameters were compared with conventional concrete.

2. Material Specifications

2.1. Cement

Ordinary Portland Cement of Anjani brand of 53 grade confirming to IS: 4031 (Part 4): 1988 was used in the present study. The properties of cement are shown in Table 1.

Table 1: Properties of Cement

S.NO	Property	Result
1.	Normal consistency	32%
2.	Initial setting time	45 min
3.	Specific gravity	3.15
4.	Fineness of cement	5%

2.2 Fine Aggregate

Natural sand as per IS: 383-1987 was used. Locally available River sand having bulk density 1860 kg/m^3 was used The properties of fine aggregate are shown in Tab 2.

Table 2: Properties of fine aggregate

S. No	Property	Result
1	Specific gravity	2.7
2	Fineness modulus	3.12
3	Grading zone	IV

2.3 Coarse Aggregate

Crushed aggregate confirming to IS: 383-1987 was used. Aggregates of size 20mm and 12.5 mm of specific gravity 2.84 and fineness modulus 8.47 were used.

2.4. Fly Ash

Fly ash used was confirming to grade1 of IS: 3812-1981 and was supplied by Fly ash is collected from RTPP. The fly ash is used as a partial replacement of cement. The properties of fly ash are shown in Table 3.

Table 3: Properties of fly ash

Specific gravity	2.5
Physical form	Powder
Size (Micron)	0.1
Colour	Dark grey
SIO_2	(60-65)%
Al_2O_3	(20-25)%

2.5. Water

According to ACI water used for preparing concrete should be of potable quality. In this investigation ordinary tap water, which is fit for drinking, has been used in preparing all concrete mixes and curing.

3. Experimental Methodology

3.1. Test For Workability of Fresh Concrete

Workability is defined as the properties of freshly mixed concrete or mortar which determines the ease and homogeneity with which it can be mixed, placed, consolidated and finished. The workability was measured by conducting slump cone test and compaction factor test in accordance with IS: 1199-1959.

3.2. Experimental Procedure

The specimen of standard cube of (150mm x 150mm x 150mm) and standard cylinders of (300mm x 100mm) were used to determine the compressive strength, split Tensile strength. Three specimens were tested for 7 & 28 days with each proportion of fly ash replacement. Totally 30 cubes and 30 cylinders were cast for the strength parameters and 15 cubes for acid attack test. The constituents were weighed and the materials were mixed by hand mixing. The water binder ratio (W/B) (Binder = Cement + Partial replacement of fly ash) adopted was 0.45 weight of binder. The concrete was filled in different layers and each layer was compacted. The specimens were demoulded after 24 hrs, cured in water for 7 & 28 days, and then tested for its compressive and split tensile as per Indian Standards.

4. Test Results and Discussions

4.1 Fresh Concrete Test Results

The properties of fresh concrete can be evaluated by slump cone test with W/C ratio 0.4. The result of properties are given in table 4

Table 4: Workability of concrete with replacement of fly ash

S.NO	Details of Material	Slump in mm
1.	95%Cement+5%FA	45
2.	90%Cement+10%FA	47
3.	85%Cement+15%FA	55
4.	80%Cement+20%FA	58

4.2. Hardened Concrete Strength Results

Results of fresh and hardened concrete with partial replacement of fly ash are discussed in comparison with those of normal concrete.

Table 5: Results of Compressive strength

Mix	% of FA added	Compressive strength (N/mm^2)	
		7 Days	28 Days
M1	0	18.74	29.25
M2	5	20.30	30.50
M3	10	21.83	31.15
M4	15	22.66	36.86
M5	20	22.78	37.40

4.2.1. Compressive Strength

The results of compressive strength were presented in Table 5. The test was carried out conforming to IS 516-1959 to obtain compressive strength of concrete at the age of 7 and 28 days. The cubes were tested using Compression Testing Machine (CTM) of capacity 2000Kn. From Fig 1 the compressive strength is up to 22.78 N/mm^2 and 37.40 N/mm^2 at 7 and 28 days. The maximum compressive strength is observed at 20% replacement of fly ash. There is a significant improvement in the compressive strength of concrete because of the high pozzolanic nature of the fly ash and its void filling ability.

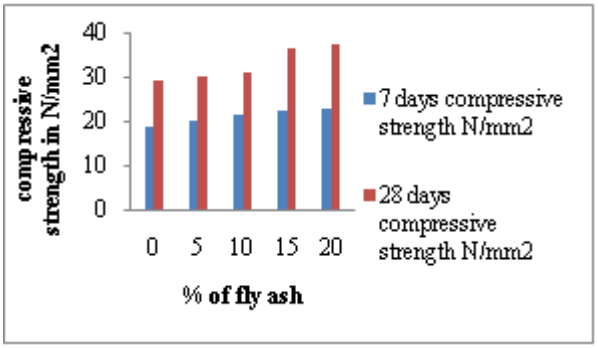

Figure 1: Effect of fly ash on compressive strength of concrete

4.2.2 Split Tensile Strength

The results of Split Tensile strength were presented in Table 5. The test was carried out conforming to IS 516-1959 to obtain Split tensile strength of concrete at the age of 7 and 28 days. The cylinders were tested using Compression Testing Machine (CTM) of capacity 2000Kn.From Fig 2 the increase in strength is 2.14N/mm^2 and 3.01N/mm^2 at 7 and 28 days. The maximum increase in split tensile strength is observed at 20% replacement of fly ash. The optimum fly ash replacement percentages for tensile strengths have been found to be a function of w/c ratio of the mix. The optimum 28-day split tensile strength has been obtained in the range of 20%.

