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Strength Properties of Self Curing Concrete using Light Weight Aggregates

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Abstract; The effectiveness of conventional compaction methods may be hampered in projects that have a high density of reinforcement, resulting in increased labor and construction time requirements. The inclusion of self-compacting qualities is crucial for improving the surface smoothness, strength, and durability of concrete. In addition to compaction, the process of curing has similar significance in achieving the desired strength and durability of concrete. Traditional curing methods are often associated with a substantial need on human effort, extended time periods, and notable expenses. Furthermore, the development of self-curing concrete may be attributed to other causes, including the inadequate curing process and limited water availability in arid locations.

The workability properties of self-compacting concrete (SCC) mixtures, which incorporate up to 15% prewetted lightweight expanded clay aggregate (LECA) and fine aggregate admixture (FAA), satisfy the workability requirements outlined by the European Federation for Specialist Construction Chemicals and Concrete Systems (EFNARC). The objective of this research was to examine the influence of prewetted lightweight aggregates as self-curing agents on the mechanical properties of the self-cured hardened self-compacting concrete (SCC). The primary objective of the study was to evaluate the impact of several factors on many mechanical properties, including compressive strength, split tensile strength, modulus of rupture, modulus of elasticity, pullout behavior, and flexural behavior. The experimental findings have consistently shown that the SCSCC mixes exhibit improved mechanical properties in comparison to the control mix.

Keywords: self-compacting concrete (SCC), cement, water, light expanded clay aggregate (LECA), fly ash aggregate (FAA), fine and coarse aggregate, and superplasticizer, EFNARC.

1. INTRODUCTION

Due to the distinct demands it faces, the construction industry has seen a significant proliferation of innovative types of concrete globally. The construction industry is now using a diverse range of innovative materials, such as chemical admixtures, mineral admixtures, and environmentally friendly binders, in order to augment the desired properties of concrete and fulfill the requirements of the sector. Furthermore, it is crucial to emphasize suitable compaction and curing techniques to achieve ideal levels of strength and durability in the concrete, in conjunction with the use of these aforementioned elements.

1.1 Self-Compacting Concrete

The calculation of the mix percentage for self-compacting concrete (SCC) considers several factors, including the structural conditions, such as the form, size, and density of reinforcement, as well as the surrounding environment of the structure. The primary need for self-consolidating concrete (SCC) is the ability to perform compaction

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without relying on external vibration. The strength and durability of the material should be equivalent to those of traditional concrete. Dumne (2014) asserts that the use of superplasticizers and air-entraining admixtures is essential for achieving the requisite performance in both the fresh and hardened phases of self-compacting concrete (SCC). Self-compacting concrete (SCC) may be classified into three separate categories: powder type, viscosity type, and powder-cum-viscosity type SCC.

1.2 Scope Of The Present Study

The Processes Of Curing And Compaction Play A Crucial Role In Attaining The Desired Strength And Durability Of Concrete. Traditional Compaction Methods Sometimes Require More Effort And Time And May Not Be Sufficient For Attaining Optimal Compaction In Regions With Dense Reinforcement. Various Efforts Have Been Made To Incorporate Self-Compacting Capabilities Into Concrete By Using Suitable Constituents And Mix Design. Previous Endeavors Have Been Made To Investigate Alternate Methods For Curing Concrete With The Aim Of Improving Its Effectiveness. Furthermore, Much Study Has Been Previously Undertaken About The Advancement Of Curing Agents For Integration Into Concrete In Order To Assist The Process Of Self-Curing. Furthermore, The Field Of Concrete Technology Has Seen The Advent Of Chemical Admixtures

1.3 Objectives Of The Study

- Lightweight expanded clay aggregate (LECA) and fine aggregate addition (FAA) must be taken into account when figuring out the best mix of ingredients for making self-compacting concrete that cures itself (SCSCC).
- The primary aim of this study is to examine the characteristics of a novel kind of concrete, specifically focusing on its capacity to fill voids, flow through narrow spaces, and resist separation. The investigation will be conducted within the framework of self-compacting steel fiber-reinforced concrete (SCSCC).
- The aim of this study is to evaluate the properties of hardened concrete, such as compressive strength, split tensile strength, modulus of rupture, modulus of elasticity, and bond strength, with a special focus on self-compacting steel fiber reinforced concrete (SCSCC).
- We want to find out how well self-compacting concrete (SCC) beams that are reinforced with saturated lightweight expanded clay aggregate (LECA) and fine aggregate angularity (FAA) bend under load. We will do this by doing experiments and math.
- The study's goal is to look at the microstructural features of self-compacting concrete that has fine aggregate (FAA) and saturated lightweight expanded clay aggregate (LECA).
- The main goal of this study is to figure out how strong concrete will be in the long term by looking at a lot of different factors, such as its sorptivity, RCPT (rapid chloride penetration test), corrosion resistance, sulfate attack resistance, salt attack resistance, acid attack resistance, volume change, and abrasion resistance.

