ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 2, Issue 5, August 2015

STRENGTH AND DURABILITY STUDIES ON FLY ASH CONCRETE IN SEA ENVIRONMENT

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Abstract

In order to save drinking water; the usage of sea water in concrete was investigated. Only 2.5 % of the world's water bodies are said to be of fresh water and the remaining constitute of sea water. Cement is responsible for greenhouse gas emissions causing a threat to environment through global warming. The unit cost of concrete can be reduced as much as possible by partially replacing cement with fly ash and GGBS. Waste products like fly ash when used in concretes have been known to have higher resistance to chloride ion penetration than concrete made with Ordinary Portland Cement.

In this paper our study mainly compressive strength, weight reduction, chloride attack, sulfate attack, corrosion resistance, carbonation, alkalinity and weight reduction in age of 7, 28 and 90 days .In this project to study M_{40} grade concrete. Concrete made by replacing 10%,20% and 30% of cement by fly ash. We can conclude concretes made by fly ash up to replace 20% to 25% and mineral admixture GGBS has good strength and durable properties comparison to conventional concrete in sea environment.

Keywords—fly ash, GGBS, strength ,durability ,chloride attack, sulfate attack

1. INTRODUCTION

1.1. General

A pozzolan is a siliceous or siliceous / aluminous material which when mixed with lime and water forms a cementitious compound. Fly ash is the best known, and one of the most commonly used, pozzolans in the world. Fly ash is the notorious waste product of coal- based electricity generating thermal power plants, known for its ill effects on agricultural land, surface and sub-surface water pollution, soil and air pollution and diseases to mankind. In order to save drinking water, the usage of seawater in concrete was investigated. The cement is the most costly and energy intensive component of concrete. The unit cost of concrete can be reduced as much as possible by partial replacement of cement with fly ash.

1.2. Chemical Attack of Sea Water on Concrete

1. Magnesium sulphate
2. Carbonate and bicarbonate
3. Alkalies
4. Chlorides

1.2.1. Magnesium sulphate attack

Sulphate attack is generally attributed to formation of expansive ettringite ($3Cao.Al_2\ O_3\ .3CaSO_4\ .31\ H_2\ O$) (Calcium aluminate sulfate). Both ettringite and gypsum occupy a greater volume as large as 20 % after crystallization in the pores of concrete than the compounds they replace.

The process of sulfate attack on concrete may be explained by following series of chemical reactions:

$3CaO.Al_2O_3+3(CaSO_4.2H_2O)+26H_2O$------------$CaO.Al_2O_3\ .3CaSO_4\ .32H_2O$

Deterioration of concrete due to chloride and sulfate attack is time dependent problem. These salts react with various hydration products and from detrimental voluminous.

1.2.2 Carbonate and bicarbonate attack on concrete

The carbonate and bicarbonate ions may participate in the reaction of carbonation of calcium ion or calcium hydroxide formed during hydration of cement. Carbon dioxide dissolved in the water as carbonic acid that caused local softening and disintegration.

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1.2.3 Alkali reaction on concrete

The reaction of some forms of silica and carbonate in aggregates with alkalis in cement produces a gel, which causes expansion and crack. Apart from cracking , the major effect of ASR is reduction in compressive strength, tensile strength and modulus of elasticity.

1.2.4 Environmental Related Causes of Concrete Durability Problems

Durability problems related to environmental causes include the following: steel corrosion, delamination, cracking, carbonation, sulphate attack, chemical attack, scaling, spalling, abrasion and cavitation.

2. SCOPE AND OBJECTIVE

- To studies on strength and durability of fly ash concrete in marine environment and comparing laboratory condition.
- To save drinking water.
- To identify and study the following properties of low calcium fly ash (replacement up to 30 %) and ordinary Portland cement concrete:
- Compressive strength of the concrete.
- Split tensile strength of the concrete.
- Chloride attack.
- Corrosion resistance.
- Carbonation.
- Weight losses
- Alkalinity
- To evaluate the strength of concrete cubes that present in sea environment and comparing with laboratory condition.

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3. MATERIALS USED

3.1 CEMENT

In this 43 grade Ordinary Portland Cement is used in this experimental study. And all the properties of the cement were tested by referring IS 12269-1987 specification of OPC grade 53.And they are tested for its various proportions as per the IS 4031-1988.

