To Study the Behavior of Concrete with and without Fly Ash When Subjected To Sulphate Attack

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Abstract— Concrete occupies unique position among the modern construction materials, Concrete is a material used in building construction, consisting of a hard, chemically inert particulate substance, known as an aggregate (usually made for different types of sand and gravel), that is bond by cement and water. Pozzolonas are Supplementary cementitious materials (SCMs) used to partially replace cement in concrete. They are often added to mortar to make the mixtures more economical, reduce permeability, increase strength and increase durability. The use of supplementary cementitious materials in concrete is advantageous in many ways. Their use improves and increases rheological properties, the strength of concrete and the resistance to sulphate attack. Supplementary cementitious materials are also advantageous in reducing the permeability to water and other fluids, the corrosion rate of embedded steel, the risk of delayed ettringite formation, and deleterious expansion due to the alkali-silica reaction. Durability of concrete is its ability to resist weathering action, chemical attack, abrasion and all other deterioration processes. Weathering includes environmental effects such as exposure to cycles of wetting and drying, heating and cooling, as also freezing and thawing. Chemical deterioration process includes acid attack, expansive chemical attack due to moisture and chloride ingress. The primary objective of present study is to investigate the strength properties (compressive and split tensile strength) and sulphate resistance with different percentage of fly ash. The specimen after 28 days of water curing are immersed in 10% of sodium sulphate solution for 30 days and are evaluated for loss in strength and weight for different percentage of fly ash.

Key words: Concrete, Fly Ash, Durability

I. INTRODUCTION

A. *General Introduction*

Concrete is the most widely consumed material in the world, after water. Placing the freshconcrete requires skilled operatives using slow, heavy, noisy, expensive, energy-consuming and often dangerous mechanical vibration to ensure adequate compaction toobtain the full strength and durability of the hardened concrete.. Fresh concrete or plastic concrete is freshly mixed material which can bemoulded into any shape hardens into a rock like mass known as concrete. The hardening is because of chemical reaction between water and cement, which continues for long period leading to stronger with age.

Durability is the ability of concrete to resist weathering action, chemical attack,and abrasion while maintaining its desired engineering properties. Different concretesrequire different degrees of durability depending on the exposure environment and the properties desired. Concrete ingredients, their proportioning, interactions between them,placing and curing practices, and the service environment determine the ultimate durability and life of the concrete

Sulphate attack is a complex form of deterioration that has damaged concrete structures throughout the world. Sulphate attack is particularly complex because the source of sulphate can be external or internal (delayed ettringite formation), and the distress can be chemical in nature, due to alteration of hydration of products, or physical in nature, due to phase changes in the penetrating sulphate solution

B. *Objectives*

The main objectives was:

- To determine the hardened properties such as compressive and split tensile strength after curing for 28 days.
- To determine durability characteristics with & without fly ash after immersing in 10% sodium sulphate solution for 30 days.
- To compare the % of weight loss & strength loss for different % of fly ash before & after immersion in 10% sodium sulphate solution for 30 days.

C. *Brief Review on Sulphate Attack*

1) *Sulphate Attack*

Sulphate attack is a common form of concrete deterioration. It occurs when concrete comes in contact with water containing sulphates (SO4). Sulphates can be found in some soils (especially when arid conditions exist), in seawater, and in wastewater treatment plants.

2) *Types of Sulphate Attacks*

There are of two types of sulphate attack.

- External sulphate attack
- Internal sulphate attack

3) *External Sulphate Attack*

Sulphates can enter concrete through many external sources such as soils and groundwater. Sulphate can be of natural origin or derived from agricultural fertilizers or industrial effluents. This is the more common type and typically Extensive cracking.

- Expansion
- Loss of bond between the cement paste and aggregate
- Extensive cracking

The effect of these changes is an overall loss of concrete strength. The above effects are typical of attack by solutions of sodium sulphate or potassium sulphate.

