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EFFECT OF LECA ON CORROSION RESISTANCE OF SELF-CURING CONCRETE

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Abstract: Self-curing concrete using pre-saturated lightweight particles is a well-established way of preventing self-desiccation and autogenous shrinkage. The current research compares self-curing concrete qualities with LECA as self-curing agents for water retention. In this investigation, lightweight aggregate (LECA) 0 percent, 10%, 15%, 20%, and with nano silica 1%, 2%, and 3% by volume percent were chosen. The strength property of M30 grade concrete was found. Mechanical parameters such as compressive strength, split tensile strength, and flexural strength are evaluated on a regular basis up to 28 days after curing. Concrete containing LECA produces the greatest results across all curing regimes, with high water retention and strong mechanical qualities.

Keywords: *lightweight aggregates , LECA*, Corrosion resistance ,Nano silica;

1 INTRODUCTION

Concrete is one of the most often utilised building materials on the planet. Curing is required for conventional concrete, which is a combination of cement, fine aggregate, coarse aggregate, and water. Curing for a minimum of 28 days is necessary for proper hydration and achieving goal strength. The characteristics of hardened concrete are greatly influenced by curing. Curing concrete is the process of maintaining the moisture and temperature conditions of concrete such that the hydration reaction continues regularly and the concrete acquires hardened qualities over time. Concrete curing has a significant impact on the strength and durability of the material. Improper curing may easily impair the performance and durability of concrete. External curing is used after mixing, putting, and finishing in traditional curing. Water is the most used commodity, and as a result, the water table level is dropping on a daily basis. If water must be acquired for building purposes, the cost of construction skyrockets. Continuous curing is also challenging in the case of high-rise concrete construction, vertical members, sloping roofs, and pavements.

When concrete is exposed to the environment, water evaporates and the loss of moisture reduces the initial water-cement ratio, resulting in inadequate hydration of the cement and thereby degrading the quality of the concrete. Wind velocity, relative humidity, air temperature, the water-cement ratio of the mix, and the kind of cement used in the mix all have an impact on the hydration process. Evaporation causes plastic shrinkage cracking during the first stage of setting and drying shrinkage cracking during the latter step of setting. One of the key parameters influencing the pace of strength growth is the curing temperature. Ordinary concrete loses strength at high temperatures owing to the production of fractures between two thermally incompatible elements, namely cement paste and particles. Self-curing chemicals primarily aid in water retention in concrete by minimising evaporation during the hydration process. Self-cured concrete retains water from evaporation better than traditional concrete.