2. MATERIALS AND METHODOLOGY

2.1 Cement

Ordinary Portland Cement (OPC) Grade 53 was used in the present project. This particular grade was produced in line with the Indian Standard 12269-1987. For the purpose of evaluating the cement's physical and chemical qualities, the procedures described in IS 4031-1988 and IS 12269-1987, respectively, were used.

Table :1 Physical properties of cement

S.			Requirement as per

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No	Physical properties	Test Results	IS:4031-1988
1.	Standard consistency	34%	-
2.	Initial setting time	94 min	Min. 30 min
3.	Final setting time	240 min	Max. 600 min
4.	Fineness by sieving	4%	Max. 10%
5.	Soundness	0.4 mm	Max. 10 mm
7.	Compressive strength:		
	3 days	30	27 MPa
	7 days	42	37 MPa
	28 days	56	53 MPa

2.2 Fly Ash

Fly ash is a solid, powdery material that is created when pulverized coal is burned in thermal power plants. Fly ash gives thermal power plants their name. The very small particle size of fly ash is one of its defining characteristics. It is a waste product that an electrostatic precipitator (ESP device) produces, to put it simply. Fly ash is characterized by its chemical and mineralogical makeup, which is determined by the characteristics and composition of the coal that is burned in the power plant.

Table :3 Chemical composition of fly ash

S. No	Constituents	Test Results
1.	Silica (SiO_2)	53.11%
2.	Calcium Oxide (CaO)	1.13%
3.	Magnesium Oxide (MgO)	0.24%
4.	Iron Oxide (Fe_2O_3)	7.03%
5.	Aluminum Oxide (Al_2O_3)	18.58%
6.	Loss of Ignition (LOI)	1.25%

2.3 Fine Aggregate

Fine aggregate was comprised of a certain amount of river sand that was readily accessible in the area, and its evaluation was carried out in line with the Indian Standard 2386-1963. This fraction was able to be maintained on a screen with a size of 150 microns and was able to pass through a sieve that had a size of 4.75 millimeters.

Table 4 Physical properties of fine aggregate

S. No	Physical parameters	Test results
1.	Specific gravity	2.535
2.	Bulk Density (loose)	1495 kg/m^3
3.	Bulk Density (compacted)	1545 kg/m^3
4.	Fineness modulus	2.54
5.	Water absorption	0.62%

2.4 Coarse Aggregate

In the present investigation, crushed aggregate with a maximum dimension of 12.5 mm, which conforms to the well-graded aggregate criteria specified in IS 383-1970, was used. The methodology described in the IS 2386-1963 standard was used to carry out experiments on the coarse aggregate. The results collected have been shown in Table 3.5.

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Table:5 Physical properties of coarse aggregate

S.No	Physical parameters	Test results
1.	Specific gravity	2.73
2.	Bulk density (loose)	1548.4 kg/m^3
3.	Bulk density (compacted)	1581 kg/m^3
4.	Fineness modulus	7.47
5.	Water absorption	0.45 %
6.	Aggregate impact value	13 %
7.	Aggregate crushing value	18 %

2.5 Superplasticizer

A superplasticizer is a chemical admixture used to improve the workability of a substance, obviating the need for additional water. The BASF Company's superplasticizer Glenium B233 served as the study's chemical substance. The material has a specific gravity of 1.22. The chemical exhibits conformity with the specifications given in IS 9103-1999, functioning efficiently as a high-range water-reducing additive. The use of Glenium B233 has the potential to reduce the occurrence of bleeding and segregation.