4) *Internal Sulphate Attack*

Internal sulphate attack is a phenomenon that has been identified relatively recently, and is thus less understood that external sulphate attack. Internal sulphate attack is commonly characterized as any sulphate attack caused by sulphate originating from within the concrete (i.e. hydration products, aggregate).

D. *What Happens When Sulphates Get Into Concrete?*

It combines with the C-S-H, or concrete paste, and begins destroying the paste that holds the concrete together. As sulphate dries, new compounds are formed, often called ettringite. These new crystals occupy empty space, and as they continue to form, they cause the paste to crack, further damaging the concrete. Attack occurs when the sulphates are able to react with the free lime released during hydration of the Portland cement and with calcium aluminates present in the cement. This reaction results in the formation of a range of sulphate compounds including sulphoaluminates. Because these compounds occupy a greater volume than the original concrete components they cause expansion and eventual failure of the concrete.

II. Experimental Programme

A. *General*

The aim of the experimental program is to compare the properties of concrete made with and without fly ash when subjected to sulphate attack.

B. *Constituent Materials of Normal Concrete*

The constituent materials used for the production of normal concrete are as followings:

- 53 Grade Ordinary Portland cement.
- Coarse aggregate
- Fine aggregate
- Super plasticizer (conplast sp430)
- Fly ash
- Water
- Sodium sulphate

1) *Cement*

Cement is a fine, grey powder. Grade 53 coromandel cement to the requirements of IS 12269 was used in this study. The cement was of uniform colour and was free from any hard lumps. The quantity of cement required for the experiments was collected from one single source and the bags were stored in nearly air tight container. Summary of the various test conducted on cement are as under given below in table 3.1

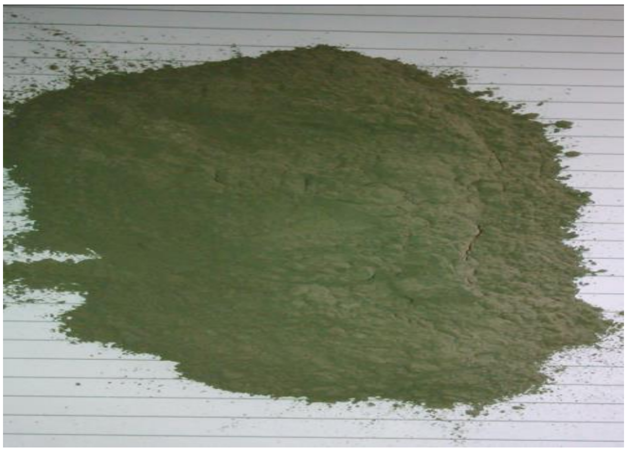

Fig. 1: Cement (coromandel)

Sl No	PHYSICAL PROPERTIES	Results	As per IS 12269-1987
1.	Normal Consistency in (%)	33	-
2.	Specific Gravity	2.8	-
3.	Setting Time (in Minutes) a) Initial Setting Time b) Final Setting Time	45 300	Not less than 30 min Not more than 600 min
4.	Compression Strength (Mpa) (70.6 X 70.6 X 70.6 mm Cubes) 28 days strength	55	≥53

Table 1: Physical properties of the cement

2) *Aggregates*

Coarse aggregates: In this project work crushed angular stone aggregate of 20mm down size from a local source was used as coarse aggregate. The physical property of coarse aggregate is shown the table 3.2.

Fig. 2: Coarse aggregate

Fine aggregates:In this project workriver sand was used as fine aggregate. The physical properties of fine aggregate are shown in table 3.2.The sand confirms to Zone-2 as per Indian Standard.

Fig. 3: River sand

Physical properties	Fine aggregates (river sand) zone –II	Coarse aggregates (Crushed angular)
Specific gravity	2.6	2.7
Water absorption (%)	1.0%	0.5%

Table 2: Physical Characteristics of aggregates

3) Admixtures

4) Super Plasticizer

Super plasticizer (SP) is an essential component of normal concrete to provide the necessary workability. The main purpose of using a super plasticizer is to produce flowing concrete with very high slump.

