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Experimental investigation of strength of self curing concrete incorporated with light weight aggregate as mineral admixture

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Abstract - *In present study the internal curing or self curing is achieved by adding Light weight aggregate namely Light weight expanded clay aggregate (LECA) in replacement of coarse aggregate. Seven mixes of M40 grade were casted and tested with varying percentage of LECA in replacement of coarse aggregate i.e. 0%, 5%, 10%, 15%, 20% and 25%. Among these, first and second mix (M1 & M2) were nominal mixes with 0% LECA. M1 was cured in a curing tank whereas M2 by wet gunny bags. These specimens were then tested for Compressive strength, Split tensile strength, Flexural strength, ultrasonic pulse velocity and continuous immersion in salt water. Results shown that replacing coarse aggregate with LECA up to 10% will produce improvement in strengths in compression, tension and flexure also this mix has shown good resistance to chloride attack when tested in continuous immersion test with improvement of 10.74% in compressive strength. Whereas mix with 15% LECA has shown excellent quality of concrete in ultrasonic pulse velocity test and attained adequate strengths in compression and flexure. This leads to conclude that the optimum content of LECA in replacement of course aggregate in concrete should be 10% and it should not exceed 15% for attaining the required strength.*

Key Words: Self curing, Light weight aggregate, Light weight expanded clay aggregate, Polyethylene glycol , Compressive strength, split tensile strength, flexural strength, Ultrasonic pulse velocity, Chloride attack.

1. INTRODUCTION

At the point when the mineral admixtures respond totally in a mixed concrete framework, their interest for relieving water (outside or inward) can be a lot more prominent than that in a customary common Portland concrete cement. At the point when this water isn't promptly free, because of depercolation of the hairlike porosity, for instance, huge autogenous distortion and (early-age) breaking.

Because of the substance shrinkage happening during concrete hydration, void pores are made inside the concrete glue, prompting a decrease in its inner relative stickiness and furthermore to shrinkage which might cause early-age breaking. This present circumstance is heightened in HPC (contrasted with traditional cement) because of its by and large higher concrete substance, decreased water/concrete (w/c) proportion and the pozzolanic mineral admixtures (fly debris, silica smolder). The vacant pores made during self-drying up initiate shrinkage stresses and furthermore impact the energy of concrete hydration process, restricting the last level of hydration. Frequently uncommonly in HPC, it isn't effectively imaginable to give restoring water from the top surface at the rate expected to fulfill the continuous synthetic shrinkage, because of the very low porousness frequently accomplished. To defeat such circumstances there is a need of water in concrete inside for complete hydration to accomplish the normal strength. This is accomplished by Inside relieving utilizing various specialists which give the water to hydration through narrow activity even after dissipation outside restoring water. In present review the inward restoring is accomplished with the assistance of Light weight expanded clay aggregate (LECA).

1.1 Definition of Internal Curing (I.C.)

The ACI-308 Code expresses that "inward curing alludes to the interaction by which the hydration of concrete happens in view of the accessibility of extra inner water that isn't important for the blending Water." Traditionally, relieving substantial means making conditions to such an extent that water isn't lost from the surface i.e., relieving is taken to happen 'from an external perspective to inside'. Conversely, 'inner relieving' is taking into consideration restoring 'from within to outside' through the interior supplies made. 'Inside relieving' is frequently likewise alluded as 'Self-curing.'

1.2 Light Weight Aggregate

Lightweight aggregates are those minerals, regular stone materials, items, and results of assembling processes that are utilized as mass fillers in lightweight underlying concrete, substantial workmanship units, precast cement primary items, street surfacing materials, mortar totals, and protecting fill. Light weight extended mud total is kind of light weight total fabricated by pyro handling in turning oven.

2. LITRATURE REVEIW

A. Mueller, S.N. Sokolova b, V.I. Vereshagin[1] "Attributes of lightweight totals from essential and reused unrefined components" in Elsevier diary , (2008), pp 703-712, Carried out examinations in the research facility and in the pilot plant have exhibited that the range of constituents reasonable for lightweight total creation can be widened. Reasonable are zeolite rocks, of which there are stores in numerous locales of Russia. In Germany, stone work rubble could be utilized as elective natural substance. The innovative cycle for the production of the granules is comparable for the two materials.