2. LITERATURE REVIEW

A review of the literature on the work done by many authors on self-curing concrete by adding certain self-curing chemicals; they are useful in carrying out the current study's work. A. S. El-Dieb and colleagues [1] looked into Water retention is greater in self-curing concrete mixes than in traditional concrete mixes, as measured by weight loss over time. When compared to conventional concrete, self-curing concrete experienced reduced self-desiccation under sealed settings. When compared to traditional concrete, self-curing concrete resulted in improved hydration with time under drying conditions. Water transfer is lower in self-curing concrete than in air-cured conventional concrete. Water sorptivity and permeability values for self-curing concrete declined with age, showing a decreasing percentage of permeable pores as a consequence of cement hydration. Pamnani Nanak and others [2] Polyethylene Glycols were used to study self curing self compacting concrete (SCSCC) in this article (PEGs). The influence on compressive strength of M30 grade SCSCC with typical immersion curing and dry curing techniques is reviewed and compared. Curing with Polyethylene Glycol–600 (PEG600) results in extremely excellent compressive strength after 28 days, about 95 percent of the strength produced with immersion curing; nevertheless, early age compressive strength of specimens is substantially lower than immersion treatment. Curing with Polyethylene Glycol–1500 (PEG1500) at 28 days results in compressive strength that is about 89 percent of the strength obtained with immersion curing and a comparable early age compressive strength. Sri Rama Chand Madduru and colleagues [3] investigated the effect of self-curing chemicals in self-compacting mortars. PEG 4000 and PEG 200 were utilised as self-curing agents in this investigation. These compounds cure the mortars inside, resulting in increased hydration and C–S–H gel formation. Two self compacting mortars, 1:1 with a water-cement ratio of 0.34 and 1:3 with a water-cement ratio of 0.5, are examined in this study using two self curing agents (Poly Ethylene Glycol 4000 and PEG 200). The compressive strength of self-cured self-compacting mortar specimens was approximately equivalent to that of wet-cured specimens. In Mix-A (water-cement ratio 0.34), self compacting mortar specimens containing 0.5 percent PEG 200 and 1.0 percent PEG 4000 demonstrated 27.8 percent and 45.2 percent higher compressive strength than uncured specimens. In Mix-B (water-cement ratio 0.5), 1.0 percent PEG 200 and 0.1 percent PEG 4000 increased compressive strength by 28.9 percent and 49.5 percent, respectively, as compared to uncured specimens. SEM pictures of self-cured mortars show improved microstructure owing to better hydration than samples of uncured mortar. Self-cured self-compacting mortars were found to have a dense pore structure and low porosity. Patel Manishkumar Dahyabhai et al. [4] investigated the use of Poly Ethylene Glycol as an additive in traditional concrete to improve hydration and hence concrete strength. In this research paper, the individual effect of admixture PEG600 & PEG1500 on strength properties of concrete by varying the percentage of PEG600 and PEG1500 by weight of cement 0.5%, 1.0%, 1.5% and 2% were studied. According to the findings, PEG600 and PEG1500 might aid in achieving the strength of traditional curing. It was also found that 1% of both PEG600 and PEG1500 by weight of cement was optimum for M25 grade concrete for achieving maximum strength without compromising workability. The test result indicates that use of water soluble polymers in concrete has improved performance of concrete. They concluded that the compressive strength of self curing concrete was increased by applying the self-curing admixtures such as PEG 600, PEG 1500 by 37% and 34% respectively. Vedhasakthi and Saravanan [5] studied the workability and strength characteristics of Normal Strength and High Strength Concrete, cast with the self curing agents have been studied and compared with the corresponding conventionally cured concrete. For the Normal Strength Self Curing Concrete of grade M20, M30 and M40, IS method of mix design was adopted. Mix proportions of High Strength Self Curing concrete of grade M60, M70 and M80 were obtained based on the guidelines given in modified ACI 211 method suggested by P.C.AITCIN. Super plasticizer dosage was varied with grade of concrete. Trial dosages of 0.8%, 1% and 1.2% of the weight of cement were used for M60, M70 and M80 grades of concrete respectively. Two self curing agents have been tried, out of which one has been found to be very effective. Trial dosage of 0.25% and 0.3% of the weight of cement was used for normal strength concrete and trial dosage of 0.4% of the weight of cement was used for High Strength Concrete. From the workability test results, it was found that the self curing agent has improved workability. It is found that concrete with this self curing agent gives more strength than that of the conventionally cured concrete. Also the percentage saving in cost of water has been found out and hence Self Curing Concrete