5) Fly ash

Fly ash is a by- product of the combustion of pulverized coal in thermal power plants. Because of its fineness and pozzolanic and sometimes self cementitious nature, fly is widely used in cement and concrete. The fly ash from Raichur thermal power plant is used in the study.

Fig. 4: Fly ash

6) Water

Generally, water that is suitable for drinking is satisfactory for use in concrete.

7) Sodium Sulphate

Powder form of sodium sulphate was obtained from fisher scientific chemicals. It was white in colour. Its solution of strength 10% by adding it to water was made and used for sulphate resistance test.

Fig. 5: Sodium Sulphate

8) Mix Design for Normal Concrete

The mix design is carried out by using IS code 10262-2000.

III. RESULTS AND DISCUSSIONS

A. Hardened Properties

1) Compressive Strength

During the investigation, the total % of fly ash addition was from 0 to 30%.The test results have revealed that, addition of fly ash i.e. 10% by weight of cement has shown an increase in compressive strength. From 20% of fly ash addition, compressive strength starts decreasing.

Si No	% Of Fly Ash	Average Compressive Strength After 28 Days In Mpa
1	0	44.8
2	10	47.9
3	20	43.6
4	30	33.7

Table 3: Average Compressive strength of concretewith and withoutfly ash cured in water for 28 days of water curing

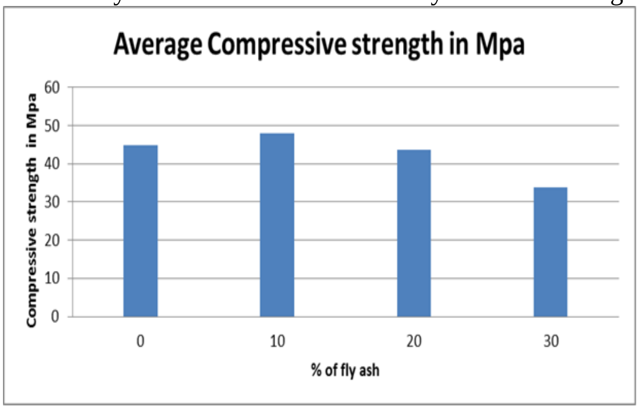

Fig. 6: Average compressive strength of specimens with and without fly ash cured in water for 28 days

2) Split Tensile Test

Split tensile strength studies were carried out at the age of 28days. The test results have revealed that, addition of fly ash i.e.10% by weight of cement has shown an increase in split tensile strength. From 20% of fly ash addition, split tensile strength starts decreasing.

Si No	% Of Fly Ash	Average Split Tensile Strength In Mpa
1	0	3.21
2	10	3.75
3	20	3.4
4	30	2.7

Table 4: Average Split tensile strength of with and without fly ash cured in water for 28 days of water curing

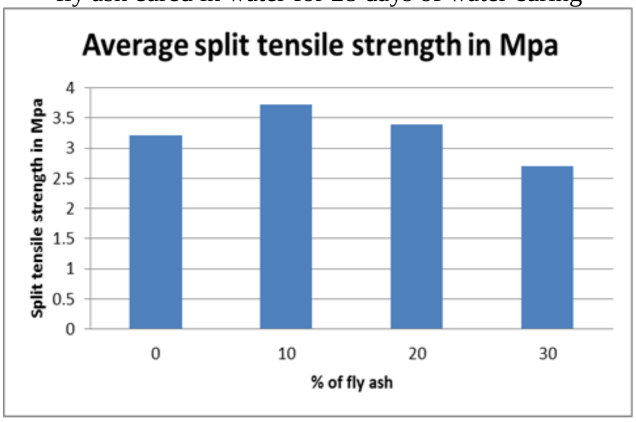

Fig. 7: Average split tensile strength of specimens with and without fly ash cured in water for 28 days

3) Resistance to Sulphate Attack of Concrete

The cubes and cylinders were casted and cured in water for 28 days. Sodium sulphate solution of strength 10% is used to evaluate sulphate resistance of concrete. Cubes and cylinders are immersed in 10% sodium sulphate solution after 28 days water curing and are tested for percentage of weight loss, compressive strength and split tensile strength 30 days and results are tabulated below.