Dayalan J, Buellah. M[2] "Inward restoring of substantial utilizing prewetted Lightweight Total" in Global Diary of imaginative Exploration in Science , Designing and innovation, Walk 2014 pp 10554-10560, closed after trial examination that the inside relieved concrete is ended up being superior to traditionally restored concrete definitely. The utilization of lightweight total for inner restoring of cement is especially advantageous as it diminishes different shrinkage breaks. The compressive strength for the inside restored concrete brought about values 20% higher when contrasted with the plain concrete. Empowers a high relative stickiness inside the pore design of the substantial which diminishes inward drying and expands hydration process which subsequently builds strength and toughness of the substantial.

Patel Manishkumar Dahyabhai, Prof. Jayeshkumar R. Pitroda[3], "Presenting Oneself Relieving Concrete in Development Industry"in Global Diary of Designing Exploration and Innovation, Walk 2014,pp 1286-1289 find an end that Compressive strength of self-restoring concrete is expanded by applying oneself relieving admixtures. The compressive strength of substantial blend expanded by 37% by adding 1.0% of PEG600 and 33.9% by adding 1.0% of PEG1500 when contrasted with the regular cement. The ideal measurements of PEG600 for greatest compressive qualities was viewed as 1% of weight of concrete for M25 grades of cement. The ideal dose of PEG1500 for most extreme compressive qualities was viewed as 1% of weight of concrete for M25 grades of cement. Self-relieving concrete is the best answer for the issues looked in the desert area and looked because of absence of appropriate restoring.

Alaa A. Bashandy [4], "Execution of Self relieving concrete at raised temperatures" in Indian Diary of Designing and Material sciences, February 2105, pp 93-104, finished up the discoveries after series of examinations to research remaining strength of OC and SCC exposed to raised temperature going from 200oC to 600oC for warming span between 2hours to 4 hours that leftover SCC is chiefly impacted by to target temperature, warming time and cooling technique. The Deficiency of solidarity of SCC increments with raised temperature and uncovered period. Air cooling is more powerful than water cooling at high temperatures. Utilizing water cooling is appropriate for SCC up to 400oC with warming time as long as 2 hours as it were. At last reasoned that one can enact utilization of SCC at raised temperature.

Ahmad Mustafa Sabaoon, Navinderdeep singh [5], "A Survey Paper on Self Restoring Concrete", Worldwide Exploration Diary of Designing and Innovation (IRJET), January 2018, pp 745-747, saw that As a self-relieving specialist the polyethylene glycol - 400 or polyethylene glycol - 600 is a decent admixture and by adding of 1% of this admixture for M25 and M20 grade of substantial it had great outcome however adding 2% of polyethylene glycol diminished strength of cement. From considering of many papers it found that strength of self-restoring concrete is more than traditional cement. We can utilize wood powder as self-restoring specialist. Self-restoring concrete is the way for tackling the trouble confronted with relieving. Self-relieving concrete is the most appropriate response for desert region where the accessibility of water is exceptionally less or not accessible.

Amal Viswam1, Arjun Murali2[6], "Survey on the investigation of self relieving concrete", in IJARIIE, January 2018, pp 271-274, shown a review that Water maintenance for the substantial blends consolidating self-restoring specialist is higher contrasted with traditional substantial blends, as found by the weight reduction with time, Self-relieving concrete brought about better hydration with time under drying condition contrasted with regular cement, Water transport through self relieving concrete is lower than air-restored customary cement and Rut esteem increments with expansion in the amount of Stake 5 Self relieving concrete is the solution to numerous issues looked because of absence of legitimate relieving.