Table 1: Properties of Cement

S.NO	Property	Value
1	Specific Gravity	3.15
2	Fineness	97.25
3	Initial Setting Time	30 min
4	Final Setting Time	185 min
5	Fineness Modulus	6.5%

3.2 GGBS

Ground granulated blast furnace slag (GGBS) Ground granulated blast furnace slag (GGBS) is a byproduct from the blast-furnaces used to make iron. These operate at a temperature 1,500 degrees centigrade and are fed with a carefully controlled mixture of coke, iron-ore and limestone. The iron ore reduced to iron and the remaining materials form a slag that floats on top of the iron. This slag is periodically tapped off as a molten liquid and if it is to be used for the manufacture of GGBS it has to be rapidly quenched in large volumes of water. This 'granulated' slag is then dried and ground to a fine powder. The composition of minerals and the physical properties of GGBS are shown. In the present study, the percentages of GGBS used are 10 %, 20 %, 30% to the weight of cement.

Table 2: Properties of GGBS

Chemical properties	Physical properties

Calcium oxide	40%	Colour	Off-white
Silica	35%	Specific gravity	2.9
Alumina	13%	Bulk density	1200 kg/m^3
Magnesia	8%	Fineness	>350kg/m^2

3.3 FINE AGGREGATE

In this the fine aggregate as good quality and its readily available and easily obtained and processed. The gravels are often accompany with the sand deposits and might have not been laid uniformly, it means a potential change in their quality. Its generally the fines are classified depends upon the size that is below 4.75mm is regarded as fine aggregate..

Table 3: Properties of Fine Aggregate (River Sand)

S.No	Property	Value
1	Specific Gravity	2.63
2	Fineness modulus	4.40
3	Water Absorption	6%
4	Surface texture	Smooth

3.4 COARSE AGGREGATE

In this research paper the coarse aggregate of nominal size of about 20mm is chosen and tested to determine the different physical properties as per code IS 383-1970. And the test results that conform to the Is 383 (PART 3) as per the recommendations of the code practice.

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Table 4: Properties of Coarse Aggregate

S.No	Property	Value
1	Specific Gravity	2.72
2	Fineness modulus	7.10
3	Water Absorption	8%
4	Particle shape	Angular
5	Impact value	8.5%
6	Crushing value	18

3.5 FLY ASH

Flyash used in this study was obtained from Ennore thermal power plant .It falls in the category of class "F" grade and its chemical composition is given in table the physical properties of fly ash are determined as per IS:1727-1967

Table 5 physical properties and chemical properties of flyash

SI No	Properties	Testing result
	Physical properties	
1	Specific gravity	2.3
2	Fineness% passing on	84(75m sieve)
	Chemical properties	
3	SiO_2	62.10
4	Al_2O_3	27.44
5	Fe_2O_3	4.57
6	TiO_2	1.09
7	CaO	0.83

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8	MgO	0.55
9	Na_2O	0.04
10	K_2O	1.17
11	Mn2O3	0.04
13	SO3	0.40
14	LOSS ON IGNITION	0.76

3.6 WATER

Portable water and sea water is the natural resource which is said to be least least expensive and to less in their Ph value of water. The water, which is used for making concrete should be clean and free from harmful impurities such as oils, alkalis, acids etc., in general, the water that is fit for drinking should be used for making concrete.

4. EXPERIMENTAL TESTS

Mix design was done for M_{40} concrete as per the Indian standard code specifications (IS 10262-2007). The initial tests on all the ingredients of concrete were done and the results were tabulated. Fresh concrete tests such as slump cone test, flow table test etc., were also been conducted. Testing of the hardened concrete plays a vital role in controlling and confirming the quality of cement concrete works.

Table 6: Mix proportions

S.No.	OPC43 grade %	Fly ash %	GGBS %
1	100%	0%	0%
2	60%	10%	30%
3	50%	20%	30%
4	40%	30%	30%

Tests have been conducted on Fresh Concrete

- Slump flow test

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International Journal Of Core Engineering & Management (IJCEM)
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Tests have been conducted on Hardened Concrete

- Compressive strength test

Durability test

- Corrosion resistance test
- Chloride test
- Alkalinity test
- Carbonation test
- Weight reduction test

4.1 Cube Compressive Strength

At the age of 28 days cube compressive strength is tested on cubes of size 150mmx150mmx150mm and 28 days compressive strength is tested. The compressive strength is one of the most significant properties of the hardened concrete in general it is the characteristic material value for classification of concrete.