holds economical. For M20 grade concrete the maximum compressive strength was 27.4 Mpa which is increased by 4.0% with the addition of 0.3% of PEG. For M30 grade concrete the maximum compressive strength was 37.32 Mpa which is increased by 6.56% with the addition of 0.3% of PEG. For M40 grade concrete the maximum compressive strength was 46.35 Mpa which is increased by 2% with the addition of 0.3% of PEG. For M60, M70 and M80 grade concrete the maximum compressive strength increased by 2%, 1.5% and 3.2% respectively with the addition of 0.4% of PEG. Magda Mousa, et al. [6] studied physical properties of self-curing concrete (SCUC). In this study the effect of two different curing-agents has been examined in order to compare them for optimizing the performance of concrete. The first used type is the Pre-soaked lightweight aggregate (leca) with different ratios; 0.0%, 10%, 15% and 20% of volume of sand, and the second type is a chemical agent of polyethylene-glycol (Ch.) with different percentages; 1%, 2% and 3% of weight of cement. The use of self-curing agent (saturated leca) in concrete mixes up to 15% of sand volume improves the physical properties of concretes under dry-air curing regime which can be attributed to better internal curing that provides more and continuation of the hydration process of cement paste which produces less porous and more compact concrete. On the other hand, 20% saturated leca did not adversely affect the permeability (30% reduction); however, it has adversely affected the Volumetric Water Absorption (VWA), the sorptivity, and the mass loss (increased by about 2%, 6.3%, and 10%, respectively). Saran kumar and Suresh babu [7] studied the affect of admixture (PEG-400) on compressive strength, stress-strain behavior at 0.5%, 1% and 1.5% for M25 mix was studied and compared with conventional concrete. Optimum Strength values obtained at 1.5% of poly ethylene glycol-400 and good self curing agent because in the durability and normal compressive strength aspects it was giving good results when compared with both conventional concrete. At the place of Water scarcity areas these types of agents will give a better result. Young's Modulus of self curing concrete is also in the same range as that of conventional concrete. Modulus of elasticity value for conventional concrete is 27 MPa and for self-curing concrete is 30 MPa. Stress-strain behavior for self-curing & conventional concrete is same. Magda Mousa, et al. [8] studied Mechanical properties of self-curing concrete (SCUC). In this study, two materials were selected as self-curing agents with different amounts, and the addition of silica fume was studied. The self-curing agents were, pre-soaked lightweight aggregate (Leca); 0.0%, 10%, 15%, and 20% of volume of sand; or polyethylene-glycol (Ch.); 1%, 2%, and 3% by weight of cement. To carry out this study the cement content of 300, 400, 500 kg/m3, water/cement ratio of 0.5, 0.4, 0.3 and 0.0%, 15% silica fume of weight of cement as an additive were used in concrete mixes. In all cases, either 2% Ch. or 15% Leca was the optimum ratio compared with the other ratios. The use of self-curing agents (Poly Ethylene Glycol or saturated leca) 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 aggregate. Bala Subramanian [9] studied the development of high strength self curing concrete using super absorbing polymer and polyethylene glycol-400. In this paper PEG 400 was used at 0.2%, 0.3% and 0.4% by weight of cement. Concrete was obtained high strength by adding mineral admixture Silica fume (SF) as replacement of cement with varying percentage as 5%, 10% and 15% and by increasing the workability by mixing of chemical admixture (Super Plasticizer–Glenium B233). The grade of concrete investigated is M 60, M70 and M80. The subsequent tests such as Compressive strength, Split tensile strength, Flexural strength, Rapid Chloride Permeability Test and Water sorpitivity test were carried out for High Strength Concrete and High Strength Self Curing Concrete. The strength development of concrete is more if the replacement percentage of silica fume by weight of cement is 10% but Rapid chloride permeability of concrete decreases if the replacement percentages of silica fume by weight of cement is 15%. The strength of the concrete increases significantly with the increase of self-curing agent i.e., concrete with 0.4% of PEG gives more strength than that with 0.2% and 0.3%. S. Azhagarsamy and Dr. S. Sundararaman [10] studied the strength and durability properties of concrete using water soluble Polyethylene Glycol (PEG 400) 0.5% as self-curing agent using M20 grade concrete. The compressive strength at 3 days, 7days and 28 days have been obtained with normal curing and self curing condition. It was found that an average increase in compressive strength of 12.73% and split tensile strength 13.31% with 0.5% of PEG-400 was observed. This shows that self curing concrete showed a better performance than the conventional concrete. An average increase of 10.68, 16.07 and 7.78% were observed when the self curing concrete with PEG 400 was exposed to HCl, H_2SO_4 and Na_2SO_4 of 5% concentration solution.

