International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-9 Issue-7, May 2020

Effect of Carboxylic Acid (Benzene Crystallable) in Cement Concrete and Geopolymer Concrete

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Abstract*: *The present study appraises the recitals of carboxylic acid- based admixture to increase concrete water tightness and self-sealing capacity of the cement and geopolymer concrete. Outcomes of the previous studies in particular, adding 1% by cement mass of the carboxylic polymer reasons for reduction in the water dispersion under pressure of 7-day wet cured concrete by 50% associated to that of the conforming reference concrete. At 7 days, M4 mix compressive strength is about 43.5% less than M3 mix. The compressive strength of M4 increases and is about 37.6% less than M3 mix at 28 days of curing. At 7 days, M4 mix split tensile strength is about 17.5% less than M3 mix (cement concrete with 0.45 w/c ratio). The split tensile strength of M4 declines and is about 42.3% less than M3 mix at 28 days of curing. The strength of the geopolymer concrete tends to increase as the time period increases due to the presence of fly ash in it. So it is expected that geopolymer concrete will give more strength than cement concrete in long term with the presence of carboxylic acid.

Keywords* : *Carboxylic acid, Concrete, Geo-polymer Concrete, water tightness

I. INTRODUCTION

For many spans of year, concrete has been deliberated as an everlasting material, genuine by any methods of deprivation. RC structures shown several liabilities on the design, placing and environmental exposure conditions. As a result of this, for many of the structures constructed in the twentieth century damages happened comprising infrastructures in a widespread manner. In recent years, Expenses for Maintenance and restoration of prevailing structures devour significantly, when compared with funds for new edifices. The concrete structures maintenance and repair are usually scrupulous and costly, or even challenging to device, particularly in the case of infrastructures or extensive concrete structures.

Revised Manuscript Received on May 30, 2020.
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For these reasons, the new practices and improvement of products are the prime factors to descent of maintenance operations over the whole duration of structures which are critical for recognition of any concrete structures, since the fortification of the situation and the decrease in energy consumption and natural resources are vital concerns. Over the past few years, self-sealing products have substantial consideration from the scientific community. The self-healing designates the material capability to reinstate the mechanical properties while of self-sealing denotes the capability to seal the cracks. Geopolymer concrete is an advanced material that is described by lengthy cuffs or systems of inorganic particles is a probable substitute to conventional Portland cement concrete for the usage in construction of transportation infrastructure. Geo-polymer concrete contains, Fly ash is amusing with silica and aluminium, Sodium silicate (or) Potassium silicate and Sodium hydroxide (or) Potassium hydroxide. Geo-polymers are members of the family of inorganic polymers. The main elements of geo-polymers are namely the source materials and the alkaline liquids. The source materials for geo-polymers based on alumina-silicate have amusing in silicon (Si) and aluminium (Al). These may possibly be natural minerals such as kaolinite, clays, etc. Fly ash, silica fume, slag, rice-husk ash, red mud, etc. are by-product materials might be used alternatively as source materials. Based on the features such as accessibility, price, usage nature, and explicit request of the consumers, source materials for geo-polymer will be selected.

[1] invented that the addition of 1% of carboxylic acid by cement mass clues to a decrease in the water permeation under force by half compared to concrete made without waterproofing chemicals. [2] studied that as water is ejected during curing and successive drying of geo-polymer concrete (GPC), it makes additional strong to heat, water entry, alkali – aggregate reactivity and other chemical attack. They investigated with geopolymer concrete and revealed it to be 1.5 times stronger than OPC concrete. The compressive strength of concrete was also increased by increasing the temperature between 30˚C and 90˚C. They also found out that that geopolymer concrete is non – toxic, bleed free, impermeable and hence has good durability properties. [3] revealed that the reactivity of geopolymer depends upon the chemical composition, mineralogical composition, morphology, fineness and glassy phase content . Also they established that NaOH possesses greater ability to liberate silicate and aluminate monomers. In their study, GPC showed augmented resistance to acetic, nitric and sulphuric acid when compared to OPC.

