Compressive Behavior of Self-curing Concrete with Lightweight Porous Aggregate and Polyethylene Glycol

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Abstract— Curing of concrete is maintaining satisfactory moisture content in concrete during its early stages in order to develop the desired properties. Any laxity in curing will badly affect the strength and durability of concrete. The aim of the investigation is to evaluate the use of water-soluble polyethylene glycol as self-curing agent with partial replacement of conventional fine aggregate with light weight fine aggregate such as sand stone and to optimize the quantity of lightweight aggregate and poly-ethylene glycol. By studying the mechanical properties of concrete by replacing the fine aggregate with lightweight fine aggregate by 0%, 10%, 15%, 20% and 25%, the optimum quantity of lightweight aggregate was found as 25%. Self-curing concrete of M30 grade were cast by replacing fine aggregate with 25% lightweight fine aggregate, whose water absorption property is high, and by varying quantity of polymeric glycol by 0.5%, 1%, 1.5% and 2%, the optimum percentage of polyethylene glycol was found as 1%. In this study, compressive strength of self-curing concrete with varying quantity of polyethylene glycol was evaluated and compared with the conventional concrete specimens.

Keywords: Water-soluble, Self-curing, Mechanical property, Light weight porous aggregate, polyethylene Glycol 400

I. INTRODUCTION

In conventional construction, this is achieved through external curing, applied after mixing, placing and finishing. Internal curing (IC) is a very promising technique that can provide additional moisture in concrete for a more effective hydration of cement and reduced self-desiccation. Proper curing of concrete structures is important to ensure they meet their intended performance and durability requirements. Internal curing implies the introduction of a curing agent into concrete that will act as an internal source of water. Currently, there are two major methods available for internal curing of concrete. The first method uses saturated porous lightweight aggregate (LWA) in order to supply an internal source of water, which can replace the water consumed by chemical shrinkage during cement hydration. The second method uses super-absorbent polymers (SAP), as these particles can absorb a very large quantity of water during concrete mixing and form large inclusions containing free water, thus preventing self-desiccation during cement hydration. For optimum performance, the internal curing agent should possess high water absorption capacity and high water desorption rates.

II. EXPERIMENTAL INVESTIGATION

A. Materials

1) Cement: The Bureau of Indian Standards (BIS) has classified OPC in three different grades. The classification is mainly based on the compressive strength of cement-sand mortar cubes of face area 50 cm2 composed of 1 part of cement to 3 parts of standard sand by weight with a water-cement ratio arrived at by a specified procedure. The grades are (i) 33 grade (ii) 43 grade (iii) 53 grade. The grade number indicates the minimum compressive strength of cement sand mortar in N/mm2 at 28 days, as tested by above mentioned procedure. In this project, 43 Grade Ordinary Portland Cement was used conforming IS 12269:1987.
2) Fine Aggregate: Aggregate which passed through 4.75 mm IS Sieve and retained on 75 micron (0.075 mm) IS Sieve is termed as fine aggregate. Fine aggregate is added to concrete to assist workability and to bring uniformity in mixture. Usually, the natural river sand is used as fine aggregate. Ordinary river sand conforming IS 383-1970 was used in this project.
3) Coarse Aggregate: The coarse aggregate for the works should be river gravel or crushed stone. Angular shape aggregate of size is 20 mm and below. The aggregate which passes through 75 mm sieve and retain on 4.75 mm are known as coarse aggregate. It should be hard, strong, dense, durable, clean, and free from clay or loamy admixtures or quarry refuse or vegetable matter. The pieces of aggregate should be cubical, or rounded shaped and should have granular or crystalline or smooth (but not glossy) non-powdery surfaces. Aggregate should be properly screened and if necessary washed clean before use. Coarse aggregate containing flat, elongated or flaky pieces or mica should be rejected. The grading of coarse aggregate should be as per specifications of IS 383-1970.In this project, maximum normal size of coarse aggregate was 20mm for controlled concrete
4) Water: The water should be fit for mixing. The water should not have high concentrations of sodium and potassium and there is a danger of alkali aggregate reaction. Natural waters that are slightly acidic are harmless, but water containing organic acids may adversely affect the hardening of concrete. Such water as well as highly alkaline water should be tested. The water should conform to IS 456-2000 standards. Generally, water satisfactory for mixing is also suitable for curing purposes. However, it is essential that curing water should be free from substances that attack hardened concrete like freeCO2 etc.
5) Lightweight fine aggregate: Lightweight fine aggregate used in this study is a natural lightweight aggregate, which was obtained From a sandstone quarry from gurgaon.
6) Polyethylene Glycol: Polyethylene glycol is a condensation polymers of ethylene oxide and water with the general formula H (OCH2CH2)nOH, where n is the average number of repeating oxyethylene groups

typically from 4 to about 180. The abbreviation (PEG) is termed in combination with a numeric suffix which indicates the average molecular weights. One common feature of PEG appears to be the water-soluble. In this project, polyethylene glycol with molecular weight of 400 (PEG-400) was used as a self-curing agent, which was manufactured by Sisco research lab.

