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Experimental Study on Strength Characteristics of Self Curing Concrete using Poly Ethylene Glycol and Light Weight Aggregate

Remya K M[1], Shilpa.V S [2], Dhanusha.M[3], Ashna L Sukumar[4] , Ashna ismayil[5], Sreerag K[6]

Civil engineering department[1], college of engineering vadakara[1]
Undergraduate students[2, 3, 4,5,6], college of engineering vadakara [2, 3, 4,5,6]
email: kmremya@gmail.com[1] , shilpavs9942@gmail.com [2]

Abstract- Concrete is the most widely used construction material due to its good compressive strength and durability. Depending upon the nature of work the cement, fine aggregate, coarse aggregate and water are mixed in specific proportions to produce plain concrete. The properties of hardened concrete are greatly influenced by curing since it has a remarkable effect on the hydration of the cement. The present study involves the use of shrinkage reducing admixture polyethylene glycol (PEG 600) in concrete which helps in self curing and better hydration and strength. In this study pre soaked light weight aggregates are partially replaced by fine aggregates and PEG-600 is added at a rate of 0.5%, 1%, 1.5% and 2% of weight of cement. The compressive strength, flexural strength and split tensile strength of self curing concrete at 3,7,14 and 28 days is compared with those of conventionally cured concrete for a design mix of M20. It is found that the optimum dosage of PEG-600 for maximum strengths was found to be 1%. The compressive, split tensile and flexural strength of conventional concrete of 28 day was attained in 3 days with the addition of self-curing concrete at 1% PEG-600.

Index Terms-self curing concrete, poly ethylene glycol, light weight aggregate, physical properties, compressive strength, split tensile strength, flexural strength

1. INTRODUCTION

Proper curing of concrete structures is important to meet their intended performance and durability requirements. In conventional construction, this is achieved through external curing, applied after mixing, placing and finishing. That is, conventionally, curing concrete means creating conditions such that water is not lost from the surface i.e., curing is taken to happen 'from the outside to inside'. Internal curing(IC) is a promising technique that can provide additional moisture in concrete for a more effective hydration of cement and reduced self-desiccation. Internal curing implies the introduction of a curing agent into concrete that will act as an internal source of water. Internal curing is often referred to as "Self Curing".

Water/moisture required for internal curing can be supplied by incorporation of saturated-surface dry (SSD) lightweight fine aggregates (LWA). The fine lightweight aggregate, in saturated condition, produce a more uniform distribution of the water needed for curing throughout the microstructure. The originated from pumice is used for preparing concrete to achieve better curing and more economy. A non-toxic chemical, polyethylene glycol-600 is also added in concrete to facilitate the process of curing and thus to improve the strength of concrete.

2.2. *Materials*

LWA can be used for internal curing without considerable detrimental effects on strength when added in the amounts just required to eliminate self-desiccation.

The concept of polyethylene-glycol is to reduce water evaporation from concrete, and hence increase the water retention capacity of concrete compared with conventional concrete which leads to improved compressive strength. The use of polyethylene-glycol in concrete mixes improves the mechanical properties of concretes under air curing regime which may be attributed to a better water retention and causes continuation of the hydration process of cement past resulting in less voids and pores, and greater bond force between the cement paste and aggregates.

2. MATERIALS USED FOR THE STUDY

2.1. *General*

The materials used for preparing concrete were 43 grade ordinary portland cement, natural fine aggregate, coarse aggregate and water. In addition to

2.2.1. Ordinary portland cement

Cement used in this investigation was 43 grade ordinary Portland cement. This type of cement is typically used in construction and is readily available. Higher strength and greater resistance to different types of chemicals are its main advantages.

2.2.2. *Fine aggregate*

Fine aggregates are those which pass through IS 4.75 mm sieve. The advantages of these materials are that it gives strength to concrete, reduce the total cost of construction and avoid cracking. The fine aggregates conforming to zone-2 were used.

2.2.3. *Coarse aggregate*

Coarse aggregates are those which retain on IS 4.75 mm sieve. It should be free from organic or other impurities causing decay of the contents. It is typically round in shape. These are well graded, i.e. particle size is distributed in a specific proportion.