Tuptewar Shriprasad Madhavrao, Unde Rajeshwar Houshiram, Rukare Suraj Sangappa, Salunkhe Shubhamkumar Suresh [7], "Review and plan of self relieving concrete for m30 grade", Worldwide Exploration Diary of Designing and Innovation, May 2017, pp 1076-1078, Researched Water maintenance of cement containing self restoring specialists, Substantial weight reduction and inward relative dampness estimations with time were completed, to assess the water maintenance of self restoring concrete. Non-evaporable water at various ages was estimated to assess the hydration. Water transport through concrete is assessed by estimating absorption%, porous voids%, water absorptivity, and water penetrability. The water transport through self-relieving concrete is assessed with age. The impact of the substantial blend extents on the presentation of self-restoring concrete and closed from the tests led, it is seen that self-relieving concrete doesn't have shrinkage as contrasted and ordinary concrete and self-restoring concrete is more conservative in view of it wipe out the relieving charges.

2.1 Gap in literature

The literature study has shown that there are attempts made to find the strength of self curing concrete using different agents. Particularly lightweight aggregate is added in a concrete mix in percentile replacement of fine aggregate with which the required strength is not attained unless a shrinkage reducing admixture i.e. Polyethylene glycol (PEG) is added in proportion of weight of cement. When we treat LWA as building material for sustainable development it should produce good result as far as strength of concrete mix is concerned without addition of PEG as manufacturing of PEG has its own Environmental Impact. Hence self curing concrete should be prepared using lightweight Expanded Clay Aggregate as a mineral admixture in certain percentiles of weight of coarse aggregate and strength of this mix should be tested. Even if it attains expected strength of concrete without usage of PEG this will be also great initiative towards water conservation and sustainable development.

3. METHODOLOGY

3.1 Material properties

Cement-The Ordinary Portland Cement of 43 grade conforming to IS: 12269-1987 is used. Various tests were performed to find the properties of cement. The specific gravity of cement was found to be 3.16. The standard consistency of cement was obtained to be 40% .The initial and final setting times for cements are found to be 145 minutes and 265 minutes.

Coarse Aggregate -The fractions from 20 mm to 4.75 mm are used as coarse aggregate, conforming to IS: 383 is used. The properties of coarse aggregates such as specific gravity were found to be 2.69 and water absorption was 3.08%. The fineness modulus obtained was 2.672.

Fine Aggregate- The fine aggregate type used in the study was manufactured sand. The manufactured sand is screened to eliminate over size particles. According to IS: 383 the fine aggregate conforming to zone I was used. The properties of sand such as specific gravity was found to be 1.567 and water absorption was 16.29%. Fineness modulus obtained is 3.12

Light Weight Aggregate- For the present work lightweight aggregate used was light weight expanded clay aggregate (LECA). The light weight aggregate of the fraction between 7 and 15 mm has a specific gravity of 0.253. This LECA will be surface coated with lime powder in order to reduce the porosity of LECA. The specific gravity of this lime coated LECA is found to be 0.557 with water absorption of 31.25%.The fineness modulus obtained as 2. 67.

Water- Potable water.

Lime powder -To provide surface coating on LECA lime powder of specific gravity 2.26 was used.

Superplasticizer - Conmix SP1030 was superplasticizer used for making M40 grade of concrete. Marsh cone test was conducted for determining the saturation point and optimum dosage of this superplasticizer results of which are mentioned in below table. The saturation point is observed on 1.1% dosage of superplasticizer i.e. 22ml for 2Kg of cement.

3.2 Casting program

Casting programme consists of

- Preparation of moulds as per IS 10086:1982, preparation of materials, weighing of materials and casting of cubes, beams and cylinders.

- Mixing, compacting and curing of concrete to be done according to IS 516:1959.

- Concrete mix are to be prepared as per design mix and for each mix following specimens of both conventional and self curing concretes are to be casted.