B. Mix Proportions

General: As per IS method, mix design for M30 grade concrete was carried out using the test data for cement, coarse Aggregate and fine aggregate obtained by preliminary investigations.

	Cement	Water	F.A.	C.A.
Kg/m^3	423.25	182	655.90	1220.90
Ratio	1	0.43	1.54	2.82

Table 1: ratios of material used in cube formation

III. PROCEDURE

A. Control Specimens

Total 09 numbers of specimens will be prepared for concrete mixture M30 without using PEG400. 09 specimens will be tested for compressive strength.

B. Specimen with PEG400 and LWPA

Total 81 numbers of specimen will be prepared for concrete mixture M30 using PEG400 and LWPA. Out of 90 numbers of specimens, 81 will be with PEG400 and LWPA at M-30 grade of concrete. Compressive strength of concrete mixture M30 with PEG400 and LWPA will be recorded at seven, fourteen and twenty-eight day of curing with water and compared with strengths of control specimens at their corresponding ages.

IV. RESULT AND DISCUSSION

A. Slump:

Slump test is used to determine the workability of fresh concrete. Slump test as per IS 1199: 1959 is followed. The apparatus used for doing slump test were slump cone and tamping rod. The internal surface of the mould was thoroughly cleaned and freed from superfluous moisture and adherence of any old set concrete before commencing the test. The mould was then filled in four layers, each 1/3 of the height of the mould, each layer being tamped 25times with a standard tamping rod taking care to distribute the strokes evenly over the cross section.

After top layer had been rode, the concrete was struck off level with a trowel and tamping rod. The mould was removed from the concrete immediately by raising it slowly and carefully in a vertical direction. This allowed concrete to subside. This subsidence was referred as slump of concrete. The difference in level between the height of the mould and that of the highest point of the subsided concrete was measured. This difference in height in mm was taken as slump of concrete.

B. Compressive Strength:

The compressive strength test for cubes was conducted in compression testing machine as per IS 516: 1964. The cubes were tested in compressive testing machine at the rate of 140 kg/cm2/min and the ultimate loads were recorded the bearing surface of machine was wiped off clean and the surface of the specimen was cleaned. The specimen was placed in machine in such a manner, load was applied to opposite sides of the cubes such that casted side of specimen was not top and bottom. The axis of the specimen was carefully aligned at the centre of loading frame. The load applied was increased continuously at a constant rate until the resistance of the specimen to the increasing load breaks down and no longer can be sustained. Maximum load applied on specimen was recorded

C. Lightweight Aggregate:

The results of the investigation carried out for finding the optimum percentage of lightweight aggregate by
Determining the mechanical properties of concrete were as mentioned below in table 2

1) Slump Value

It was observed that the slump value decreased with increase in percentage of lightweight aggregate. The graphical representation is shown in figure 1.

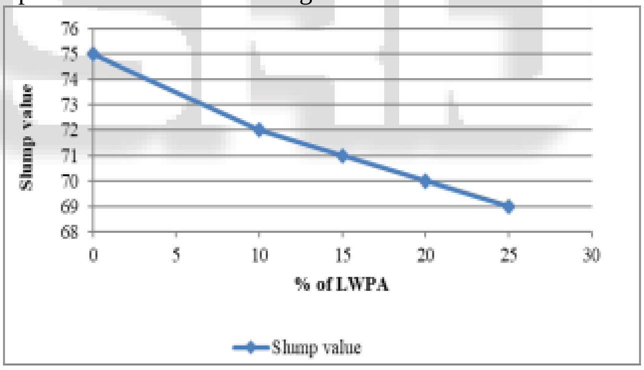

Fig. 1: Variation of Slump Value for M30 Concrete with Replacement of Fine Aggregate with Lightweight porous Aggregate from 0% to 25%

2) Compressive Strength

From table 2.1, it was observed that, average compressive strength at 7 days, 14 days and 28 days increased with increase in percentage of lightweight porous aggregate up to 25% with 1% PEG. The graphical Representation of the variation of average compressive strength at 7 days, 14 days and 28 days is shown in figure 2.