3. Materials

3.1 Cement

All concrete mixes in this construction were made using ULTRATECH cement of grade 53. The cement was homogeneous in colour, grey with a mild greenish tint, and devoid of hard lumps. Cement tests include beginning and final setting time, specific gravity, fineness, and compressive strength, among other things. Cement was tested in accordance with IS: 12269-1987. Table 1 summarises the results of several tests performed on the cement.

Table 1 Physical properties of cement

S.No	**Properties**	**Values obtained**	**Standard value as per IS code 12269-1987**
1	Specific gravity	3.13	3.11 - 3.15
2	Normal consistency	33.75%	-
3	Initial setting time	55 min	Not be less than 30 min
4	Final setting time	245min	Not be greater than 600 min
5	Fineness (%)	4%	Not be greater than 10

3.2 Coarse Aggregate

The current study made use of locally accessible coarse aggregates with a maximum size of 20mm. The coarse aggregates were tested in accordance with IS: 383-1970. They were then cleaned to eliminate dust and debris and dried to the surface. Tables 2 and 3 show the results of several experiments performed on coarse aggregate. Figure 1 shows a semi log graph produced for sieve analysis of coarse material.

Table 2 Physical properties of coarse aggregate

S.No	**Properties**	**Values obtained**
1	Type	Crushed
2	Maximum size	20 mm
3	Specific gravity (20 mm)	2.808
4	Fineness modulus	6.71
5	Bulk density(kg/m3)	1536
6	Water absorption	0.5%
7	Impact test	11.29
8	Elongation test	20.34%
9	Flakiness index	16.95%

3.3 Fine Aggregate

The sand used in the experiment was obtained locally and conforms to IS: 383-1970 grading zone II. The sand was sieved using a 4.75 mm sieve to eliminate any particles larger than 4.75 mm before being rinsed to remove dust. Table 2 lists the physical features of fine aggregates.

Table 2 Physical properties of fine aggregate

S.No	Properties	Values obtained
1	Type	Crushed
2	Specific gravity	2.63
3	Fineness modulus	2.86
4	Bulk density (kg/m^3)	1674
5	Water absorption	1%
6	Grading zone	Zone II

3.4 LECA

The current study makes use of LECA received from Chennai. Table 3 shows the physical properties of the self-curing agent LECA. Figure 1 depicts an image of the LECA.

Fig 1 Light Expanded Clay Aggregate (LECA)

Table 3 Physical properties of LECA

S.No	Properties	Values obtained
1	Type	Crushed
2	Specific gravity	1.29
3	Fineness modulus	2.62
4	Bulk density (kg/m^3)	669
5	Water absorption	16%

3.1 MIX DESIGN OF CONCRETE

Mix design is the process of choosing appropriate concrete materials such as cement, aggregates, and water and establishing their relative proportions with the goal of creating concrete with the requisite minimum strength, workability, and durability as affordably as feasible. IS: 10262-2009 is used to calculate the mix proportions of M30 grade concrete. Annexure-A describes the detailed mix design for M30 grade concrete. Table 4 shows the M30 mix design proportions.

Table 4 Mix proportion of M30 grade concrete for 1 cubic meter

Unit of batch	**CEMENT (kg/m^3)**	**Fine Aggregate (kg/m^3)**	**Coarse Aggregate (kg/m^3)**	**Water (kg/m^3)**
Content	413.33	681.5908	1187.33	186
Ratio of ingredients	1	1.649	2.873	0.45

4. **RESULTS AND DISCUSSION**

4.1 Electrical Resistivity Test:

The electrical resistivity test results on high strength concrete with varying percentages of fine aggregate substitution with LECA are presented in the table below. According to the test findings, all of the mixes exhibit good corrosion resistance, with the mix including 40% LECA slag exhibiting slightly higher resistance and the mix containing 100% LECA slag exhibiting slightly lower corrosion resistance than the typical mix (fig 2).

Table 37: Electrical Resistivity Test of HSC

Mix no	Proportions	Resistivity P(KΩ-cm)	AASTHO TP95 range
mix-1	CC	27.67	High
mix-2	20% **LECA**	28.96	High
mix-3	40% **LECA**	30.91	High
mix-4	60% **LECA**	26.52	High
mix-5	80% **LECA**	25.28	High
mix-6	100% **LECA**	21.42	High
mix-7	100% **LECA** +1%NS	31.16	High
mix-8	100% **LECA** +2%NS	25.31	High
mix-9	100% **LECA** +3%NS	20.88	Moderate

