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DETERMINATION OF OPTIMUM DOSAGE OF POLY CARBOXYLIC ETHER IN CONCRETE

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Abstract - Super plasticizers are used as dispersants to avoid particle segregation and to improve the flow characteristics of suspensions such as in concrete application. It reduces the water to cement ratio without affecting the workability of the mixture. It reduces water content by 20% during slump mixture and also increases paste quality which yields higher compressive and flexural strength of the concrete. It is important to note that excess amount of Super plasticizers added to the concrete will leads to reduction in strength of concrete. In this project the strength of concrete assessed with different percentages of Polycarboxylic ether added with concrete such as 0.5%, 1%, 1.5% and 2% by the weight of cement added in the concrete. Eventually the Compressive strength test, Split tensile strength test and Flexural strength test has been conducted and the results compared with conventional concrete to estimate the optimum dosage level of Polycarboxylic ether to be added to the concrete without affect the strength.

***Key Words*:** Super plasticizer, Water reducer, Polycarboxylic ether, compressive strength and split tensile strength

1. INTRODUCTION

Super plasticizer is also known as high range water reducers; it produces extreme workability flowing concrete. It has the efficiency of dispersing fine-grained particles like cement, fly ash, ground granulated blast furnace slag, and silica. They increase slump for ease of placement, creates the denser and more durable concrete. Plasticizers are chemical compounds that enable the production of concrete with approximately 15% less water content. Super plasticizers allow a 30% or more reduction in water content. It is chemical admixtures that are added to the concrete to improve their flowing ability, they help to reduce the amount of water in the concrete and to improve the strength and durability of concretes.

a. Types of Superplasticizer

1. Sulphonated Melamine – Formaldehyde Condensates (SME)
2. Sulphonated Naphthalene Formaldehyde Condensates (SNF)
3. Modified Lignosulphonates (MLS)
4. Polycarboxylate superplasticizer- Carboxylated Acrylic Ester Co-polyme

b. Polycarboxylate super plasticizer

Polycarboxylate super plastics, also known as high-grade water reducers, they are chemicals that are used where well-dispersed particle suspensions are required. These polymers are used as dispersants to avoid particle aggregation to improve the flow characteristics or rheology of solid applications such as suspensions Super plasticizers are mainly used in pumping concrete, casting heavily reinforced members and precast elements of concrete.

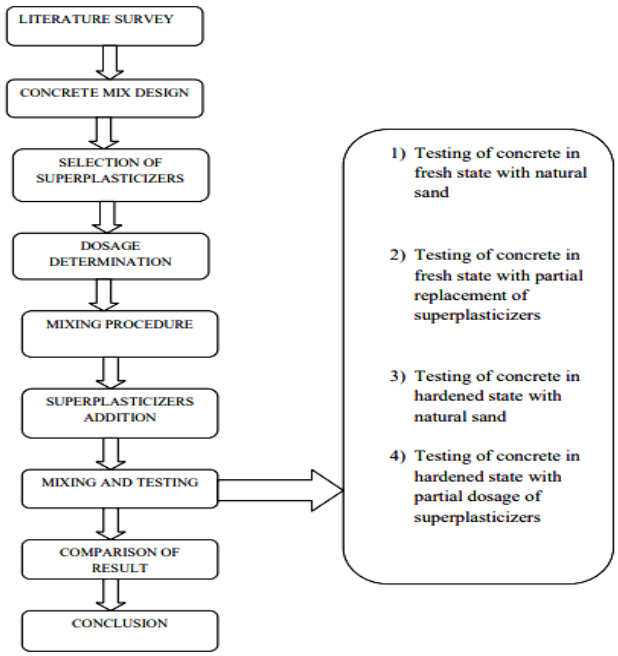
2. OBJECTIVES OF THE PROJECT

The main objectives of the study are summarized below;

1. To study the properties of Poly carboxylic ether as one of the commonly used as a super plasticizer in concrete.
2. To prepare the concrete specimen with different percentages of ploy carboxylic ether to estimate the strength of concrete.
3. To compare the test results with conventional concrete specimen to evaluate the optimum dosage level of poly carboxylic ether to be used in concrete.

3. METHODOLOGY

The methodology which was followed in this project has shown in below.