Cubes of size 150mm X 150mm X150mm

Cylinder of size 150mm diameter and 300mm height

Beam of size 150mm X150 mm X700 mm

Table -1: Mix proportion of material per m^3

Sr. No	Mix	Cement (Kg)	Coarse Aggregate (Kg)	Natural Fine Aggregate (Kg)	Light Weight Fine Aggregate (Kg)	Water (Lit)
1	M1(M40,0 % LECA, convention al curing)	450	1063	588	0	157
2	M2(M40,0 % LECA, wet gunny bag curing)	450	1063	588	0	157
3	M3 (LECA 5%)	450	1009.8 5	588	11	157
4	M4 (LECA 10%)	450	956.7	588	22	157
5	M5 (LECA 15%)	450	903.55	588	33	157
6	M6 (LECA 20%)	450	850.4	588	44	157
7	M7 (LECA 25%)	450	797.25	588	55	157

Self-cured specimens should be developed using self-curing agents like light weight expanded clay aggregate.

Initial mix (M1) is prepared without using light weight expanded clay aggregate and cured in curing tank. Then another conventional mix (M2) is prepared and cured under wet gunny bags like generally columns and other vertical members are cured in field. Then the specimens made by adding different percentages of light weight expanded clay aggregate. The cubes which are intended for self-curing should be kept in indoor/shade at room temperature and cured by wet gunny bags.

The mix design and material required for mix are shown in Table 1.

Table -2: Statistics of test specimen

Sr. No	Mix	No. of cubes	No. of beams	No. of cylinders
1	M1(M40,0% LECA)	12	3	3
2	M2(M40,0% LECA)	12	3	3
3	M3 (LECA 5%)	12	3	3
4	M4 (LECA 10%)	12	3	3
5	M5 (LECA 15%)	12	3	3
6	M6 (LECA 20%)	12	3	3
7	M7 (LECA 25%)	12	3	3
	Total	**84**	**21**	**21**

3.3 Testing program

To find the properties of self-relieving concrete the accompanying test were directed on both self-restored concrete and customary cement.

Compressive Strength Test-The shape examples of size 150mm X 150 mm X 150 mm were tried on compression testing machine. The bearing surface of machine was cleared off clean and sand or other material eliminated from the outer layer of the example. The example was put in machine in such a way that the heap was applied to inverse sides of the 3D shapes as casted that is on top and base. The heap applied was expanded ceaselessly at a consistent rate until the obstruction of the example to the rising burden separates and never again can be supported. The maximum load applied on sample was recorded. Compressive strength is determined utilizing the formulae

fc = p/A,

Where, p is the maximum load

An is the cross-sectional area

Split tensile strength Test-The cylindrical samples of size 150 mm breadth and 300 mm level were tried on compression testing machine and the load is applied until the disappointment of cylinder along the upward width. When the load is applied along the generatrix an element on the vertical diameter of the cylinder subjected to a horizontal stress and found the split tensile strength using subsequent formulae. Split tensile strength is calculated using the formulae

$$fct=2P/\pi dl$$

Where, P= maximum load in Newton applied to the specimen

l = length of the specimen (in mm),

d = cross sectional dimension of the specimen (in mm)

Flexural Strength Test-Flexural strength is the capacity of pillar or chunk to oppose disappointment in bowing. The bar examples of size 150 mm X 150 mm X 700 mm were tried on pressure testing machine. The flexural strength is communicated as modulus of crack in N/mm^2. The heap applied was expanded persistently at a consistent rate until the obstruction of the example to the rising load separates and never again can be maintained. The maximum load applied on example was recorded. Flexural strength is determined utilizing the formulae

$fb= pl/bd^2$

Where p = maximum load

l= length of the specimen

b= breadth

Ultrasonic pulse velocity test-In this test technique, the ultrasonic pulse is delivered by the transducer which is held in touch with one surface of the substantial part under test. In the wake of crossing a known way length L in the substantial, the pulse of vibrations is changed over into an electrical sign continuously transducer held in touch with the other surface of the substantial part and an electronic timing circuit enables the transit time (T) of the pulse to be measured. The pulse velocity (V) is given by:

V = L/T

Continuous immersion test-The shape example of 150mm side are ready and relieved for 28 days in curing tank and afterward these example are cured in 5% salt water solution for 28 days. The compressive strength of these cubes is tested in Compression testing Machine (CTM). This strength is contrasted and traditionally restored substantial shapes. It gives the impact of chloride on concrete.

