An Experimental Investigation of Self Curing Concrete using Light Expanded Clay Aggregates (LECA) and Polyethylene Glycol (PEG)

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Abstract— In Today's life concrete is important material used in the construction because of its strength and durability properties. To attain better strength and durability curing is must. The scarcity of water, inaccessibility of structures in hilly areas, improper curing by human negligence's demands alternate solution for curing. In the present study both LECA (Light Expanded Clay Aggregates) and Poly Ethylene Glycol PEG400 were used as potential materials for self-curing of concrete. The effect of both PEG400 and LECA on the mechanical properties of concrete can be done by changing the percentage of PEG400 by the equivalent weight of cement from 0%to 2% and coarse aggregates are replaced by LECA of about 10%were studied for M30 grade of concrete. In conventional concrete 0%PEG and also 10%of coarse aggregates are replaced by dry LECA aggregates. In self-curing concrete the PEG400 is varied from 0.5% to2% by weight of cement for each variation of PEG400 chemical 10%of coarse aggregates are replaced by LECA aggregates. It was found that mechanical properties like compressive strength, spit tensile strength, flexural strength of self-curing concrete is more than the normal curing concrete.
Key words: Self Curing Concrete, LECA, Polyethylene Glycol, Conventional Curing

I. INTRODUCTION

Self-curing is also called by other name i.e, "Internal curing" and is defined as the phenomena in which the hydration of cement occurs by extra-internal water that is not included in mixing water. Internal curing concrete can be done by using self-curing agents; the function of self-curing agents is to reduction of the vaporization of water from the concrete, due to this the water folding capacity of concrete increases. Water soluble polymers are used in the curing of concrete, due to proper curing the microstructure and pore structure of concrete develops due to this durability and performance of concrete increases. the self curing in the concrete can be achieved by light weight aggregates also the water held in the pores of light weight aggregates will acts as a reservoir at the time of curing that water is used at time of curing, In day today life the scarcity of water is increasing day by day, some structures in the hilly areas are not reached so easy, due to human negligence's the proper curing is not achieved hence we have to think of alternate solution for curing.

A. *Mechanism of Self Curing Concrete*

After concreting the concrete surfaces are exposed to external environment, the environmental factors like pressure and temperature will affect curing by evaporation of water molecules, and hydration of cement will releases lot of heat this will also increase the rate of evaporation when the polymer based chemicals are added to the concrete the chemical will develops the hydrogen bond with the water molecules that reduces the free energy between the water molecules due to this vapour pressure is decreases and then rate of vaporization from the exposed surface of the concrete is decreases.

B. *Significance of Self Curing*

Curing is important process in order to gain the strength, if the rate of evaporation of free water available in the concrete is high due to high temperature and hydration process of cement, when this free water is not easily available during hydration process micro cracks are formed in the concrete that will creates the empty pores insides the cement paste, the hydration of cement is fast during early stage hence curing is necessary during early stage, if proper curing is not done in early stage leads to micro cracks.

C. *Potential Materials for Self Curing*

The following materials can provide internal water reservoirs:

1) Light Weight Aggregates(LWA)
2) Light Weight Sand(LWS)
3) Super Absorbent Polymers(SAP)
4) Shrinkage Reducing Admixtures; like polyethylene glycol (PEG)
5) Wood powder

II. OBJECTIVES OF PROJECT

The aim of this investigation is to solve the problems of improper curing. In India many areas have water problem, even it is difficult to get the water for drinking in such cases we have to go for self-curing concrete using shrinkage reducing admixtures like Poly Ethylene Glycol (PEG) and along with this chemical use of light weight LECA aggregates which having higher water absorption rate the water held in the pores of LECA aggregates will acts as a reservoir which will provide the water at the time of curing. Some of the following objectives are listed below;

1) The main objective of our project is to solve the problems of improper curing.
2) To find the optimum dosage of shrinkage reducing admixture Polyethylene glycol PEG 400 for M30 grade concrete in which coarse aggregates is replaced by 10% LECA aggregates.
3) To study the workability properties of self-curing concrete and the conventional curing concrete.
4) To find out the suitability of Polyethylene glycol PEG 400 and the light weight LECA aggregates as the potential materials of self-curing concrete.
5) To examine the mechanical properties of self-curing concrete and conventional curing concrete.