2.6 Light Expanded Clay Aggregate (Leca)

GBC, a company based in Ahmadabad, Gujarat, India, carried out the acquisition of the Last Eukaryotic Common Ancestor (LECA). The primary component used in this method is plastic clay, which undergoes initial preparation prior to being subjected to high temperatures and expansion inside a rotating kiln. During the last phase, the product is subjected to combustion within a temperature range of about 900°C to 1250°C, resulting in the formation of the ultimate lightweight expanded clay aggregate (LECA) product. The material is composed of tiny and lightweight clay particles that have experienced combustion, as seen in Figure 3.1. The many tiny air pockets in LECA (lightweight expanded clay aggregate) may help keep heat in, as shown in Figure 3.2. The physical and chemical properties of LECA (lightweight expanded clay aggregate) were studied according to the steps in ASTM C330-2000 and IS 2386-1963. The results obtained from this study are shown in Table 3.6.

Table :6 Physical properties of LECA aggregate

S. No	Physical parameters	Test results
1.	Specific gravity	1.52
2.	Bulk density (dry state)	443 kg/m^3
3.	Size of aggregate	1.18 – 4.75 mm
4.	Fineness modulus	4.53
5.	Water absorption	35 %

2.7 Mix Proportioning Of SCSC

The composition of the mix must be able to satisfy all of the performance parameters for the concrete in both its fresh and hardened stages in order to be in compliance with the specifications. The creation of SCSCC mixes

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followed procedures that were in line with the suggestions made by EFNARC. This was done as part of the continuous attempt that was being undertaken. In order to get the most favorable results,

Table :7 Mix proportion for SCSCC with LECA aggregate

S. No	Mix Id	Cement (kg/m³)	Fly Ash (kg/m³)	LECA (kg/m³)	Fine Aggregate(kg/m³)	Coarse Aggregate(kg/m³)	Water(kg/m³)	Super plasticizer (kg/m³)
1.	CM_{wc}	439.5	134.4	0	819.6	774.2	177.7	4.02
2.	CM_{rt}	439.5	134.4	0	819.6	774.2	177.7	4.02
3.	L_5	439.5	134.4	12.62	778.62	774.2	177.7	4.02
4.	L_{10}	439.5	134.4	25.24	737.64	774.2	177.7	4.02
5.	L_{15}	439.5	134.4	37.87	696.66	774.2	177.7	4.02
6.	L_{20}	439.5	134.4	50.49	655.68	774.2	177.7	4.02
7.	L_{25}	439.5	134.4	63.11	614.70	774.2	177.7	4.02

Table:8 Mix proportion for SCSCC with FAA aggregate

S. No	MixId	Cement (kg/m³)	Fly Ash (kg/m³)	FAA (kg/m³)	Fine Aggregate (kg/m³)	Coarse Aggregate (kg/m³)	Water (kg/m³)	Super plasticizer (kg/m³)
1.	F_5	439.5	134.4	29.99	778.62	774.2	177.7	4.02
2.	F_{10}	439.5	134.4	59.97	737.64	774.2	177.7	4.02
3.	F_{15}	439.5	134.4	89.96	696.66	774.2	177.7	4.02
4.	F_{20}	439.5	134.4	119.94	655.68	774.2	177.7	4.02
5.	F_{25}	439.5	134.4	149.93	614.70	774.2	177.7	4.02

3. RESULT AND DISCUSION

3.1 General

This chapter provides an examination of the feasibility parameters, mechanical characteristics, elasticity modulus, and flexural performance of self-compacting sustainable concrete composites (SCSCC), including lightweight expanded clay aggregate (LECA) and fine aggregate alternatives (FAA). This chapter presents a comprehensive analysis of the durability of SCSCC in relation to several parameters, including sorptivity, RCPT, corrosion resistance, sulfate resistance, salt resistance, acid resistance, volume change, and abrasion resistance.

3.2 Workability Of SCSCC

Many tests were done on the concrete to see how easy it was to work with. These included slump flow, T50 cm slump flow, V-funnel, J-Ring, L-Box, U-Box, and sieve segregation tests. These tests were done on all self-compacting concrete mixes, which included prewetted lightweight expanded clay aggregate (LECA) and fine

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aggregate addition (FAA).