The corrosion resistance has also improved due to high value of pH. New method of design on self-healing to patch-up cracks in cracked concrete was recommended and the self-healing chattels of cracked concrete using various mineral admixtures were investigated [4]. Test on geo-polymer concrete with various molarities of sodium hydroxide solution i.e. 3M, 5M, and 7Mand 9M conducted by [5]. And also they adopted double unlike curing i.e. 500°C oven curing and by placing the specimens to straight sunlight curing made. From the above literatures it is acknowledged that,

- Geopolymer concrete requires no curing and is more alkaline
- When fly ash used in Geopolymer concrete and its price is 10-20 % less than Normal concrete.
- Fly ash reacts slowly and hence activator solution is employed to speed the reaction. It is mainly alkali solution of sodium hydroxide and sodium silicate.
- The strength increases with escalation of molarity of the solution and hence taken as 12M.
- Addition of carboxylic acid into the specimens decreases the cracks formed in the surfaces of the specimen.

This study is intended to find the effect of carboxylic acid in cement concrete and geo-polymer concrete.

II. METHODOLOGY AND MATERIALS USED

This is study carried out based on the flow chart given in Fig.1.

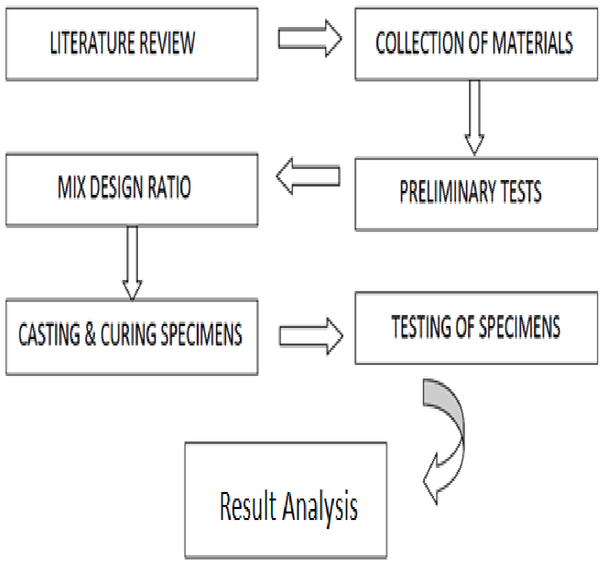

Fig 1. Flowchart of Methodology

A. Cement

53 grade Ordinary Portland Cement (OPC) is adopted for this study. Its specific gravity is 3.15.

B. Coarse Aggregate

One of the crucial components in concrete is Coarse aggregate and dwell in the largest volume in the mix. Concrete mix design greatly depends on coarse aggregates properties such as strength, maximum size, shape, and water absorption influence water demand, the quantity of cement and fine aggregate in concrete mixture. Coarse aggregate are taken based on [8] and its specific gravity is 2.73.

C. Fine Aggregate

Fine aggregate is one of essential ingredient in concrete that comprises of natural sand or crushed stone. Excellence and density of fine aggregate strappingly effect the properties of hardened concrete. The fine aggregate used in this study is M-Sand and it has the specific gravity of 2.62. The size of M-Sand is less than 4.75mm. Since the manufactured sand can be obtained from hard granite rocks it can be freely obtainable at nearby place, dropping the cost of conveyance from far of river sand bed.

D. Flyash

Flyash is a by-product of the incineration of powdered coal in thermal power plants. In modern coal-fired power plants, Flyash is generally captured by electrostatic precipitators or other particle purification apparatus before the duct fumes touch the chimneys. The type of Flyash used is 'Class F' grade which was obtained from Mettur. The fineness of the fly ash is found out using air permeability test and its value is around 380 m2/kg.