III. Materials Used

A. Cement:

This project work has been carried out by using OPC 53 grade of (CCI cement) the properties of cement are given below in Table 1.

Sl.no	Properties	Value
1	Specific Gravity	3.15
2	Normal Consistency	31.5%
3	Initial Setting Time	1Hr 30 Minutes
4	Final Setting Time	3Hr 45 Minutes
5	Soundness	1mm

Table 1: Properties of Cement

B. Fine Aggregate (Sand)

In our present project work the locally available natural river sand is used. The sand is brought from the bed of the Bhīma River which is the major tributary of the Krishna River. The Properties of sand are shown in Table 2.

Sl.no	Properties	Value
1	Size and Zone	4.75mm down(Zone II)
2	Specific Gravity	2.65
3	Water Absorption	1.4%
4	Moisture Adsorption	2%
5	Fineness modulus	3.95

Table 2: Properties of Fine Aggregates

C. Coarse Aggregates

In our present project work the coarse aggregate basalt is used. The basalt was supplied from Prabhudev Stone Crushing Unit, Sedam road, Kalaburagi, Karnataka, India. The properties are shown below Table 3.

Sl.no	Properties	Value
1	Size	20mm down
2	Specific Gravity	2.81
3	Water Absorption	1.2%
4	Moisture Adsorption	0.806%
5	Shape	Angular

Table 3: Properties of Coarse Aggregates

D. LECA (Light Expanded Clay Aggregates)

In our project LECA is used as the self curing agent along with the polyethylene glycol chemical, the LECA aggregates are produced in the kiln at a temperature of about 1200ºC to 1500º C, the LECA aggregate has better sound insulation, thermal insulation and having higher water absorption capacity. In the present study LECA was obtained from RTEC Inc., ® India, Chennai, TamilNadu.

Properties of LECA aggregates are listed below Table 4.

Sl.no	Properties	Value
1	Size	8 to 16mm
2	Specific Gravity	1
3	Water Absorption	24.9%
4	Saturated Density	550 kg/m^3
5	Dry Density	292.3 kg/m^3
6	Shape	Rounded(Pink)

Table 4: Properties of LECA Aggregates

E. Water

In the present project work portable water is used for both mixing and curing of conventional concrete. And it should not contain any salts.

F. Polyethylene Glycol

The Polyethylene glycol is a polymer grouped chemical having the combination of carbon, hydrogen, oxygen atoms in it and having the formula $H(OCH_2CH_2)$ n OH, and n is the common number indicates the repeated oxyethylene groups and is varied between 4 to 180 .this chemical available in the semisolid and liquid states the viscosity of liquid is somewhat more than the water ,this chemical smells like alcohol, transparent liquid easily mix with the water, other than using it as self curing agents it is used in various medical industries, chemical industries ,and also used in cosmetics. The work of polyethylene chemical is to reduce the evaporation of internal water used at the time of mixing when the concrete surfaces are exposed to hot sun. In our present project work we have use the PEG 400 that means (polyethylene glycol of molecular weight 400).this chemical is exported or borrowed from the CHEMSOL CENTRE, #68, first main, fourth cross, sudham nagar, Bangalore, Karnataka, India.

IV. Methodology and Casting of Specimens

In our project only mechanical properties of conventional curing (P0-0% PEG (weight of cement)) and 10% dry LECA aggregates) and in case of self-curing both PEG 400 chemical is varied in the 0.5%, 1%, 1.5%, 2% (by weight of cement) and 10% presoaked LECA aggregates are used for each variation of chemical. The properties of concrete are studied for M30 concrete using IS10262-2009.

Mix proportion obtained from mix design is as follows

Mix proportion=1:1.48:2.68 AND W/C=0.45

Material	Amount in kg/m^3
Cement	438.13
Sand	650.89
Aggregates	1175.19
Water	197.16

Table 5: Mix Proportion

Sl. No	Mix designation
1	P0=0%PEG and 10% dry LECA Aggregates.
2	P1=0.5%PEG and 10% presoaked LECA aggregates.
3	P2=1%PEG and10% presoaked LECA aggregates
4	P3=1.5%PEG and10%presoaked LECA aggregates
5	P4=2%PEG and 10%PEG presoaked LECA aggregates

Table 6: Mix Designations

Each of the above Mix Designations 3 Cubes, 3 Cylinders,3 Prisms are casted, the fresh properties (workability) like slump test and compaction factor are tested before placing the concrete in the moulds as the concrete in the fresh state for all the mix designations, After testing the fresh properties of concrete, the fresh concrete is placed in the moulds and are de-moulded after 24 hours and then P0 mix designated specimens are normally water cured for the period of 7,14 & 28 days respectively, and other mix designated specimens like P1,P2,P3,P4 are kept at shaded dry place (self-curing) for the period of 7,14 & 28 days respectively, and tested after the curing period.

