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Experimental Investigation on Mechanical Properties of Silica Fume Blended Eco-Friendly Self-Curing High Strength Concrete

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ABSTRACT –

Concrete plays a vital role in constructions, without this the civil engineering can not move forward easily. Present everyone preferred concrete structure only because this are rich in durability, strength, better life span, etc. Conventional concrete required water upto 28 days for hydration of concrete. Now a days at many places present scarcity of water and labours in this point of view self-curing has been developed with many mix designs using Polyethylene glycol and Polyethylene etc, these are the key agents in self-curing concrete. These elements holds the water inside concrete and reduces the shrinkage rate. Compared with Conventional concrete the Self-curing concrete do not required the water at hydration time by included elements helps to cure internally. Self-curing is also called as internal curing, although it provides high in mechanical properties like compressive, split tensile and modulus of elasticity, etc. At preparing of self-curing concrete the polyethylene glycol has mixed with suitable ranges of weight by cement (0.5-1%) for this we can also add additional admixtures for additional strength of concrete for the better strength. For this mostly preferred silica fume and fly ash and other materials. Super plasticizers also used for water reduction in concrete and it can improves the workability of concrete. By compared this with conventional concrete better in results. The present study involves the use of shrinkage reducing admixture polyethylene glycol (PEG 4000) in concrete which helps in self curing and helps in better hydration and hence strength. In the present study, the affect of admixture (PEG 4000) on compressive strength by varying the percentage of PEG by weight of cement from 0% to 2% were studied for M70. It was found that PEG 4000 could help in self curing by giving strength on par with conventional curing. It was also found that 1% of PEG 4000 by weight of cement was optimum for M70 grade concretes for achieving maximum strength without compromising workability.

KEY WORDS: Self-curing concrete, Polyethylene glycol (PEG-4000), Compressive strength, Split tensile, Modulus of elasticity, High strength concrete.

1. INTRODUCTION

Concrete is a strengthening material to the structure formed by mixing of cement, aggregates, water and admixtures sometimes added for the different purposes like additional strength, quick setting, other causes may be reason to use admixtures. Concrete provides more strength and durability, etc. For preparing concrete different types cements also available these are consider by different conditions, mostly for the concrete Ordinary Portland Cement (OPC), Pozzolana Portland cement (PPC), etc used. Concrete is second most using material after the water in the world, because whole world consists concrete structures only from small structures to heavy structures. Concrete structures are rich in weather resistance, additional load bearing, life span approximately more than 50 years. In cement there are 3 grades of cements included there are 33, 43, 53 grades each grade used for different purposes. Concrete is hardened material which forms by aggregates together with mixing sufficient water. Among the ancient period lime and clay was used for the construction purposes. In ordinary structural concrete, the character of the concrete is largely determined by a water-to-cement ratio. The lower the water content, all else being equal, the stronger the concrete. The mixture must have just enough water to ensure that each aggregate particle is completely surrounded by the cement paste, that the spaces between the aggregate are filled, and that the concrete is liquid enough to be poured and spread effectively. Another durability factor is the amount of cement in relation to the aggregate.

SELF -CURING:

Self-curing in the concrete means to provide a continuous supply of water to the concrete so that during the release of the heat of the hydration process, concrete utilizes it and prevents the evaporation of water molecules within concrete mass. If curing is not done then, micro-cracks in concrete are developed due to loss of od water molecules from concrete, and the process of shrinkage occurs. The traditional curing process involves only interactions of concrete over the surface of concrete but not

POLYETHYLENE GLYCOL BEING USED IN CONCRETE:

Polyethylene glycol is a vital agent in Self-curing concrete. Applying Polyethylene Glycol (PEG-4000) as a chemical agent in self-curing concrete will help to reduce self-desiccation and improve mechanical characteristics. Polyethylene glycol (PEG-4000) retains the internal water for proper hydration of cement in concrete as compared to conventional concrete. Water plays a very vital role in the manufacture and curing of concrete in infrastructure projects. Water quality is mandatory for the normal curing process in a period of 28 days for cement hydration and to attain strengths Due to the scarcity of water, curing of the concrete is a difficult task in infrastructure projects. In this regard, introduce Polyethylene Glycol (PEG 4000) chemical as a self-curing solvent for bridge infrastructure projects in Ethiopia. For the M70 grade mix, three different polyethylene glycol (PEG-4000) percentages (0.5, 1.0, and 1.5) by weight of the cement have been designed. Finally, specimens were tested and compared to normal and self-cured concrete for mechanical strength properties. For the more the Construction industry is totally depending upon water.