E. Sodium Silicate

Sodium silicate is a broad label for chemical compounds with the formula $Na_{2x}SiO_{2+x}$ or $(Na_2O)_x.SiO_2$, such as sodium metasilicate Na_2SiO_3, sodium orthosilicate Na_4SiO_4, and sodium pyrosilicate $Na_6Si_2O_7$. The anions are often polymeric. These complexes are usually colorless solids or white powders, and soluble in water in several quantities. Na_2SiO_3 adopted in this study.

F. Sodium Hydroxide

Mostly sodium hydroxides remain available in solid formal by meanshydroxide will decide the cost of the ingredient. Since geopolym of tablets and fragments. The purity of sodium er is homogeneous material and its key procedure to activate the sodium silicate. So it is suggested to practice the lowest cost i.e., 94 to 98% purity. Sodium hydroxide pellets with molarity of 12 (M12) is adopted in this study.

G. Carboxylic Acid

Carboxylic acids is a homologous sequence in which the mixtures comprise a practical cluster called the carboxyl group (-COOH). Carboxylic acids contain at least one carboxyl group. It is a weak acid. Its molecular formula is $C_nH_{2n+1}COOH$.

III. MIX DESIGN

The Mix design of M25grade carried out based on references and guidelines [6]. Mix design of Geo-polymer concrete was done based on the study [7]. Based on the mix design adopted the details of mixes used is given in Table I. The fresh concrete properties were confirmed through Slump cone test as per [9] and while of tests on hardened concrete by the compression and split tensile tests were done according to the [10]. Cube specimen of size 150mm x150mm x 150mm were cast for compressive strength test and Cylinder specimen of size 150mm x 300 mm were cast for Split tensile strength test. Three cube and three cylinder specimens were casted and tested at each of 7 and 28 days.

Table- I: Mix Design Details of cement concrete and Geo-polymer concrete

S. No.	Mix	Ratio	W/C ratio / Binder ratio
Cement Concrete			
1.	M1	1:2.09:2.838	0.5
2.	M2	1:2.287:2.983	0.55
3.	M3	1:1.726:2.441	0.45
Geo – Polymer Concrete			
4.	M4	1:1.53:3.04	1:2.5

Curing is carried out at room temperature for geopolymer concrete while of cement concrete water curing is done for 7 and 28 days. From the results of Coppola et.al (2018), 1% by cement mass of carboxylic acid is take on for this study.

IV. RESULTS AND DISCUSSION

The compressive strength test carried out on cement concrete and geo-polymer concrete for 7 and 28 days and outcomes are as shown in Table II and the same is shown in Fig.2. in the graphical format.

Table- II: Compressive strength of cement concrete and Geo-polymer concrete

S. No.	Mix	Compressive Strength in N/mm^2	
		7 days	28 days
1.	M1	23.62	25.6
2.	M2	24.47	26.7
3.	M3	32.12	33.46
4.	M4	22.37	24.31

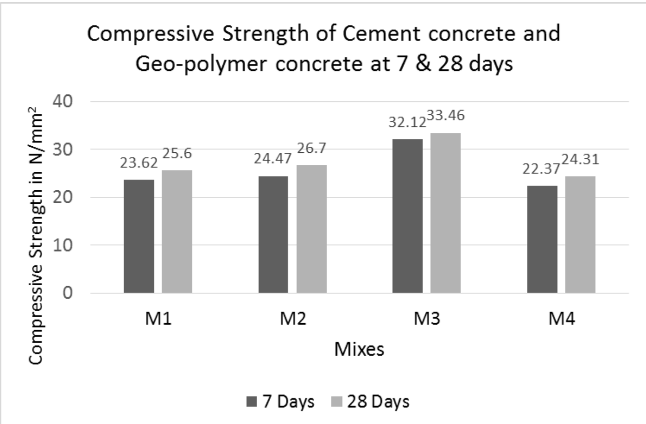

Fig. 2. Compressive Strength of Cement concrete and Geo-polymer concrete at 7 & 28 days