4. MATERIALS USED

a. Cement

Cement is a fine grayish powder. Generally it is made from limestone and clay or shale. These raw materials are extracted from quarry where they are processed and blended to correct proportions. Cement is important ingredient which acts as binding material in concrete. Ordinary cement of grade 53 confirming to IS: 12269-1987, S.G of cement is found to be 3.15 which is used in this experimental investigation.

Table-1: Chemical constituents of PPC

Lime (Cao)	60 to 67%
Silica (Sio_2)	17 to 25%
Alumina (Al_2O_3)	3 to 8%
Iron Oxide (Fe_2O_3)	0.5 to 6%
Magnesia (MgO)	0.1 to 4%
Sulphur Trioxide (SO_3)	1 to 3%
Soda and /or Potash ($Na_2O + K_2O$)	0.5 to 1.3%

b. Fine Aggregate

The aggregate which are passes through 4.75mm size IS sieve and the coarse grained materials as permitted by the above specifications are generalized as fine aggregate. M-sand used for experimental work which is locally procured and confirmed to grading. Fine aggregate passing through 4.75 mm IS sieve are used in this experimental investigation. Sieve analysis, water absorption, specific gravity are monitored as per IS: 2386-1963(Part I & II)/IS: 383-1970.

c. Coarse Aggregate

Generally coarse aggregate is obtained from blasting in stone quarries or breaking them by manually or by crusher. Aggregate is called bound materials when it is mixed with cement and referred to as unbound material when used without cement. Aggregate makes up 60 to 80% of concrete. Coarse aggregate passing through 20mm sieve is used in experimental investigation.

d. Water

Water is used for mixing and curing shall be clean and free from oils, acid, organic materials or other substances may cause defects to concrete and steel may corrode. Water controls the fresh and hardened properties in concrete.

e. Poly Carboxylic Ether

Polycarboxylate ethers (PCE) contain groups with polyoxyalkylene, especially polyethylene or polypropylene glycol groups as well as carboxylic acid and/or carboxylic acid anhydride monomers, e.g. acrylic acid, methacrylic acid, maleic acid and its anhydride, itonic acid and its anhydride. Polycarboxylate ether (PCE) comb-copolymers are widely used as water reducing agents in the concrete industry while maintaining a high fluidity via the polymer adsorption to the cement particles. Polycarboxylate polymers are found in laundry products and automatic dishwashing products to improve performance by preventing re deposition of soil. They have played an important role in recent years replacing phosphates, which have been phased out of laundry and dish care products.

The physical of Polycarboxylic Ether have been discussed in below table.

Table-2: Properties of polycarboxylic ether

Property	Range
pH	4.00-7.00
Density	1.12-1.15
Viscosity (Brookfield)	2000 - 3000
Appearance	Clear yellow viscous liquid
Chemical nature	Poly Carboxylate ether
Ionic nature	Anionic
Solubility	Soluble in water in all proportion

f. Waste foundry sand

Foundry sand can be used in concrete to improve its strength and other durability factors. Foundry Sand can be used as a partial replacement of cement or as a partial replacement of fine aggregates or total replacement of fine aggregate and as supplementary addition to achieve different properties of concrete. Waste Foundry Sand (WFS). In foundry processes, foundry sand refers to clean, uniformly sized, high quality silica sand that is used in the casting process. Sand is bonded to form molds or patterns which are used to make ferrous (iron), non-ferrous (copper, aluminum, brass) metal castings.

5. LABORATORY INVESTIGATIONS

a. Test on cement

Various tests are to be conducted on cement like Fineness, Consistency, Initial and Final setting time their results as follows.

i. Fineness of Cement

The fineness of cement is done by dry sieving as per IS: 4031 (Part 1) – 1996.The principle of this is to determine the proportion of cement whose grain size is larger than specified mesh size. The apparatus used are 90µm IS Sieve, Balance capable of weighing 10g to the nearest 10mg, A nylon or pure bristle brush, preferably with 25 to 40mm, bristle, for cleaning the sieve.

ii. Consistency Test on Cement

Vicat apparatus (confirming to IS: 5513-1968) with plunger (10mmin diameter).The standard consistency of a cement paste is defined as that consistency which will permit the Vicat plunger to penetrate to a point 5 to 7 mm from the bottom of the Vicat mould, when the cement paste is tested as described in the following procedures.

iii. Initial Setting Time of Cement

The Vicat apparatus (conforming to IS: 5513-1968) has been used to find the initial setting time of cement.