2. LITERATURE REVIEW:

Dadaji.B [2] **(**2017) Carried out experiments to study the effect of PEG4000on compressive strength and water retention by varying the percentage of PEG from 0% to 1% by weight of cement for self-compacting concrete and compare it with conventional SCC. The optimum polyethylene glycol PEG dosage at lower w/c ratio was found to be 0.1%. The weight loss increased by increasing the percentage dosage of PEG-4000. Compressive strength of self-compact concrete with lower w/c ratio improves with the addition of PEG-4000.

Vedhasakthi et. al [3] (2014) Investigated the strength characteristics and workability of normal and high strength concrete using polyethylene glycol (PEG) and sorbitol as self -curing agents. The results show that using peg more effective than using sorbitol. There is increase in the strength of (HSSCC) high strength self-curing concrete than conventionally cured high strength concrete.

Thakare et.al [4] (2016) Carried experimental work to compare between the Self Cured Concrete (SCC) and Conventionally Cured Concrete (CCC) for M20-M35 grade with plasticizers and without plasticizer (normal concrete). They concluded that the SCC gives better strength than CCC till 14 days, at 28 days result are almost same for both concrete.

Mohan raj A et.al [5] (2016) Studied on "self-curing concrete incorporated with polyethylene glycol". The compressive strength of cube for Self-cured concrete is higher than of concrete cured by conventional curing method. The split tensile strength of self-cured concrete specimen is higher than that of the conventionally cured specimen. Self-cured concrete is found to have less water absorption values compared with concrete cured by other methods. Self-cured concrete thus have a fewer amount of porous.

Okamura et al. [7] proposed a new type of concrete, which can be compacted into every corner of a formwork purely by means of its own weight. In 1986, he started a research project on the flowing ability and workability of this special type of concrete, later called self-compacting concrete. The Self Compacting ability of this concrete can be largely affected by the characteristics of materials and the mix proportions. In his study, Okamura (1997) has fixed the coarse aggregate content to 50% of the solid volume and the fine aggregate content to 40% of the mortar volume, so that Self Compact ability could be achieved easily by adjusting the water to cement ratio and super plasticizer dosage only. After Okamura began his research in 1986, Ozawa [1998] has done some research independently from Okamura, and succeeded in developing self-compacting concrete for the first time.

Shikha Tyagi [8] introduced article which help to locate the ideal dose of PEG4000 for maximum strength is observed to be 1% for M25 and 0.5% for M40 grade. The impact of PEG4000 on workability is studies by taking slump cone and compaction factor tests. In this investigation the dosage of PEG400 has been fixed from 0% to 2%. The test outcomes were contemplated both for M25 and M40 grade. Conclusion cab be made with the help of this experiment that this self-curing agent help in self-curing and gives strength compare to conventional curing technique and furthermore enhanced workability.

MATERIALS:

CEMENT: As per IS 8112-1989 code. The Ordinary Portland cement 53 grade gives more strength and durability even better than 33, 43 grades of cement. This cement is used for heavy structures also.

FINE AGGREGATE: Fine aggregates generally classifies as 4 zones, these are zone-1, zone-2, zone-3, zone-4 for construction purpose mostly preferred river sand or pit sand and maximum size of fine aggregates 4.75 microns.

COARSE AGGREGATE: Coarse aggregates are generally available many different sizes but maximum size here consider 12mm.

WATER: Water is a main agent in concrete to form all materials into concrete. The potable water is used for mixing of concrete.

SUPERPLASTICIZER: Polycarboxylate superplasticizer, is type of admixture is used for reduction of water percentage in concrete, this ingredient can also reduces the shrinkage rate.

SILICA FUME: Silica fume (SiO2) is a by-product of the ferrosilicon. It is a product of highly additional strengthening provider to the concrete, it can also increase mechanical properties of concrete.