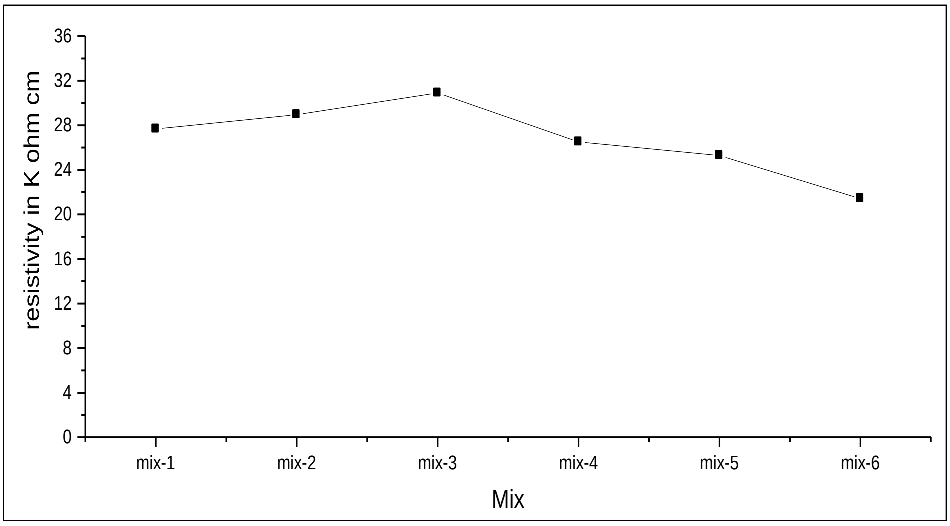

Fig 2: Variation of Electrical Resistivity with different percents of LECA

4.1.1 Effect of Nano silica on electrical resistivity of concrete:

The electrical resistivity of concrete was enhanced by adding 1% Nano silica to a 100% LECA mix, and higher additions of Nano silica beyond 1% lowered the resistivity marginally but within allowable limits (Fig3).

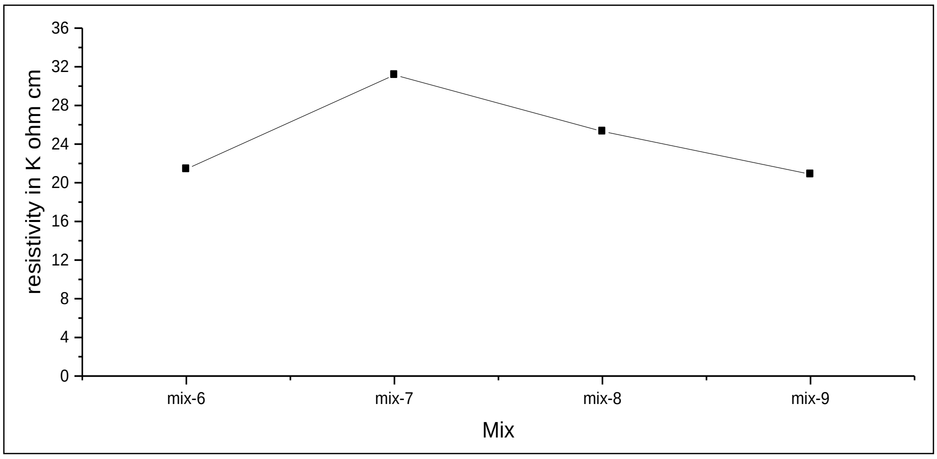

Fig 3: Variation of Electrical Resistivity with different percents of Nano-Silica

4.1 SCANNING ELECTRON MICROSCOPE:

The electrical resistivity of concrete was enhanced by adding 1% Nano silica to a 100% LECA mix, and higher additions of Nano silica beyond 1% lowered the resistivity marginally but within allowable limits (Fig3).