4. RESULTS

Following test results were obtained after conducting above said tests.

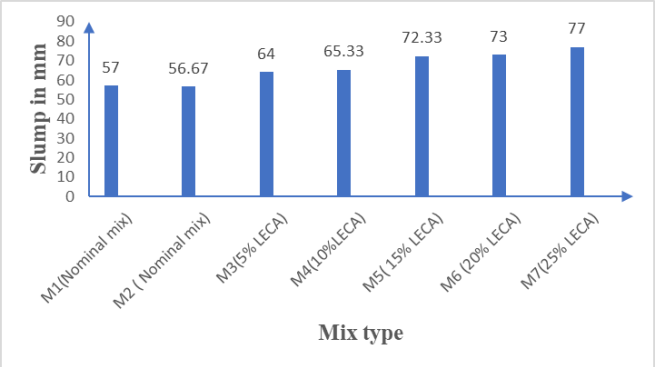

Chart -1: Graphical analysis of slump test results

Table -3: Compressive strength test results

Mix	Mean Compressive strength		
	7 days	14 days	28days
M1(Nominal mix)	41.63	43.6	52.34
M2 (Nominal mix)	40.87	42.4	49.24
M3(5% LECA)	42.19	47.42	49.91
M4(10%LECA)	49.76	53.27	67.2
M5(15% LECA)	43.17	57.13	61.39
M6 (20% LECA)	37.14	45.89	48.58
M7(25% LECA)	33.59	37.54	43.76