V. RESULTS AND DISCUSSIONS

A. Fresh Concrete Results

The fresh properties (workability) like slump and compaction factor test were conducted and the results are shown in the below table 7.

Sl. No	Mix designation	Slump in mm	Compaction factor
1	P0	84	0.86
2	P1	106	0.88
3	P2	132	0.91
4	P3	158	0.93
5	P4	186	0.96

Table 7: Slump and Compaction Factor Values

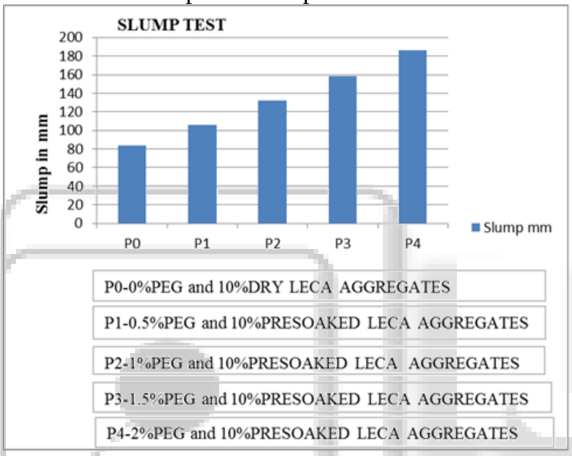

Fig. 1: Slump Value for Different Designations

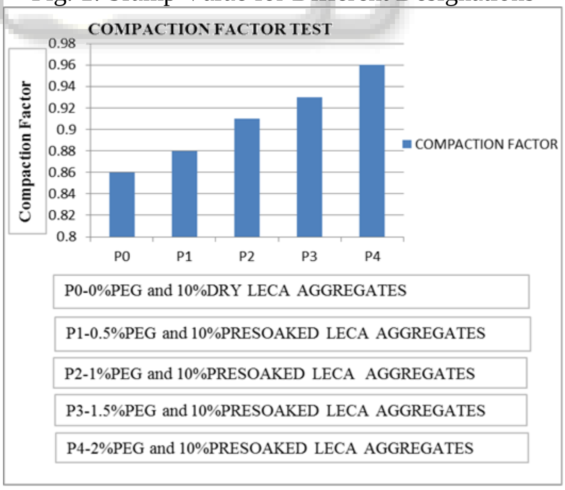

Fig. 2: Compaction Factor Value for Different Designations

B. Compressive Strength Test

The cubes compressive strength results are listed in the following table 8.

Sl. No	Mix Designation	Compressive strength in N/mm²		
		7 Days	14 Days	28 Days
1	P0	25.32	3.045	36.78
2	P1	26.13	31.19	37.62
3	P2	27.35	31.85	38.15
4	P3	25.48	29.69	36.31
5	P4	24.17	27.79	34.18

Table 8: Compressive Strength Results

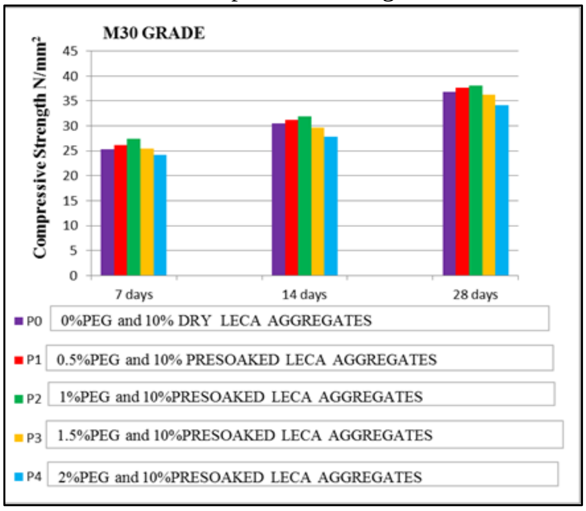

Fig. 3: Compressive Strength for Different designation

C. Split Tensile Strength Test

The spit tensile strength test results are listed in table 9.