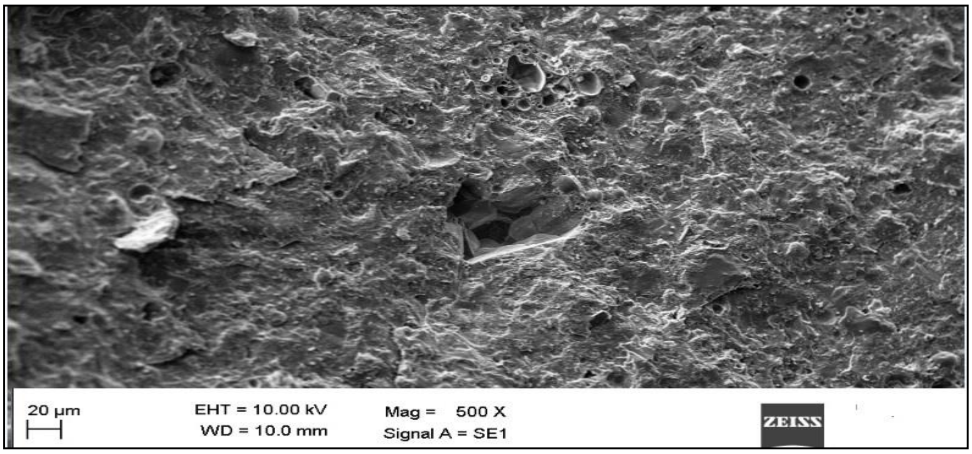

Fig 8: SEM image of 100% LECA mix at 20 microns

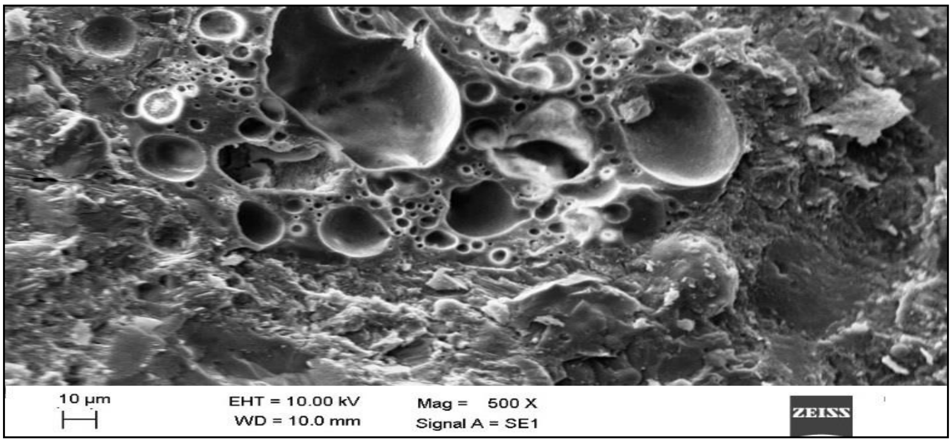

Fig9: SEM image of 100% LECA mix at 10 microns

4.2 Effect of Nano silica on 100% LECAmix:

The filler effect of nano silica particles leads in the creation of an extremely dense structure. The inclusion of nano silica lowers segregation and bleeding while improving concrete cohesiveness. The use of Nano silica decreases the viscosity of the cementitious matrix, balances the negative impact of entrapped air, and minimises hardened concrete porosity.

Figure 10 shows that nano silica combines with calcium hydroxide, resulting in the production of secondary C-S-H gel. This secondary C-S-H gel fills all of the pores and capillary channels in hardened concrete, making it denser and improving its strength and longevity.

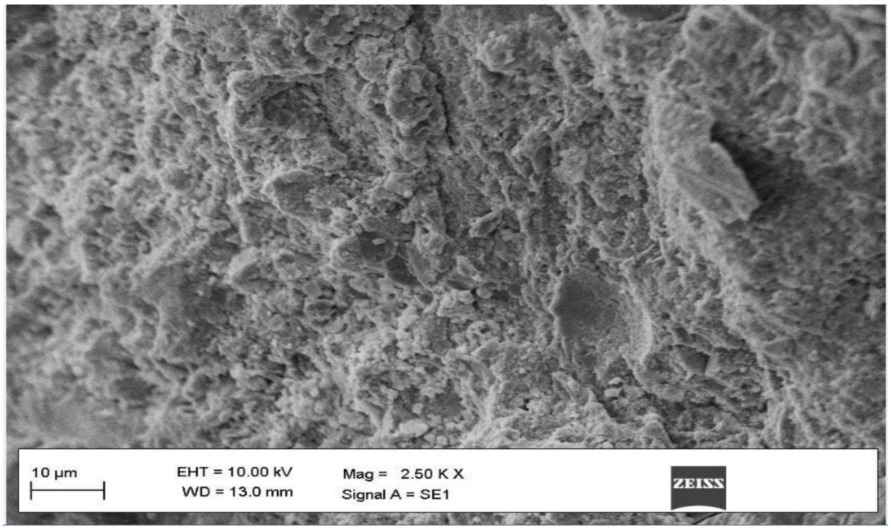

Fig 10: SEM image of 100% LECA+2% Nano Silica mix at 10 microns

5.CONCLUSION

Based on the findings of the above investigation, the following conclusions are drawn about the strength qualities of self-curing concrete when three different self-curing agents, such as LECA, are used.

1. As the amount of self-curing chemicals in concrete grows, so does its workability.
2. At 15% of LECA, the highest compressive strength was 40.89 N/mm2.
3. The corrosion of concrete was improved at 40% LECA, and by increasing the percentage of LECA above 40%, the corrosion was decreased, and the least corrosion was achieved at 100% LECA mix by adding 1% Nano silica to 100% LECA mix.
4. SEM photos indicate that adding 1% Nano Silica to 100% LECA mixes fills all gaps and capillary channels, making the concrete denser and improving its mechanical and durability qualities.
5. The addition of self-curing chemicals LECA to concrete increases its mechanical qualities.

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