Materials used for self-curing high strength concrete:

Polyethylene glycol is a vital agent in Self-curing concrete. Applying Polyethylene Glycol (PEG-4000) as a chemical agent in self-curing concrete will help to reduce self-desiccation and improve mechanical characteristics. Polyethylene glycol (PEG-4000) retains the internal water for proper hydration of cement in concrete as compared to conventional concrete. Water plays a very vital role in the manufacture and curing of concrete in infrastructure projects. Water quality is mandatory for the normal curing process in a period of 28 days for cement hydration and to attain strengths Due to the scarcity of water, curing of the concrete is a difficult task in infrastructure projects. In this regard, introduce Polyethylene Glycol (PEG 4000) chemical as a self-curing solvent for bridge infrastructure projects in Ethiopia. For the M70 grade mix, three different polyethylene glycol (PEG-4000) percentages (0.5, 1.0, and 1.5) by weight of the cement have been designed. Finally, specimens were tested and compared to normal and self-cured concrete for mechanical strength properties. For the more the Construction industry is totally depending upon water.

EXPERIMENTAL SET UP:

The below procedure should follow for preparing Self-curing high strength concrete by using Polyethylene glycol (PEG-4000) by the weight of cement (0%, 0.5%, 1%, 1.5%) & silica fume 15%:

Arrange the materials together like cement, water, fine aggregate ,coarse aggregate, water, polyethylene glycol (PEG-4000), superplasticizer(polycarboxylate).Mix the concrete as per IS 10262-2019. Mix the concrete uniformly until desired. Add Polyethylene glycol (PEG-4000) to the concrete mix on the weight of cement 0.5% or 1% or 1.5% based on mix proportion. Mix the PEG thoroughly into the concrete to ensure it is evenly distributed throughout the mix. Add a water-reducing superplasticizer blend to the mix to improve workability and reduce water requirements. replace silica fume in cement as 15% constantly in concrete in every mix. Mix the ingredients thoroughly with a cement mixer for at least 5-7 minutes to ensure an even mix.

Pour the concrete mix into the cylinders and level the surface with a tamping rod. Vibrate the concrete with a vibrating machine to remove air gaps in the concrete. Use a trowel or hand trowel to smooth and finish the concrete surface. Pour the concrete mix into the desired shape and compact to remove air pockets. Allow concrete to cure on its own without the need for external curing methods. The PEG-4000 will gradually release water over time to keep the concrete moist and allow it to harden. After the concrete has been mixed.

DETAILS OF SPECIMEN PREPARATION:

Cylinders of size 150 x 300mm were poured to determine the strength of Self-curing concrete. Cylinders with a size of 150 x 300 mm were cast by replacing cement with silica fume in different proportions, i,e. 15%, was replaced. Cylinders measuring 150 x 300 mm were cast to determine the strength and durability of self- curing concrete by adding different proportions of polyethylene glycol (PEG-4000).The experiment study is carried out for three different proportions of polyethylene glycol (PEG-4000),0.5%, 1%, 1.5% by the total weight of cement.The different proportions of polyethylene glycol (PEG-4000) were calculated by weight from cement to concrete. Cylinders with three different percentages of polyethylene glycol (PEG-4000) were made with concrete. Finally, the results were tabulated.

TESTS CONDUCTED:

COMPRESSIVE TEST :

These specimens are tested by compression testing machine after 7 days, 14days and 28 days curing. The compressive strength of the concrete cube test provides an idea about all the characteristics of concrete. By this single test one judge that whether Concreting has been done properly or not.

Reference standards

IS: 516-1959 – Methods of tests for strength of concrete.

Equipment & apparatus

1.Compression testing machine (2000 KN) 2.Balance (0-10 Kg)

Procedure:

1. Representative samples of concrete shall be taken and used for casting cubes 10 cmx10cm x 10 cm.

2. The concrete shall be filled into the moulds in layers approximately 5 cm deep. It would be distributed evenly and compacted either by vibration or by hand tamping. After the top layer has been compacted, the surface of concrete shall be finished level with the top of the mould using a trowel.

3. After filled the cube specimens shall be stored at normal temperature conditions.

4. For conventional concrete we use curing after 24 hours of casting. Here we do not follow this procedure due self-curing.

5. Then de-mould the cubes and keep in dry in place until test time.

6. The bearing surface of the testing specimen shall be wiped clean and any loose material removed from the surface. In the case of cubes, the specimen shall be placed in the machine in such a manner that the load cube as cast, that is, not to the top and bottom.

