AN EXPERIMENTAL INVESTIGATION ON PROPERTIES OF CONCRETE BY THE ADDITION OF FLY ASH AND POLYCARBOXYLATE ETHER

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Abstract: This experimental investigation on polycarboxylate ether (PCE) concrete by reducing the volume of cement with adding mineral admixture (fly ash).This experiment presents the effect of polycarboxylate ether on various properties of concrete such as compressive strength, tensile strength and workability with various contents of fly ash (0%, 10%, 15%, 20%, 25%).The result of this investigation indicates that by adding of PCE shows reduce in the quantity of cement but with the same compressive and tensile strength.

Key words: ***Polycarboxylate ether, fly ash, M30 concrete, addition of fly ash and polycarboxylate ether, maximum strength, decreasing cement content, reducing water content.***

1. INTRODUCTION

Concrete has better resistance in compression while steel has more resistance in tension. Conventional concrete has limited ductility, low impact and abrasion resistance and little resistance to cracking. A good concrete must possess high strength and low permeability. Hence, alternative composite materials are gaining popularity because of ductility and strain hardening. Thus fly ash is added in the concrete as partial replacement of cement. In high strength concrete it acts as additional cementitious material.

Fly ash was introduced commercially in the Lower Mainland (Vancouver) during the 1970s and was typically used to replace about 10% of the portland cement in a concrete mix. There was some initial resistance in the construction industry, but by the early 1980s the benefits were better understood. Results in higher strength if cured for a long time. Concrete is by nature a brittle material that performs well in compression, but is considerably less effective when in tension. Reinforcement is used to absorb these tensile forces so that the cracking which is inevitable in all high-strength concretes does not weaken the structure. Due to addition of fly ash calcium silica hydroxide is produced due to which pore size gets reduced. Typically, fly ash is added to structural concrete at 15-35 percent by weight of the cement, but up to 70 percent is added for mass concrete used in dams, roller-compacted concrete pavements, and parking areas.

These Polycarboxylate Ether Superplasticizer are maintained over extended periods of time compared to conventional plasticizers, such as sulfonated naphthalene/melamine formaldehyde condensates, where flow properties and workability tend to deteriorate significantly over time. CONFLOW-CP is a polycarboxylate based advanced superplasticizer for use in cementitious systems, particularly "low" or "no" slump mixtures.

Features:

- Improved cohesion.
- Reduced water absorption.
- Applicable for all Portland and Slag cement.
- Reduced efflorescence.

Polycarboxylate-ether (PCE) superplasticizers are a fundamental constituent of modern cementbased materials due to their impact on the rheology of the fresh mix and mechanical performance of the hardened material. The interaction between PCE and C3S pastes was investigated by an ad-hoc kinetic model based on a combination of generalized forms of the Avrami and BNG (Boundary Nucleation and Growth) models.

2. MATERIALS

2.1 CEMENT

Cement is a binder, a substance used for construction that sets, hardens, and adheres to other materials to bind them together. Cement is seldom used on its own, but rather to bind sand and gravel together. Cement mixed with fine aggregate produces mortar for masonry, or with sand and gravel, produces concrete. Cement is the most widely used material in existence and is only behind water as the planet's most-consumed resource.

Cements used in construction are usually inorganic, often lime or calcium silicate based, and can be characterized as either hydraulic or non-hydraulic, depending on the ability of the cement to set in the presence of water.

2.2 FINE AGGREGATE

The fine aggregate sample taken for study and physical properties of fine aggregate. Both river sand and crushed stones may be used. Coarser sand may be preferred as finer sand increases the water demand of concrete and very fine sand may not be essential in High Performance Concrete as it usually has larger content of fine particles in the form of cement and mineral admixtures such as fly ash, etc. The sand particles should also pack to give minimum void ratio as the test results show that higher void content leads to requirement of more mixing water.