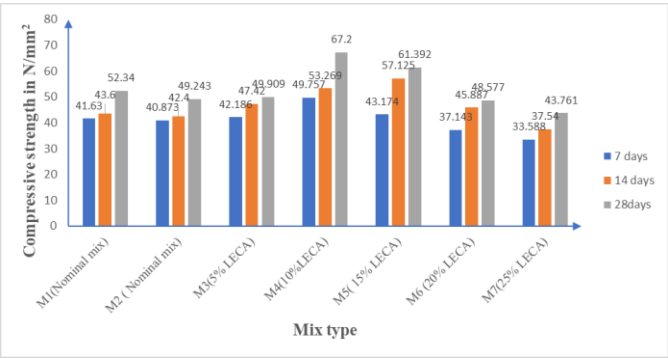

Chart -2: Graphical analysis of compressive strength test results

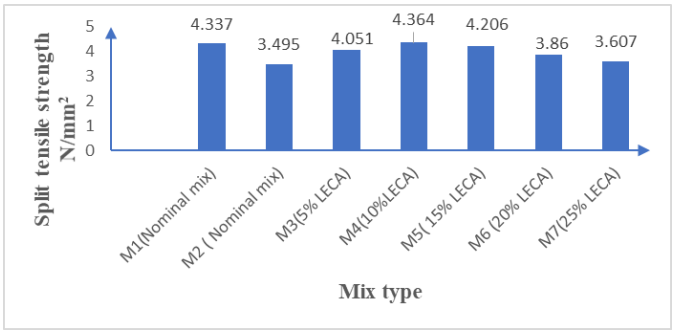

Chart -3: Graphical analysis of split tensile strength test

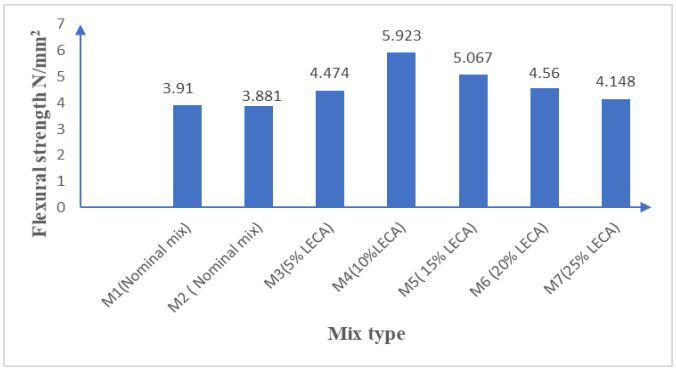

Chart -4: Graphical analysis of flexural strength test

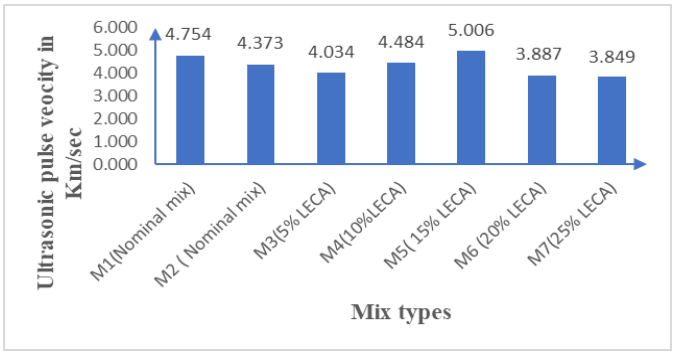

Chart -5: Graphical analysis of Ultrasonic pulse velocity test results

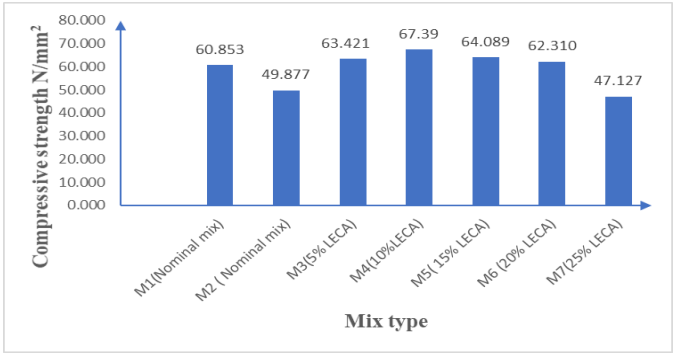

Chart -5: Graphical analysis of Continuous immersion test results

3. CONCLUSIONS

From the study of results obtained following conclusions are made

1. From results of Slump cone test it can be concluded that greater percentage of LECA makes concrete more workable.

2. From Compressive strength test results it can be concluded that for good results 10% LECA can added in replacement of coarse aggregate as it has shown improvement in compressive strength of mix up to 28.39 % as compared to nominal mix M1.

3. M5 mix (i.e. concrete with 15% LECA replaced against coarse aggregate) has attained maximum compressive strength after M4 (10% LECA) and that to more than nominal mix M1 with improvement of 17.29 %.

4. The compressive strength attained by concrete with 10% LECA and 15% LECA after 14 days curing is more than that of nominal mix after 28 days, it can be concluded from this that these mix are attaining the required strength in half of the time required for nominal concrete mix. This make the use self curing concrete beneficial in rigid pavements where curing period makes trouble to passenger after construction or repair work of pavement.

5. The split tensile strength test results shows that increasing percentage of LECA beyond 10% may lead to reduction in split tensile strength of concrete.

6. Flexural strength of nominal concrete mix is lesser than that of mixes incorporated with LECA in replacement of coarse aggregate at different percentages. Also M4 (mix with 10% LECA) has shown improvement in flexural strength by 51.48% and that in M5 (mix with 15% LECA) is found up to 29.59% as compared to nominal mix M1.

7. Quality grading of nominal mix M1 and M5 (mix with 15 % LECA) was observed as 'Excellent' while that of all other mixes was seen to be 'Good' on the basis of Ultrasonic pulse velocity test. Which shows that concrete with 15% LECA is as durable as nominal concrete mix.

8. Continuous immersion test results shows that insufficient curing to the nominal mix may lead to threat of chloride attack while concrete with LECA is observed to be resistive to the chloride attack even though it is cured under wet gunny bags. However compressive strength of M4 and M5 (i.e. with 10% and 15% LECA) was observed to get improved by 10.74 % and 5.31% respectively.

9. From above findings it can be concluded that Optimum percentage of LECA in concrete for good performance in all aspects can be taken as 10% to 15% in replacement of coarse aggregate.

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