Si No	% Of Fly Ash	Average Compressive Strength After 28 Days Water Curing In Mpa	Average Compressive Strength After 30 Days Sulphate Solution Curing In Mpa
1	0	44.8	38
2	10	47.9	41
3	20	43.6	35
4	30	33.7	29

Table 5: Comparison of compressive strength of concrete with 0%, 10%, 20% and 30% fly ash cured in water and immersed in 10% sodium sulphate solution

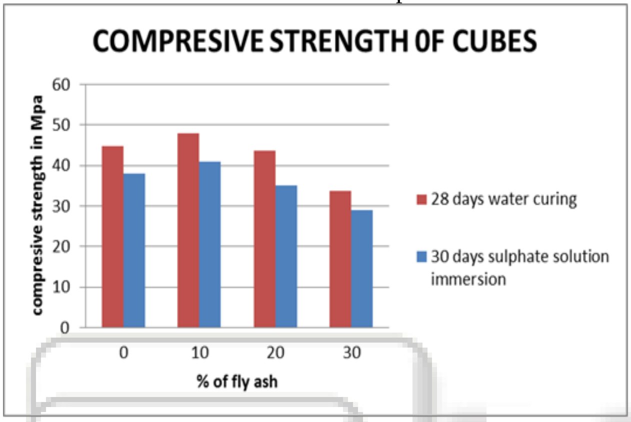

Fig. 8: Compressive strength after exposure to 10% sodium sulphate solution for the concrete specimens (0%, 10%, 20% and 30%fly ash) and compared with specimens cured in water

Si No	% Of Fly Ash	Average Split Tensile Strength After 28 Days Water Curing In Mpa	Average Split Tensile Strength After 30 Days Sulphate Solution Curing In Mpa
1	0	3.4	3.21
2	10	3.73	3.27
3	20	3.21	3.1
4	30	2.7	2.5

Table 6: Comparison of split tensile strength of concrete with 0%, 10%, 20% and 30% fly ash cured in water and immersed in 10% sodium sulphate solution

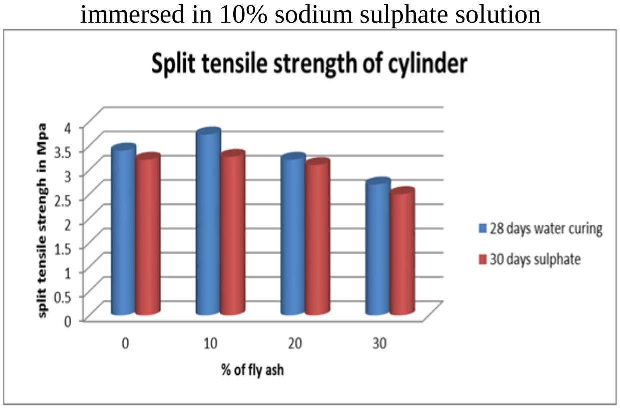

Fig. 9: Split tensile strength after exposure to 10% sodium sulphate solution for the concrete specimens (0%,10%,20% and 30%) and compared with specimens cured in water

4) Comparative Results of Percentage of Weight Loss in Cube with and Without Fly Ash for 30 Days Immersed In 10% Sodium Sulphate Solution

Sl.No	% Of Fly Ash	Weight After Water Curing	Weight After Solution Curing	% Of Loss In Weight
1	0	8.93	8.89	0.44
2	10	8.89	8.86	0.33
3	20	8.85	8.80	0.55
4	30	8.64	8.58	0.69