S.No.	Description	Percentage of PEG with 25% LWPA					
		With curing	Without curing				
		0%	0%	0.5%	1%	1.5%	2%
1	Slump Value(mm)	69	70	74	79	87	93
2	Average 7th day compressive strength of cubes (N/mm^2)	32.1	28.5	29.4	30.9	29.6	27.4
3	Average 14th day compressive strength of cubes (N/mm^2)	36.2	30.6	31.2	34.3	32.4	30.7
4	Average 28th day compressive strength of cubes (N/mm^2)	42.4	37.2	39.6	40.8	38.4	37.7

Table 2.1: Test Results for M30 Concrete for 7th, 14th & 28th day with % of PEG with 25% LWPA.

From table 2.2 , it was observed that, average compressive strength at 7 days,14 days and 28 days increased with increase in percentage of lightweight porous aggregate up to 20% with 1.5% of PEG . The graphical Representation of the variation of average compressive strength at 7 days, 14 days and 28 days is shown in figure 3.

S.No.	Description	Percentage of PEG with 20% LWA					
		With curing	Without curing				
		0%	0%	0.5%	1%	1.5%	2%
1	Slump Value(mm)	70	70	75	80	89	94
2	Average 7^{th} day compressive strength of cubes (N/mm^2)	31.8	28.0	28.7	30.3	28.7	26.9
3	Average 14^{th} day compressive strength of cubes (N/mm^2)	35.8	30.1	30.4	33.6	31.9	30.2
4	Average 28^{th} day compressive strength of cubes (N/mm^2)	41.8	36.8	39.1	40.3	37.9	37.2

Table 2.2: Test Results for M30 Concrete for 7th, 14th & 28th day with % of PEG with 20% LWPA.

From table 2.3, it was observed that, average compressive strength at 7 days,14 days and 28 days increased with increase in percentage of lightweight porous aggregate up to 15% with 2% of PEG . The graphical Representation of the variation of average compressive strength at 7 days, 14 days and 28 days is shown in figure 4 .

S.No.	Description	Percentage of PEG with 15% LWA					
		With curing	Without curing				
		0%	0%	0.5%	1%	1.5%	2%
1	Slump Value(mm)	71	71	75	80	89	94
2	Average 7^{th} day compressive strength of cubes (N/mm^2)	31.3	27.5	28.2	29.8	28.2	26.4
3	Average 14^{th} day compressive strength of cubes (N/mm^2)	35.3	28.4	29.9	33.1	31.4	29.7
4	Average 28^{th} day compressive strength of cubes (N/mm^2)	41.5	36.3	38.6	39.8	37.5	36.7

Table 2.3: Test Results for M30 Concrete For 7th, 14th & 28th day with % of PEG with 15% LWPA.

From table 2.4, it was observed that, average compressive strength at 7 days,14 days and 28 days increased with increase in percentage of lightweight porous aggregate up to 10% with 0.5% of PEG . The graphical Representation of the variation of average compressive strength at 7 days, 14 days and 28 days is shown in figure 4.

S.No.	Description	Percentage of PEG with 10% LWA					
		With curing	Without curing				
		0%	0%	0.5%	1%	1.5%	2%
1	Slump Value(mm)	72	71	75	80	89	94
2	Average 7^{th} day compressive strength of cubes (N/mm^2)	30.8	27.0	27.7	29.3	27.6	25.8
3	Average 14^{th} day compressive strength of cubes (N/mm^2)	34.8	27.8	29.3	32.6	30.9	29.2
4	Average 28^{th} day compressive strength of cubes (N/mm^2)	41.1	35.5	38.1	39.3	35.0	36.1

Table 2.4: Test Results for M30 Concrete for 7th, 14th & 28th day with % of PEG with 10% LWPA.

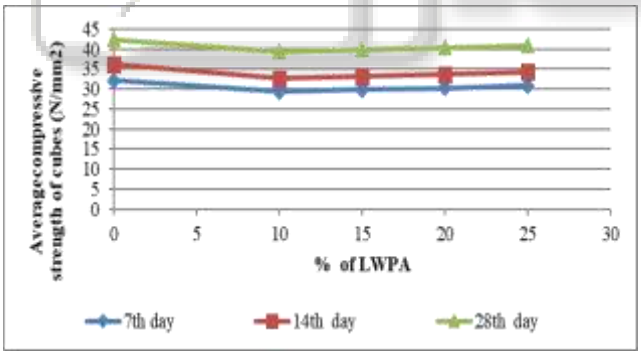

Fig. 2: Average compressive strength of cubes (N/mm2) vs % of LWPA with 1% PEG400