5. RESULTS AND DISCUSSIONS

Strength development of the OPC and the fly ash concrete under normal curing:

5.1 Compressive Strength test Results

Compressive strength of fly ash concrete and normal concrete cubes of 7, 28, 90 days.

Table 7: Compressive strength

Mix propotion	7 dyas	28 days	90 days
Control mix	30.20	42.29	47.42
10%FA+30%GGBS	32.47	44.11	48.45

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International Journal Of Core Engineering & Management (IJCEM)
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20%FA+30%GGBS	33.70	48.45	52.22
30%FA+30%GGBS	32.9	44.40	48.03

Fig 1 compressive strength

5.2 Chloride test

% of replacement	Chloride present Kg/m^3
Control mix	0.04202
10%FA+30%GGBS	0.01914
20%FA+30%GGBS	0.01418
30%FA+30%GGBS	0.02318

Fig 2 Chloride test

As per IS 456:2000 limits of chloride is 0.3.

5.3 Alkalinity test

% of replacement	**pH value**
Control mix	11.64
10%FA+30%GGBS	11.48
20%FA+30%GGBS	11.31
30%FA+30%GGBS	11.56

Fig3 Alkalinity test

5.4 Corrosion resistance test

% of replacement	Time taken (Hours)
Control mix	49
10%FA+30%GGBS	52
20%FA+30%GGBS	54
30%FA+30%GGBS	50

Fig 4 Corrosion test

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Visual appearance of corrosion of embedded steel takes 54 hours to corrode which is applicable.

5.5 Carbonation test

Phenolphthalein indicator was used to determine the carbonation effect on the cubes. It was found that both conventional and flyash concrete cubes placed at sea environment and cubes place and analysed for 28, 90 and 150 days of exposure condition. The effect of carbonation has reach a depth of 2mm for the flyash based concrete cubes and 4mm depth for conventional concrete.

Fig5 carbonation test

5.6 Weight loss test

Weight loss of conventional concrete was observed in 4%. The fly ash concrete was observed in 2%. So fly ash concrete is better performance in marine environment.

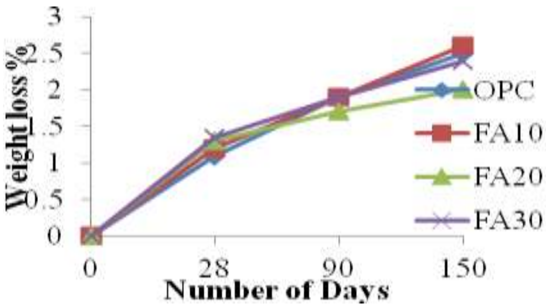

Fig6 weight loss test

6. CONCLUSION

The following conclusion are drawn from the study on fly ash concrete and are applicable for the range of parameters and materials used in this study. Test results are investigated and carried out at different periods of 7, 28 and 90 days has been studied and analyzed.

- The fly ash replacement of cement by 10%, 20%, 30% and 30% of GGBS to increase the compressive strength.20% of fly ash replacement is better performance in marine environment.
- The chloride attack controlled up to 20 % replacement fly ash concrete compared to conventional concrete.
- Acid attack of concrete control up to 20 % of replacement of fly ash compared to conventional concrete.
- Weight loss of conventional concrete was observed in 4%. The fly ash concrete was observed in 2%. So fly ash concrete is better performance in marine environment.
- Visual appearance of corrosion of embedded steel takes 52 hours to corrode which is applicable.
- Carbonation depth of conventional concrete is 2mm,and fly ash concrete depth is 1mm.So carbonation is control up to 20 % replacement of fly ash with cement.
- As compare to conventional concrete the cost is economical.

7. ACKNOWLEDGMENT

The laboratory work described in this paper was carried out by the institution of IFET College of Engineering, Villupuram. Thanks for all to the relevant staff at civil and environmental engineering of the same college for their technical support and assistance.

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