Table 7: Percentage of weight loss and loss in compressive strength of concrete with and without fly ash specimens immersed in 10% sodium sulphate solution for 30 days

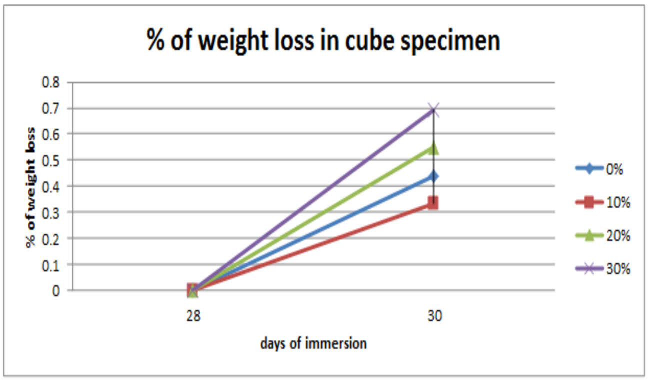

Fig. 10: Percentage Weight Loss in Cube Specimen

5) Comparative Results of Percentage of Weight Loss in Cylinder with and Without Fly Ash for 30 Days Immersed In 10% Sodium Sulphate Solution

Sl.No	% Of Fly Ash	Weight After Water Curing	Weight After Solution Curing	% Of Loss In Weight
1	0	14.15	14.11	0.31
2	10	14.14	14.1	0.28
3	20	13.9	13.85	0.33
4	30	14.15	14.1	0.35

Table 8: Percentage of weight loss and loss in split tensile strength of concrete with and without fly ash specimens immersed in 10% sodium sulphate solution for 30 days

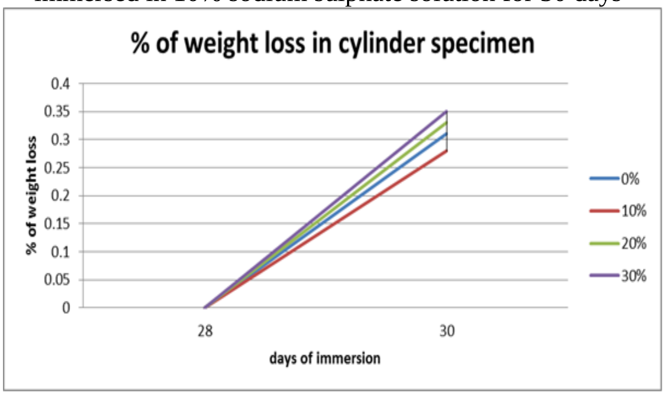

Fig. 11: Percentage Weight Loss in Cylinder Specimen

IV. CONCLUSIONS

Based on the experimental study the following conclusions are drawn

- Concrete with different percentage of fly (0%, 10%, 20%& 30%) was developed to carry durability characteristics.
- Addition of 10% fly ash attains max compressive and split tensile strength.
- The compressive and split strength of concrete specimen increases for 10% and tends to decrease for 20% and 30%.
- Addition of fly ash improves the durability properties of the concrete.
- There was a small amount of spalling at edges of specimens when exposed to 10% sodium sulphate for 30days.
- After immersion in 10% sodium sulphate solution for 30 days there was a loss in compressive strength ofabout (15.17%, 14.40%, 19.72%& 14%)
- After immersion in 10% sodium sulphate solution for 30 days there was a loss in split tensile strength of about(5.58%,12.33%,3.43%&7.41%)
- There was a weight loss of cube specimen about (0.44%,0.33%,0.55%&0.69%)
- There was a weight loss of cylinder specimen about (0.31%, 0.28%. 0.33%& 0.35%)
- The percentage of weight loss and compressive strength and split tensile strength reduces by the addition of fly ash in concrete.

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