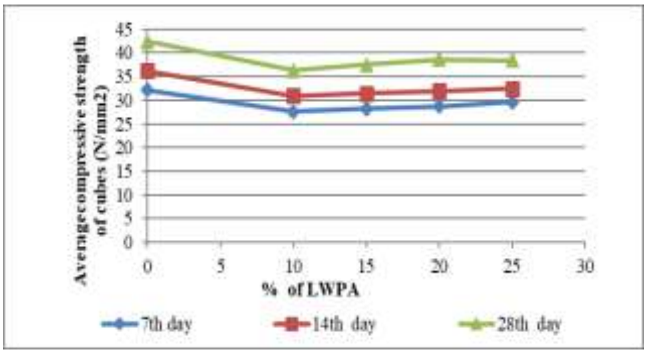

Fig. 3: Average compressive strength of cubes (N/mm2) vs % of LWPA with 1.5% PEG400

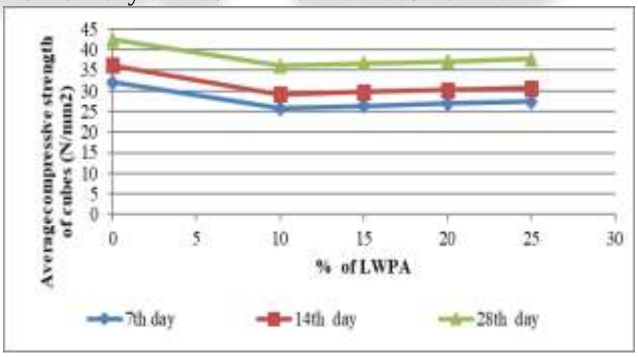

Fig. 4: Average compressive strength of cubes (N/mm2) vs % of LWPA with 2% PEG400

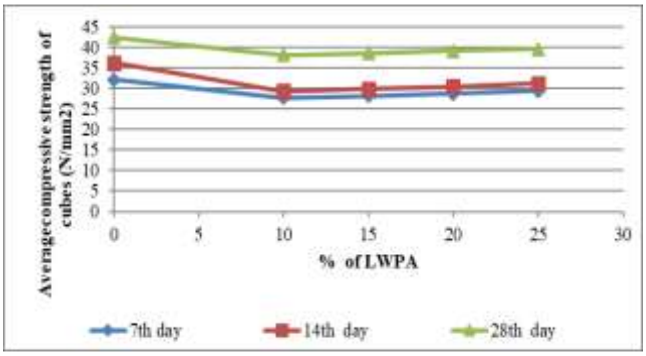

Fig. 5: Average compressive strength of cubes (N/mm2) vs % of LWPA with 0.5% PEG400

S.No.	Description	Percentage of PEG with 25% LWA					
		With curing	Without curing				
		0%	0%	0.5%	1%	1.5%	2%
1	Slump Value(mm)	69	70	74	79	87	93
2	Average 7th day compressive strength of cubes (N/mm^2)	32.1	28.5	29.4	30.9	29.6	27.4
3	Average 14th day compressive strength of cubes (N/mm^2)	36.2	30.6	31.2	34.3	32.4	30.7
4	Average 28th day compressive strength of cubes (N/mm^2)	42.4	37.2	39.6	40.8	38.4	37.7

Table 3 Test Results for M30 Concrete with 25% LWA and Variation of Polyethylene Glycol 400 7th, 14th & 28th day.

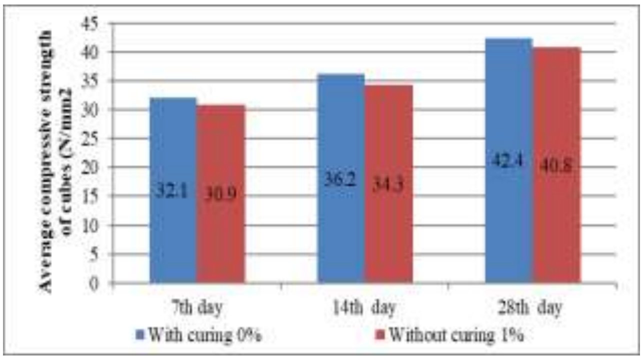

Fig. 6: Average compressive strength of cubes (N/mm2) with curing and without curing 25 % of LWPA with 1% PEG400

V. CONCLUSIONS

In this project, the mix design for control concrete grade of M30 had been designed. Self-curing concrete is useful in water scarce areas and in places where good quality water is not available. The self curing concrete required had been arrived from the control concrete by optimizing the percentage of lightweight aggregate and polyethylene glycol. From the test results observed, the following conclusion had been drawn: The optimum percentage of lightweight porous aggregate for maximum strengths (compressive, split-tensile and modulus of rupture) was found to be 25% for M30 grade of concrete. As the percentage of lightweight aggregate increased, the slump value decreased The optimum dosage of PEG400 with 25% lightweight aggregate for maximum strengths (compressive and modulus of rupture) was found to be 1% for M30 grade of concrete. As percentage of PEG400 increased, slump increased for M30 grade of concrete.

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