7. The load shall be applied slowly without shock and increased continuously.

8. until the resistance of the specimen to the increased load breaks down and no greater load can be sustained. The maximum load applied to the specimen shall then be recorded and any unusual features noted at the time of failure brought out in the report.

Calculation Compressive strength formula for any material is the load applied at the point of failure to the cross-section area of the face on which load was applied.

Compressive Strength = Load / Cross sectional Area

can be unscrewed and removed. **SPLIT TENSILE**

RESULTS AND DISCUSSIONS:

4.1 COMPRESSIVE TEST :

The compressive strength of the concrete cube test provides an idea about all the characteristics of concrete. By this single test one judge that whether Concreting has been done properly or not. Compressive strength of concrete depends on many factors such as water-cement ratio, cement strength, quality of concrete material, quality control during the production of concrete, etc. Test for compressive strength is carried out either on a cube or cylinder. Various standard codes recommend a concrete cylinder or concrete cube as the standard specimen for the test.

Compressive Strength Formula

Compressive Strength = Load / Cross-sectional Area

Fig: 4.1.1. Testing of compressive strength

The compressive strength results are obtained by testing the specimens for 7, 14, and 28 days by considering the average test results for conventional concrete by varying the percentage of Polyethylene Glycol (PEG-4000) with Silica fume.

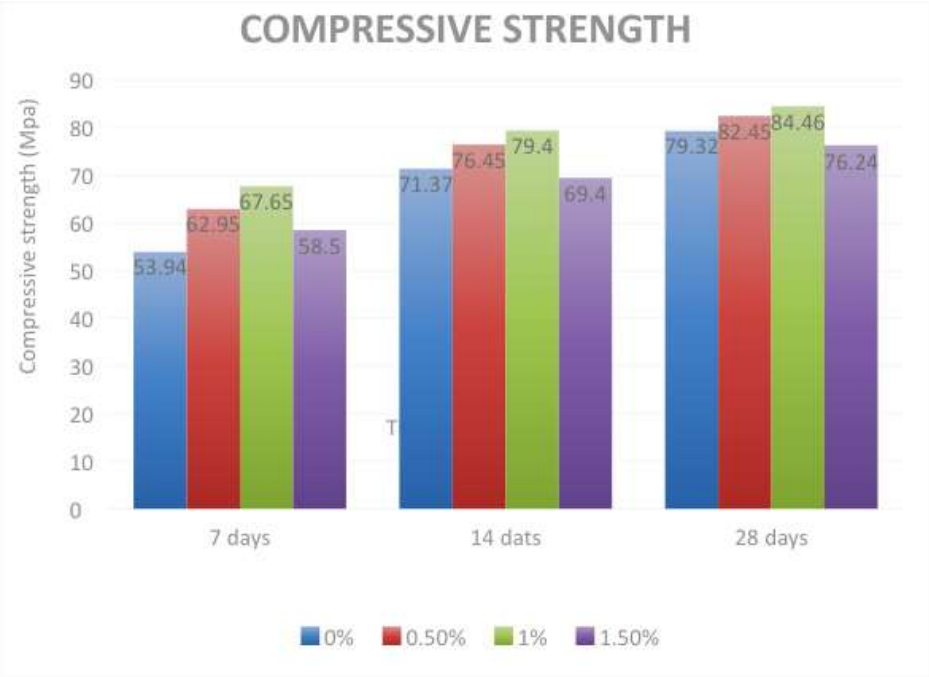
The results are tabulated below:

Table 4.1.3 Comparison of compressive strength of conventional concrete with Polyethylene Glycol (PEG-4000) and Silica fume.

Type of concrete	Grade of mix	Range of Polyethylene Glycol (%)	Days		
			7 days	14 days	28 days
Conventional Concrete	M70	0	53.94	71.37	79.32
Polyethylene Glycol (PEG-4000)	M70	0.5	62.95	76.45	82.45
		1	67.65	79.4	84.46
		1.5	58.5	69.4	76.24

Graph-4.1.4 Comparison of compressive strength of conventional concrete with Polyethylene Glycol (PEG-4000) at 7, 14, and 28 day.

Experimental results of compressive strength:



For 7 days:

The compressive strength values for self-curing concrete at 0.5% dosage of Polyethylene glycol (PEG-4000) is obtained to be 9.01% of more than conventional concrete.