From Fig.2. Compressive strength of M3 mix is higher at 7 and 28 days when related to other mixes. M1, M2 and M4 mixes demonstrate comparatively the same strengths at 7 and 28 days. 2nd highest compressive strength is obtained in M2 mix. But the Compressive strength of M4 mix is very close to M1 mix at 7 and 28 days. At 7 days, M4 mix (geopolymer concrete) compressive strength is about 43.5% less than M3 mix (cement concrete with 0.45 w/c ratio). The compressive strength of M4 increases and is about 37.6% less than M3 mix at 28 days of curing.

The split tensile strength tests were conducted on cement concrete and geo-polymer concrete for 7 and 28 days and the results are as shown in Table III and the same as shown in Fig.3.

Table- III: Split Tensile strength of cement concrete and Geo-polymer concrete

S. No.	Mix	Split Tensile Strength in N/mm^2	
		7 days	28 days
1.	M1	3.03	3.58
2.	M2	2.75	3.06
3.	M3	3.15	4.37
4.	M4	2.68	3.07

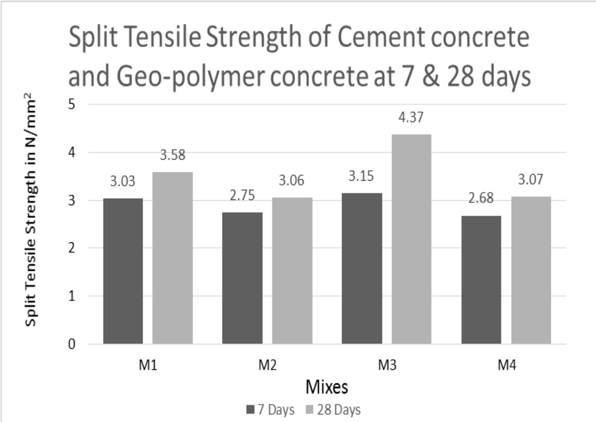

Fig 3. Split Tensile Strength of Cement concrete and Geo-polymer concrete at 7 & 28 days

From Fig.3.Split tensile strength of M3 mix is higher at 7 and 28 days when related to additional mixtures. M1, M2 and M4 mixes exhibit comparatively the same strengths at 7 and 28 days. 2nd highest spilt tensile strength is obtained in M1 mix. But the split tensile strength of M4 mix is very close to M2 mix at 7 and 28 days. At 7 days, M4 mix (geopolymer concrete) split tensile strength is about 17.5% less than M3 mix (cement concrete with 0.45 w/c ratio). The split tensile strength of M4 declines and exists about 42.3% less than M3 mix at 28 days of curing.

V. CONCLUSIONS

- The compressive strength and split tensile test results exhibits that among three w/c ratios, 0.45w/c ratio (M3 mix) provides the better strength comparing with others.
- Due to the addition of 1% of carboxylic acid into the cement concrete as well as geopolymer concrete increases the strength and decreases the development of cracks on the surfaces due to plastic shrinkage.
- At 7 days, M4 mix (geopolymer concrete) compressive strength is about 43.5% less than M3 mix (cement concrete with 0.45 w/c ratio). Compressive strength of M4 increases and is about 37.6% less than M3 mix at 28 days of curing.
- At 7 days, split tensile strength of M4 mix (geopolymer concrete) is about 17.5% less than M3 mix (cement concrete with 0.45 w/c ratio). The split tensile strength of M4 decreases and is about 42.3% less than M3 mix at 28 days of curing.

- The strength of the geopolymer concrete tends to rise as time period increases due to the presence of fly ash. So it is anticipated that geopolymer concrete will give more strength than cement concrete in long term.

ACKNOWLEDGMENT

The authors would like to express their heartfelt gratefulness to the Management, the Principal and the Head of Civil Engineering department of Sri Krishna College of Technology, Coimbatore, for the support and amenities provided to pursue this study.

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