Table-3: Laboratory test observations of Cement

Properties	Test Value	Standard Value
Consistency	30%	30%
Initial setting time	35minutes	30minutes
Fineness	6%	<10%

b. Test on Fine Aggregate

i. Specific Gravity Test

The specific gravity test helps in the identification of stone. Water absorption gives an idea of strength of aggregate. Aggregates having more water absorption are more porous in nature and are generally considered unsuitable unless they are found to be acceptable based on strength, impact and hardness tests.

ii. Fineness Modulus of Fine Aggregate

Fineness modulus of sand (fine aggregate) is an index number which represents the mean size of the particles in sand. It is calculated by performing sieve analysis with standard sieves. The cumulative percentage retained on each sieve is added and subtracted by 100 gives the value of fineness modulus.

Table -4: Laboratory test observations of Fine Aggregate

Characteristics	Test Value	Standard Value
Type	Natural sand	Natural sand
Specific Gravity	2.74	2.8
Fineness modulus	2.865	2.6- 2.9

c. Test on Coarse Aggregate

Various tests were conducted on fine aggregate like Sieve analysis, specific gravity and fineness modulus, impact test and crushing strength test and their results as follows.

Table -5: Laboratory test results of Coarse Aggregate

Characteristics	Test value	Standard Value
Type	Crushed Stone	Crushed Stone
Specific Gravity	2.74	2.5-2.8
Maximum Size	20 mm	20 mm
Fineness modulus	3.33	2.9-3.5
Impact value	44%	<45%
Crushing value	42.2%	<45%

d. Slump test on Concrete

Slump test on concrete has been conducted on conventional M20 grade concrete and super absorbent polymer added concrete and the test result has shown in below table.

Table-6: Slump con test result

S.NO	Degree of Workability	%of Magnetic sand	Slump Value
1	Slump Value (50–100)Medium	10	85
2		20	70
3		30	62

e. Compaction Factor Test on Concrete

It gives the measure of workability. The amount of water needed to compact a given mass of concrete is its compact ability. Practically, the compaction factor may be defined as the ratio of the weight of partially filled concrete (concrete from hoppers) to fully compacted concrete. Its value is always less than unity. This test is more accurate than slump test and its results are suitable for low and medium workability (i.e. CF: 0.8 - 0.9). The very low workable concrete (CF $\leq$ 0.7) cannot be fully compacted and thus this test will not be suitable.

The compaction factor value has obtained as 0.88 and which has medium degree of workability.

6. EXPERIMENTAL INVESTIGATION

a. Compressive Strength Test

As per IS: 516-1959 Compressive testing machine (2000KN), 15cm×15cm×15cm steel cube molds. Concrete gains maximum strength at 28days. Since in construction sector great amount of capital is at stake, so instead of checking strength at 28 days we can check strength in terms of concrete strength psi at 7 and 14 days to predict the target strength of construction work. Compressive strength is conducted to clarify the concreting is done properly or not. Compressive strength depends on many factors such as water cement ratio, cement strength, quality of the concrete material, quality control during casting of concrete and so on. The specimens are tested during the consequential days of 7^{th}, 14^{th}, and 28^{th} day. During the 7^{th} day of testing, we can gain the 64% to 70% of strength of 28 days strength. Before the testing in the machine the concrete should be get rid of moisture to acquire the maximum strength.

Fig.1 Compression strength test apparatus

The comparison of Compressive strength with different dosage levels such as 0.5%, 1%, 1.5% and 2% have been shown in below figure.

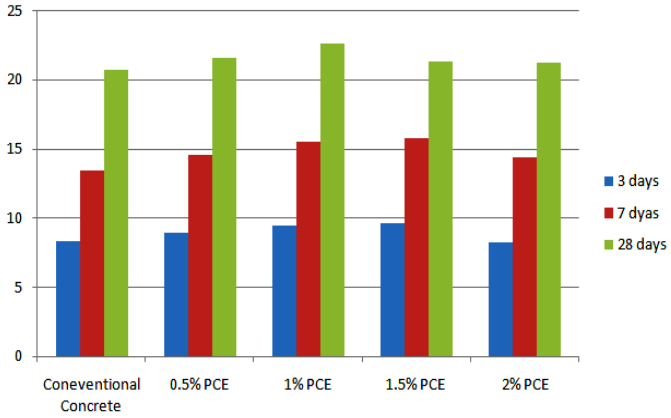


Fig.2 Comparison test results of Cubes with different percentages of PCE

b. Split Tensile Strength Test on Cylinder

As per IS 5816: 1999 the splitting tensile strength test is performed on hardened concrete to determine its tensile strength. Marginal variations in water to cement ratio, ingredient proportioning, and increase in a slump, etc impacts the desired concrete strength. This in turn affects the strength and stability of structures. There are several tests to determine the strength of concrete. The unit of tensile strength is N/mm. The splitting test is easy to perform and we can get uniform results. It is a simple, reliable and convenient method to determine the strength of concrete.