2.3 COARSE AGGREGATE:

Coarse aggregates are components found in many areas of the construction industry. They have structural uses such as a base layer or drainage layer below pavements and in mixtures like asphalt and concrete. This lesson explores the various types of coarse aggregates. The coarse aggregate sample taken for study and the physical properties of coarse aggregate. For coarse aggregate, crushed 12mm normal size graded aggregate was used. The specific gravity and water absorption of coarse aggregate were found to be 2.68 and 1.0%, respectively. The grading of coarse aggregate conforms to the requirement as per IS: 383 – 1970.The coarse aggregate is the strongest and least porous component of concrete. Coarse aggregate in cement concrete contributes to the heterogeneity of the cement concrete and there is weak interface between cement matrix and aggregate surface in cement concrete. By usage of mineral admixtures, the cement concrete becomes more homogeneous and there is marked enhancement in the strength properties as well as durability characteristics of concrete. The strength of High Performance Concrete may be controlled by the strength of the coarse aggregate, which is not normally the case with the conventional cement concrete.

2.4 WATER

Water is an important ingredient of concrete as it actively participates in the chemical reactions with cement. The strength of cement concrete comes mainly from the binding action of the hydrated cement gel. The requirement of water should be reduced to that required for chemical reaction of un hydrated cement as the excess water would end up in only formation of undesirable voids in the hardened cement paste in concrete. From High Performance Concrete mix design considerations, it is important to have the compatibility between the given cement and the chemical/mineral admixtures along with the water used for mixing.

2.5 POLYCARBOXYLATE ETHER

Polycarboxylate Ether is the third generation high range water reducer. PCE can even be used with no slump concrete (0.29 - 0.4 W/C), and the slump is increased to more than 250mm. PCE based concrete workability not sensitive to time of addition of the super plasticizer. Late addition maintains workability for longer time.

Fig-1: Polycarboxylate Ether

PCE- free radical mechanism using peroxide initiator is used for polymerization process in this system. PCE molecular structures have bulky side chain causes steric hinderence due to this dispersion is improved and lasts for longer. Typically 0.7 - 1 % of weight of cement is added.

2.6 NEED FOR POLYCARBOXYLATE ETHER:

Workability increases even though water demand decreases. Since water to cement ratio decreases the quantity of cement required decreases but strength and workability increases.

2.7 FLY ASH

Fly ash or Flue ash also known as pulverised fuel ash, is a coal combustion product that is composed of the particulates that are driven out of coal - fired boilers together with a flue gases. Fly ash is generally captured by electro static precipitators. It is classified into two types Class F and Class C.

Class - C: This is also called high calcium fly ash, and possesses both cementitious and pozzalanic properties 10 - 15 % of the material has a particle size greater than 45 microns and the fineness (dlaine) is 300 - 400 m^2 per kg. The particles are primarily solid spheres with a smooth texture. The average particle size is less than 20 microns.

Class - F: This is also called low calcium fly ash and is a normally pozzalanic material. Particles are solid spheres with a smooth texture, and the average particle size is 20 micron. 15 - 20 % of the material is larger than 45 microns, and the fineness is 200 - 300 m^2 per kg.

Fig-2: Fly Ash

2.8 NEED FOR FLY ASH:

Fly ash is by far the most powerful tool for sustainable development of the concrete industry. Worldwide approximately 500 million tonnes of fly ash are produced every year most of it is disposed by ponding and land fill. The best strategy to obtain a major reduction in carbon dioxide emission associated with cement production is reduced when fly ash is replaced with cement.

3. MIX DESIGN FOR M30 GRADE CONCRETE

Table-1: MATERIALS REQUIRED AS PER IS METHOD OF DESIGN

W/C RATIO	QUANTITY OF MATERIALS (Kg/m^3)			
	BINDER		FINE AGGREGATE	COARSE AGGREGATE
	CEMENT	FLY ASH		
0.4	307	103	815.13	1132.67

The properties of materials used are

- Specific gravity of cement =3.15
- Specific gravity of fine aggregate =2.63
- Specific gravity of coarse aggregate =2.68

3.1 EXPERIMENTAL PROGRAMME

The following tests were made after 28 days curing:

- Workability test
- Compressive strength test
- Split tensile strength test,

3.1.1 Workability test

3.1.1.1 Slump cone test

The concrete slump test is an empirical test that measures workability of fresh concrete. The test measures consistency of concrete in that specific batch. It is performed to check consistency of freshly made concrete. Consistency refers to the case with test is popular due to the simplicity of apparatus used and simple procedure. Unfortunately, the simplicity of the test often allows a wide variability in the manner in which the test is performed. The slump test is used to ensure uniformly for different batches of concrete under field conditions, and to ascertain the effects of plasticizers on their introduction. Metal mould, in the shape of the frustum of a cone, open at both ends, and provided with the handle, top internal diameter 100mm, and bottom internal diameter 200mm with a height of 300mm.