Sl. No	Mix Designation	Spit tensile strength in N/mm²		
		7 Days	14 Days	28 Days
1	P0	1.29	1.73	2.11
2	P1	1.42	1.84	2.23
3	P2	1.53	1.92	2.36
4	P3	1.31	1.76	2.13
5	P4	1.23	1.70	2.05

Table 9: Split tensile Strength Results

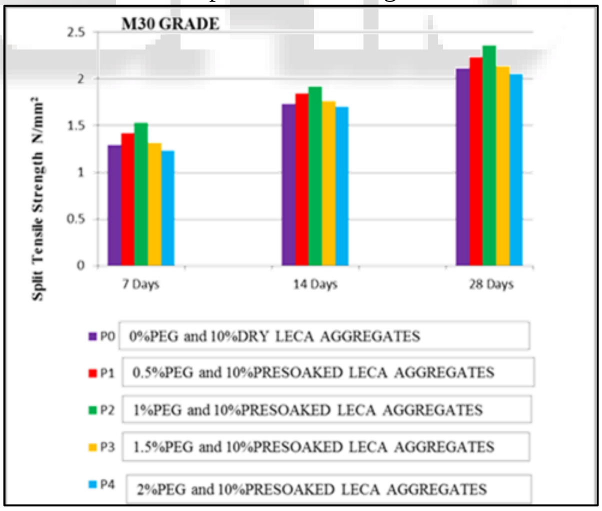

Fig. 4: Split Tensile Strength for Different designation

D. Flexural Strength Test

The flexural strength test results are listed in Table 10.

Sl. No	Mix Designation	Flexural strength in N/mm²		
		7 Days	14 Days	28 Days
1	P0	2.79	3.36	4.06
2	P1	2.88	3.44	4.15
3	P2	3.03	3.86	4.23
4	P3	2.76	3.35	4.105
5	P4	2.64	3.27	4.005

Table 10: Flexural Strength Results

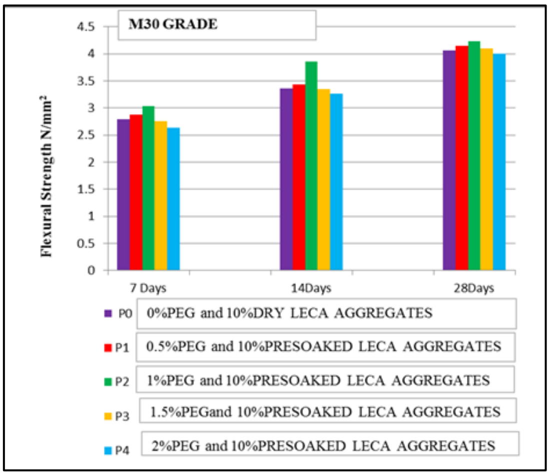

Fig. 5: Flexural Strength for Different Designations.

VI. Conclusions

1) The optimum dosage of PEG 400 was found out to be 1%for M30 grade concrete in which coarse aggregates are replaced by 10%LECA aggregates.
2) As the percentage of PEG 400 increases the workability properties like slump and compaction factor increases.
3) The compressive strength of self curing concrete using 1%PEG 400 chemical and 10% coarse aggregates are replaced by presoaked LECA aggregates is more than the conventional curing concrete using 0% PEG 400 and 10% coarse aggregates are replaced by dry LECA aggregates.
4) The spit tensile strength of self curing concrete using 1%PEG 400 chemical and 10% coarse aggregates are replaced by presoaked LECA aggregates is more than the conventional curing concrete using 0% PEG 400 and 10% coarse aggregates are replaced by dry LECA aggregates.
5) The flexural strength of self curing concrete using 1%PEG 400 chemical and 10% coarse aggregates are replaced by presoaked LECA aggregates is more than the conventional curing concrete using 0% PEG 400 and 10% coarse aggregates are replaced by dry LECA aggregates.
6) Self curing concrete will solve the many problems of improper-curing. and it is found to be beneficial in water scarcity areas or hot areas where the rate of evaporation of water is more.

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