Fig.3 Split tensile Strength test apparatus
Table-10: Compressive Strength test result of Cylinders

The comparison of Split tensile strength with different dosage levels such as 0.5%, 1%, 1.5% and 2% have been shown in below figure.

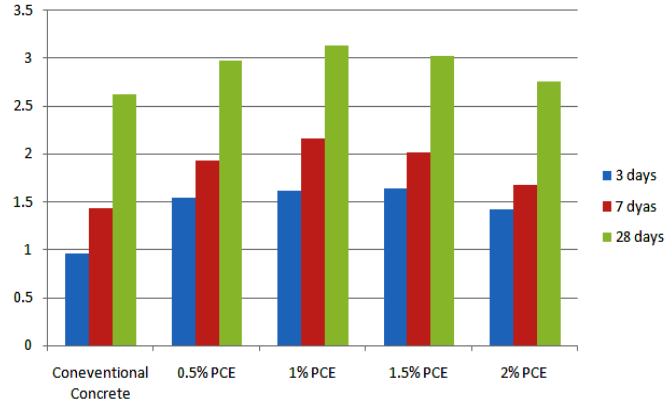


Fig.4 Comparison test results of cylinders with different percentages of PCE

c. Flexural Strength Test on Prism

Flexural test evaluates the tensile strength of concrete indirectly. It tests the ability of unreinforced concrete beam or slab to withstand failure in bending. The results of flexural test on concrete expressed as a modulus of rupture which denotes as (*MR*) in MPa or psi. The flexural test on concrete can be conducted using either three point load test (ASTM C78) or centre point load test (ASTM C293). According to ASTM the size of the specimen is 150mm width, 150mm depth and the length should not be at least three times the depth of the specimen. Indian standard determined the size of the concrete specimen as 150mm width, 150mm depth, and span of 700mm. It also states that a size of 100mm width, 100mm depth, and span of 500mm can be used if the maximum aggregate size used is not greater than 20 mm. British standards specifies square specimen cross section with 100mm or 150mm dimension and the span ranges from four to five times specimen depth. However, it preferred 150mm width, 150mm depth, and span of 750mm for the specimen.

The comparison of Split tensile strength with different dosage levels such as 0.5%, 1%, 1.5% and 2% have been shown in below figure.

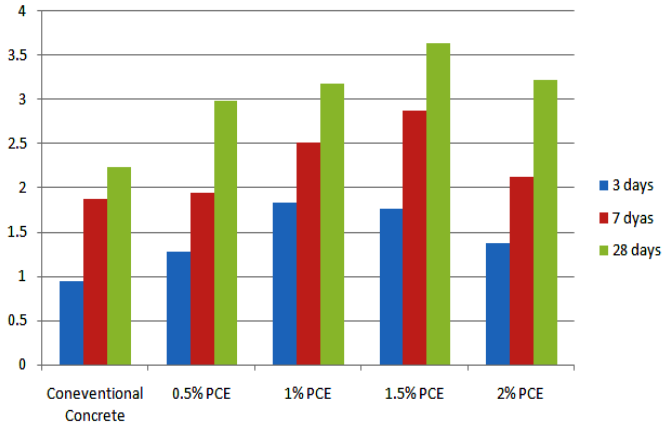


Fig.5 Comparison test results of Prisms with different percentages of PCE

7. CONCLUSION

The above experiment al result gives the following conclusions,

From the comparison test results it has been concluded that the compressive strength, Split tensile strength and Flexural strength of Polycarboxylic added concrete has been improved at the 1.5% of dosage level of Polycarboxylic added to the concrete.

Hence it is recommended that maximum dosage as 1.5% of Polycarboxylic added concrete will give definite strength than other percentages. Above 1.5 % of Polycarboxylic ether will reduce the strength of concrete.

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