2.2.4. *Light weight aggregate*

These are obtained from natural aggregates of volcanic origin such as pumice, scoria etc. Light weight aggregates can originate from natural resources or they can be man made. The major natural source is the volcanic material. Man made or synthetic, aggregates are produced by a thermal process in factories. Light weight aggregates have more water absorption ability than normal fine aggregates. It reduces the weight of concrete. The saturated porous light weight aggregates (LWA) supply an internal source of water, which can replace the water consumed by chemical shrinkage during hydration of cement. LWA used for the present study is shown in fig.1

Fig. 1: Light weight aggregate

2.2.5. *Poly ethylene glycol- 600*

Polyethylene glycol is a condensation polymer of ethylene oxide and water with the general formula H(OCH2 CH2)n OH, where n is the average number of repeating oxyethylene groups typically from 4 to about 180. It appears to be water soluble. It is non-toxic and odourless. The specific gravity is 1.13. The polyethylene-glycol is used to reduce water evaporation from concrete, and hence increase the water retention capacity of concrete which leads to improved compressive strength. The use of polyethylene-glycol in concrete mixes improves the mechanical properties of concretes which may be attributed to a better water retention and causes continuation of the hydration process of cement past resulting in less voids and pores, and greater bond force between the cement paste and aggregates. The PEG-600 used for this study is shown in fig.2

Fig.2. Poly ethylene glycol-600

2.2.6. *Water*

Portable water was used in the work for both mixing and curing purposes

3. METHODOLOGY

3.1. *General*

A design mix of desired strength is obtained according to IS : 10262-1982 with the obtained mix ratio. The casting of both conventional concrete specimen and self curing concrete specimen were done. The strength characteristics of conventional concrete specimen are prepared at 3,7,14 & 28 days. The self -curing concrete specimen were prepared by adding 20% replacement of fine aggregate with that of light weight aggregate and PEG at 0.5%,1%, 1.5%, 2% of cement .The strength characteristics of self -curing concrete is compared with conventional concrete.

3.2. *Preliminary test on materials*

Properties of materials are found out by conducting various tests. The conducted tests are fineness test, specific gravity, and setting time tests .From these results mix design is calculated.

3.3 *Quantity of materials for casting*

From the obtained mix, the amount of materials required for casting the concrete specimens were calculated. 20% the fine aggregate were replaced by light weight aggregate for self curing concrete. The PEG-600 was added at a rate of 0.5%, 1%, 1.5% and 2%of weight of cement.

3.4 *Test on concrete specimen*

Various tests conducted for the strength characteristics of concrete specimens are compressive strength test, split tensile strength and flexural strength..

4. TESTS ON CONVENTIONAL CONCRETE SPECIMEN

4.1. *General*

Various tests conducted for the strength characteristics of concrete specimens are compressive strength test, split tensile strength and flexural strength. The specimens were casted at 3, 7, 14 and 28 days.

4.2. *Test Results and Discussion*

Three major tests were conducted to find out strength of conventional concrete. Test conducted were compressive strength of cube, split tensile strength of cylinder and flexural strength of beam. the obtained test results of compressive strength on conventional concrete specimen are represented in table 1,split tensile strength are given in table 2 and flexural strength are given in table 3.

Table 1. Compressive Strength test on cubes

Day at which the test is conducted	**Compressive strength(N/mm^2)**
3 Day	9.33
7 Day	14.77
14 Day	19.45
28Day	28.55

Table 2. Split tensile strength test on cubes

Day at which the test is conducted	**Split tensile strength(N/mm^2)**
3 Day	2.07
7 Day	2.75
14 Day	3.08
28Day	3.73

Table 3. Flexural strength test on cubes

Day at which the test is conducted	**Flexural strength(N/mm^2)**
3 Day	2.2
7 Day	2.8
14 Day	3
28Day	3.4

5. TEST RESULTS AND DISCUSSION ON SELF CURING CONCRETE

5.1. *General*

Various test were conducted for the strength characteristics of self curing concrete specimens are compressive strength test, split tensile strength and flexural strength. The specimens were casted at 3, 7, 14 and 28 days.

5.2. *Compressive Strength test on cubes*

The results of the compressive strength are represented in Table 4. The 28 day compressive strength of conventional concrete obtained is 28.55 N/mm2. The compressive strength of self-cuing concrete at 3 day with 1% PEG-600 is 28.1 N/mm^2, which is nearly equal to 28 day strength of conventional concrete.