The compressive strength values for self-curing concrete at 1% dosage of Polyethylene glycol (PEG-4000) is obtained to be 13.71% of more than conventional concrete.

The compressive strength values for self-curing concrete at 1.5% dosage of Polyethylene glycol (PEG-4000) is obtained to be 4.64% of less than conventional concrete.

For 14 days:-

The compressive strength values for self-curing concrete at 0.5% dosage of Polyethylene glycol (PEG-4000) is obtained to be 5.08% of more than conventional concrete.

The compressive strength values for self-curing concrete at 1% dosage of Polyethylene glycol (PEG-4000) is obtained to be 8.03% of more than conventional concrete.

The compressive strength values for self-curing concrete at 1.5% dosage of Polyethylene glycol (PEG-4000) is obtained to be 2% of less than conventional concrete. Hence 1% dose of polyethylene glycol is optimum.

For 28 days:-

The compressive strength values for self-curing concrete at 0.5% dosage of Polyethylene glycol (PEG-4000) is obtained to be 3.13% of more than conventional concrete.

The compressive strength values for self-curing concrete at 1% dosage of Polyethylene glycol (PEG-4000) is obtained to be 5.14% of more than conventional concrete.

The compressive strength values for self-curing concrete at 1.5% dosage of Polyethylene glycol-4000 is obtained to be 3.08% of less than conventional concrete. Hence 1% dosage of polyethylene glycol is optimum.

CONCLUSION

Introduction

By experimental investigation the mechanical properties of Self-curing (PEG-4000) of concrete like Compressive, Split tensile and Modulus of elasticity has given better values compared with conventional concrete. Hence the value of polyethylene glycol (PEG-4000) has used with different percentage of

cement. The polyethylene glycol (PEG-4000) has from 0% to 0.5% and 0.5% to 1% and 1% to 1.5% but by the tests 1% of polyethylene glycol (PEG-4000) is optimum.

Conclusion 5.1

The compressive strength values of self-curing concrete at 1% dosage of Polyethylene glycol (PEG-4000) is obtained to be 13.71% of more than conventional concrete at "7 days".

The compressive strength values for self-curing concrete at 1% dosage of Polyethylene glycol (PEG-4000) is obtained to be 8.03% of more than conventional concrete at "14" days.

The compressive strength values for self-curing concrete at 1% dosage of Polyethylene glycol (PEG-4000) is obtained to be 5.14% of more than conventional concrete at "28" days.

Reference:

[1] ACI Committee 211,4R-93 "Guide for selecting proportions for High-Strength concrete with ordinary Portland cement and silica fume.

[2] Dadaji B. Jadhav and Ranjana Ghate," A Study on Self-Curing and Self--2017, pp. 1014-1019. Compacting Concrete Using Polyethylene Glycol", International Research- 15 - Journal of Engineering and Technology (IRJET), Volume: 04 Issue: 02, Feb

[3] K Vedhasakthi and M. Saravanan," Development of Normal Strength and High Strength Self Curing Concrete Using Super Absorbing Polymers (Sap).

[4] A.S. Thakare S.P. Pethe, A.A. Sarode, and R.S. Shah," Comparison Between Self Cured Concrete and Conventionally Cured Concrete", International Conference on Science and for Sustainable Development (ICSTSD)- 2016, pp. 102-106.

[5] Mohan raj A, Rajendran M, Ramesh A S, Mahalakshmi M, Manoj Prabhakar S (2016) An Experimental Investigation of Eco-Friendly Self-Curing Concrete Incorporated with Polyethylene Glycol International Advanced Research Journal in Science, Engineering and Technology,1,85-89.

[6] Okamura H & Ozawa K, "Mix-design for self-compacting concrete", Concrete Library of JSCE, No. 25, June 1995, pp.107-120. [10] Nan Su, Kung-Chung Hsu, His-Wen Chai, "A simple mix design method for self-compacting concrete", Cement and Concrete Research, 6 June 2001, pp1799- 1807.

[7] Shikha Tyagi, An Experimental Investigation of Self Curing Concrete Incorporated with Polyethylene Glycol as Self Curing Agent, International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056 p-ISSN: 2395-0072 Volume: 02 Issue: 06 | Sep-2015