Fig- 3: Slump test

The slumped concrete takes various shapes, and according to the profile of slumped concrete, the slump is termed as the true slump, shear slump or collapse slump is achieved, a fresh sample should be taken and the test repeated. A collapse slump is an indicated of too wet a mix or that it is a high workability mix, for which the slump test is not appropriate. Very dry mixes having 10 -40mm are used for foundation with light reinforcement, medium workability mixes, 50 – 90 mm for normal reinforcement concrete placed with vibration , high workability concrete > 100mm.

3.1.2 Compressive strength test

This test method covers the deformation of cube compressive strength concrete specimen. The specimen is prepared by pouring freshly mixed concrete into lubricated cube moulds. Consolidation is done extremely over vibrating table for 1-2 minutes. After vibration and finishing, the moulds are kept at normal atmosphere conditions for 231/2 ± hours after which demoulding is done. The specimen are then cured in water tank.

Fig -4: Compressive Strength Testing Arrangement

The test is conducted at surface dry condition. The specimen is tested at the age for 28 days of curing under the compression testing machine.

$$\text{Compressive strength} = \frac{\text{Maximum load at failure X1000}}{\text{Loaded surface area}}$$

The tests were carried out on a set of triplicate specimen and the average compressive strength values were taken.

3.1.3 Split tensile strength test

Splitting tensile strength test was conducted on concrete cylinders to determine the tensile nature of carbon black concrete. The wet specimen was taken from water after 28 days of curing. The surface of specimen was wiped out. The weight and dimensions of the specimen was noted. The cylinder specimen was placed on compression testing machine. The load was applied. The testconsist of applying a compressive line load along the opposite generators of a concrete cylinder placed with its axis horizontal between the compressive plates. Due to the compression loading a fairly uniform tensile stress is developed over nearly 2/3 of the loaded diameter as obtained from an elastic analysis.

Split tensile strength =2P /(Πdl)

Table 4: SPLIT TENSILE STRENGTH AT 28 DAYS

% of Fly Ash	Sample 1	Sample 2	Sample 3	Average
0%	2.72	2.87	3.02	2.87
10%	3.14	2.88	3.54	3.18
15%	3.45	3.32	3.61	3.46
20%	3.76	3.53	3.78	3.69
25%	3.53	3.87	3.91	3.77

Fig -5: Split Tensile Strength Testing Arrangement

4. RESULT AND DISCUSSION

Table 1: COMPRESSIVE STRENGTH AT 7 DAYS

% of Fly Ash	Sample 1	Sample 2	Sample 3	Average
0%	14.46	14.11	14.33	14.33
10%	18.78	18.55	18.01	18.44
15%	21.67	22.11	21	21.59
20%	24	23.22	23.55	23.59
25%	25.78	24.89	25.11	25.26

Table 2: COMPRESSIVE STRENGTH AT 28 DAYS

% of Fly Ash	Sample 1	Sample 2	Sample 3	Average
0%	27.89	28.55	29.33	28.59
10%	30.89	30.75	29.77	30.47
15%	32.34	32.87	33.55	32.92
20%	34.87	34.43	33.78	34.36
25%	35.44	36.37	36.75	36.18

Table3: SPLIT TENSILE STRENGTH AT 7 DAYS

% of Fly Ash	Sample 1	Sample 2	Sample 3	Average
0%	1.33	1.56	1.62	1.50
10%	1.76	1.54	1.97	1.75
15%	1.81	1.23	2.05	1.69
20%	2.35	2.21	1.98	2.18
25%	2.65	2.41	2.76	2.60

5. CONCLUSIONS

Based on the experimental investigation, the following findings are observed.

- Adding of fly ash upto 25% replacement of cement gives the maximum value.
- Up to 2% of polycarboxylate ether improves the workability of concrete to 200mm slump when compared with the conventional concrete.
- It shows the effective results so it reduces the cost of cement in construction
- From these results use of PCE and fly ash in low cost composites for civil infrastructure provide good mechanical properties at lower cost of fly ash.

6. REFERENCES

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