Table 4. Compressive strength of concrete cube

% of PEG-600	**Compressive Strength (N/mm^2)**			
	3 Day	7 Day	14 Day	28 Day
0.5%	22.22	27.77	31.55	35.55
1%	28.1	29.33	33.55	37.55
1.5%	22.88	27.55	28.88	34.22
2%	22	26	27.11	31.33

5.3. *Split tensile strength test on cylinders*

The results of the split tensile strength are represented in Table.5. The Split tensile strength of conventional concrete at 28 day is obtained as 3.73 N/mm^2. The 14 day split tensile strength of self-cuing concrete with 1% PEG-600 is 3.81 N/mm^2, which is nearly equal to 28 day strength of conventional concrete.

Table 5. Split tensile strength test on cylinder

% of PEG-600	**Split Tensile Strength (N/mm^2)**			
	3 Day	7 Day	14 Day	28 Day
0.5%	2.61	2.82	2.97	3.25
1%	2.33	3.25	3.81	4.03
1.5%	2.33	2.68	2.75	2.9
2%	2.22	2.47	2.68	2.97

5.4. ***Flexural Strength test on beam***

The results of the flexural strength are represented in Table.6. The flexural strength of conventional concrete at 28 day split tensile strength is obtained as 3.4 N/mm^2. The 3 day flexural strength of self-cuing concrete with 1% PEG-600 is 3.2 N/mm^2, which is almost similar to 28 day strength of conventional concrete.

Table 6. Flexural strength test on beam

% ofPEG-600	***Flexural Strength*(N/mm^2)**			
	3 Day	7 Day	14 Day	28 Day
0.5%	2.4	3.2	3.8	4
1%	3.2	3.6	4	4.4
1.5%	2.6	2.8	3.4	4
2%	2.4	2.6	3.2	3.6

6. COMPARISON OF RESULTS BETWEEN CONVENTIONAL CONCRETE AND SELF CURING CONCRETE

6.1. ***General***

The variation of compressive strength, split tensile strength and flexural strength test on conventional and self curing concrete is done.

6.2 ***Comparison of compressive strength***

Graphical representation of variation of split tensile strength is shown in fig.3. The abscissa of graph represents compressive strength of concrete cube in N/mm^2 and the ordinate represents the day at which tests are conducted. The various lines in graph indicate 3, 7, 14, 28 day compressive strength of specimen with different percentages of PEG-600. The compressive strength is found to increase up to 1% PEG-600 and then decreased.

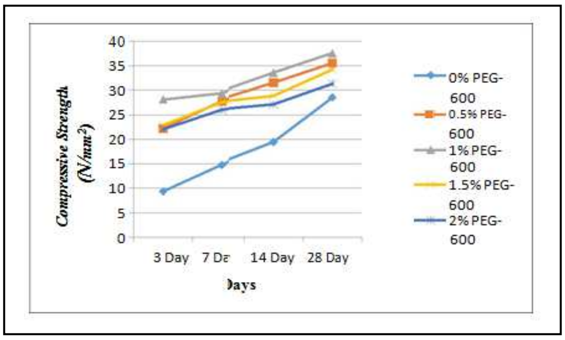

Fig. 3. Variation of Compressive Strength

6.3 ***Comparison of split tensile strength***

Graphical representation of variation of split tensile strength is shown in fig.4. The abscissa of graph represents split tensile strength of concrete cube in N/mm^2 and the ordinate represents day at which tests are conducted. The various lines in graph indicate 3, 7, 14, 28 day split tensile strength of specimen with different percentage of PEF-600.The split tensile strength is found to be increase up to 1% PEG-600 and then decreased.

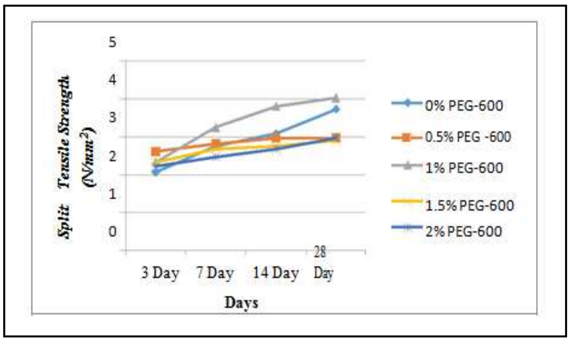

Fig. 4. Variation of split tensile Strength

6.4 ***Comparison of flexural strength***

Graphical representation of variation of flexural strength is shown in fig.5. The abscissa of graph represents flexural strength of concrete cube and ordinate represents days at which tests are conducted. The various lines in graph indicate 3, 7, 14, 28 day flexural strength of specimen with different percentages of PEG-600. The flexural strength is found to increase up to 1% PEG-600 and then decreased.