Table 6: Results of Split Tensile Strength

Mix	% of FA added	Split Tensile Strength (N/mm^2)	
		7 Days	28 Days
M1	0	1.53	2.63
M2	5	1.06	2.09

M3	10	1.60	2.64
M4	15	1.84	2.74
M5	20	2.14	3.01

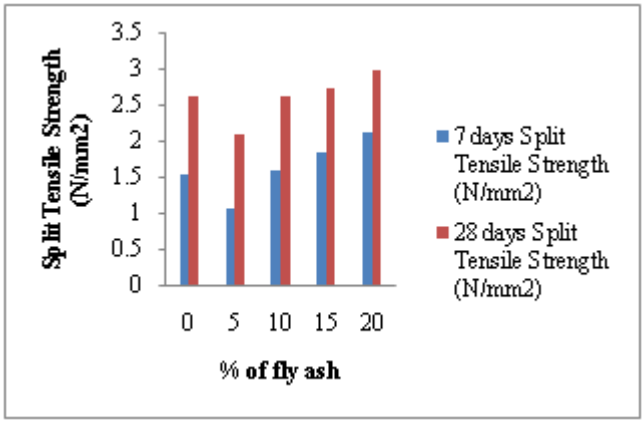

Figure 2: Effect of fly ash on split tensile strength of concrete.

4.3 Durability Test

4.3.1 Acid Resistance

Cubes of sizes 150mm were cast and cured for 28 days. After 28 days curing cubes were taken out and allowed for drying for 24 hours and weights were taken. For acid attack 5% dilute hydrochloric acid is used. The cubes were to be immersed in acid solution for a period of 30 days. The concentration is to be maintained throughout this period. After 30 days the specimens were taken from acid solution. The surface of specimen was cleaned and weights were measured. The specimen was tested in the compression testing machine under a uniform rate of loading 140Kg/cm^2 as per IS 516. The mass loss and strength of specimen due to acid attack was determined.

Table 7: Effect of Acid Attack on Weight.

S.NO	*% FA*	*Dry weight (Kg)*	*Weight after immersed in acid (Kg)*	*Loss in weight(%) At 30 days*
1.	0	8.335	8.015	3.99
2.	5	8.448	8.184	3.22
3.	10	8.600	8.345	3.05
4.	15	8.539	8.319	2.81
5.	20	8.556	8.315	2.84

Acid Attack

The action of acids on concrete is the conversion of calcium compounds into calcium salts of the attacking acid. These reactions destroy the concrete structure. The percentage of loss in weight was 3.99%, 3.22%, respectively. Thus replacement of fly ash is found to have decreased the durability against acid attack. This is due to the silica present in fly ash which combines with calcium hydroxide and reduces the amount susceptible to acid attack. In acid attack weight was decreased and compressive strength is decreased.

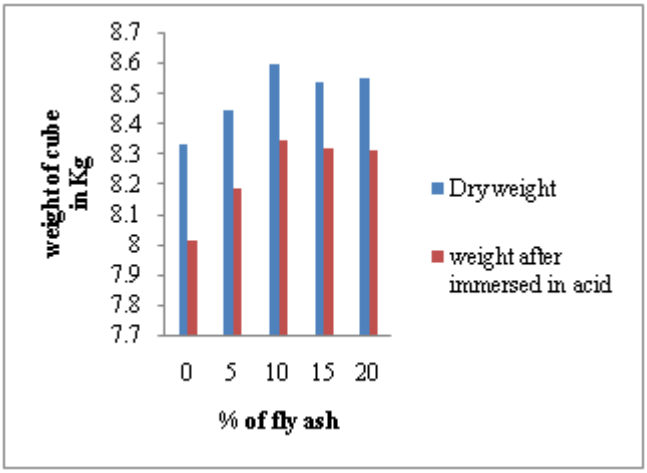

Figure 3: Effect of acid attack on weight and compressive strength of cubes

5. Conclusions

Consistency of cement depends upon its fineness. Fly ash is having greater fineness than cement so the consistency increases greatly, when fly ash percentage increases. The normal consistency increases about 40% when fly ash percentage increases from 0% to 20% and workability was also increased The optimum 7 and 28-day compressive strength have been obtained in the range of 20 % fly ash replacement level. Increase in split tensile strength beyond 20 % fly ash replacement. Fly ash seems to have a more pronounced effect on the flexural strength than the split tensile strength. When compared to other mix the loss in weight percentage was found to be reduced by 3.99 to 2.84. and compressive strength was reduced when the cement was replaced by 0% to 20% of fly ash.

References

[1] ACI Committee 211 (1993), ―Guide for Selecting Proportions for High Strength Concrete with Portland Cement and Fly ash‖, ACI Materials Journal, Vol.90, No.3, pp. 272 – 283.
[2] Bharat Kumar, B. H., Narayanan, R., Raghu Prasad, B. K., Ramachandra murthy, D. S. (2001)., ―Mix proportioning of high performance concrete‖, Cement & Concrete Composites, Vol.23, pp. 71 – 80.
[3] Gopalan, M. K., Haque, M. N. (1986), ―Strength development of fly ash concretes‖, Engineering Materials and Structures, Vol.19, No.1, pp. 33-37.
[4] Mehta, P. K. (1985), ―Influence of Fly Ash Characteristics on the Strength of Portland Fly Ash Mixtures‖, Vol.15, pp.669 – 674.
[5] Xu, A., Sarkar, S.L. (1993), ―Hydration and Properties of Fly ash Concrete‖, in S.N.Ghosh edited Mineral Admixtures in Cement and Concrete, Progress in Cement and Concrete series, Akademia Books International, New Delhi, India, pp. 174 – 225.
[6] Slanicka, S. (1991), ―The Influence of Fly Ash Fineness on the Strength of Concrete‖, Cement and Concrete Research, Vol.21, pp. 285 – 296.