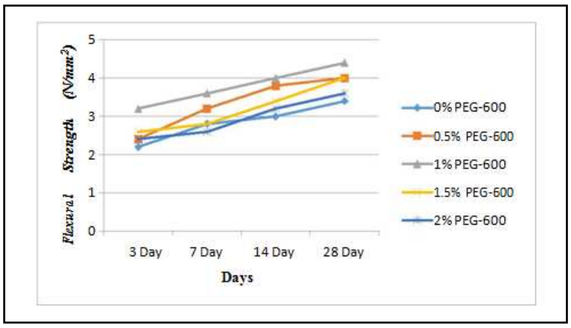

Fig. 5. Variation of split flexural Strength

7. DISCUSSION

The results of compressive strength, split tensile strength and flexural strength are analyzed. It can be concluded that self-curing concrete with 20% replacement of fine aggregate with light weight aggregate has maximum strength at an optimum value 1% PEG-600 of weight of cement.

Graphs are plotted by comparing strength of conventional concrete and self-curing concrete with optimum dose of PEG-600. fig 6. indicates variation of compressive Strength of conventional concrete and self-curing concrete at 1% PEG-600. fig.7 indicates variation of split tensile strength and fig.8 indicates variation of Flexural Strength.

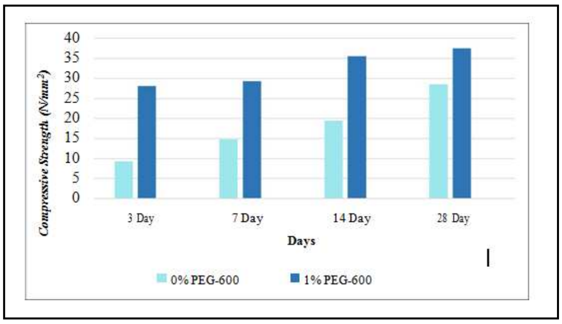

Fig. 6. Variation compressive strength of conventional concrete and self curing concrete with 1% PEG-600

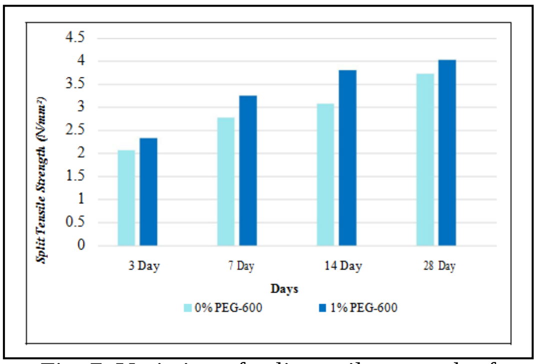

Fig. 7. Variation of split tensile strength of conventional concrete and self curing concrete with 1% PEG-600

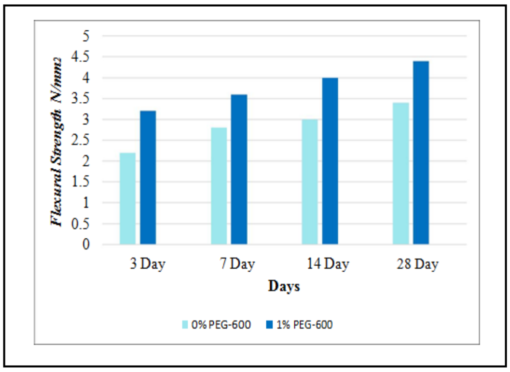

Fig. 8. Variation of flexural strength of conventional concrete and self curing concrete with 1% PEG-600

8. CONCLUSIONS

- The optimum dosage of PEG-600 for maximum strengths (compressive, tensile and flexural strength) is found to be 1% for M20 grade of concrete.
- The compressive, split tensile and flexural strength of conventional concrete of 28 day is attained in 3 day of self-curing concrete at 1% PEG-600.
- Poly ethylene glycol-600 which is used as a shrinkage reducing agent and as an absorbent polymer in concrete.
- The chemical shrinkage during the cement hydration can be reduced by the action of Polyethylene glycol. So the strength achieved by self (internal curing) could be more than that possible under saturated conditions.
- Self-curing concrete can be adopted in construction, which is beneficial in economical since the constituents of self-curing concrete are cheaper and easily available.

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