3.3 Segregation Resistance

The sieve segregation test was employed to evaluate the capacity of mixtures to withstand segregation. The ability to preserve uniformity when transporting and placing materials in highly reinforced areas is an essential characteristic. This test provides empirical support for the homogeneity of the mixture. The test results indicate that all of the SCSCC mixes possess resistance to segregation and adhere to the requirements set by EFNARC. Mixtures characterized by a higher concentration of lightweight expanded clay aggregate (LECA) and fine aggregate admixture (FAA) exhibited a reduction in the degree of sieve segregation. Singh (2009) posits that the use of a lower-value mix leads to an increase in cohesiveness.

Table :9 Properties of fresh SCSCC mixes

S. No	MixID	Slump flow (mm)	T_{50} cm Slump(sec)	V-funnel(sec)	J-ring (mm	L-box H_2/H_1	U-box (h_2~h_1) (mm)	Sieve segregation(%)
SCSCC with LECA								
1.	CM_{wc}	700	3.1	9.7	6.5	0.81	29	12.51
2.	CM_{rt}	700	3.1	9.7	6.5	0.81	29	12.51
3.	L_5	680	3.4	9.6	6.6	0.94	30	10.5
4.	L_{10}	697	3.2	8.5	6.1	0.91	27	9.75
5.	L_{15}	708	2.9	7.8	5.9	0.88	26	8.75
6.	L_{20}	702	3.1	8.1	6.2	0.92	31	7.50
7.	L_{25}	700	3.2	8.0	6.2	0.95	35	4.25
SCSCC with FAA								
8.	F_5	686	3.1	9.5	6.8	0.93	30	11.15
9.	F_{10}	699	3.2	8.4	6.4	0.89	28	10.15
10.	F_{15}	710	2.8	7.9	6	0.86	27	9.55
11.	F_{20}	705	3.3	7.9	6.3	0.9	28	8.25
12.	F_{25}	703	3.2	8.1	6.3	0.96	33	5.75
SCSCC with LECA and FAA								
13.	F_5L_5	705	3.0	8.6	6.3	0.86	24	12.15
14.	F_5L_{10}	693	3.2	8.9	6.5	0.89	25	10.36
15.	F_5L_{15}	678	3.6	9.4	6.9	0.93	27	8.78
16.	F_5L_{20}	665	4.1	10.3	7.5	0.98	29	7.05
17.	$F_{10}L_5$	696	3.2	8.8	6.6	0.84	25	11.74
18.	$F_{10}L_{10}$	687	3.4	9.3	6.9	0.87	26	10.05
19.	$F_{10}L_{15}$	674	3.7	9.8	7.5	0.92	28	8.17
20.	$F_{10}L_{20}$	660	4.3	10.7	8.0	0.95	30	6.45
21.	$F_{15}L_5$	690	3.4	9.1	6.9	0.83	27	10.68
22.	$F_{15}L_{10}$	681	3.7	9.5	7.2	0.88	28	9.32
23.	$F_{15}L_{15}$	665	4.1	10.3	7.8	0.91	29	7.67
24.	$F_{15}L_{20}$	653	4.6	11.1	8.5	0.93	31	6.25
25.	$F_{20}L_5$	684	3.7	9.4	7.1	0.81	28	9.87
26.	$F_{20}L_{10}$	673	4.1	9.9	7.5	0.84	29	8.20

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27.	$F_{20}L_{15}$	662	4.4	10.8	8.1	0.87	30	6.08
28.	$F_{20}L_{20}$	650	4.8	11.6	8.7	0.90	33	5.12
EFNARC Acceptance criteria		650 - 800	2 - 5	6 - 12	0 - 10	0.8 -1	0 - 30	0 - 15

3.4 Mechanical Properties Of SCSCC

The compressive strength and split tensile strength of a self-compacting sustainable concrete composite (SCSCC), including lightweight expanded clay aggregate (LECA) and fine aggregate alternative (FAA), were assessed at different time intervals, namely 3, 7, 28, 56, and 90 days. Furthermore, the characteristics that were evaluated include the modulus of rupture, modulus of elasticity, pull-out test, and flexural behavior.

3.5 Compressive strength of SCSCC with LECA

The compressive strength test results of self-compacting concrete with lightweight expanded clay aggregate (LECA) are shown in Table 9. The compressive strength of the control concrete mix (CMwc) that underwent water curing was determined to be 38 MPa and 44.1 MPa at 7 and 28 days, respectively. On the other hand, the concrete subjected to the process of curing at ambient temperature, which is often known as the control concrete mix (CMrt), exhibited compressive strengths of only 35.56 MPa and 41.25 MPa after 7 and 28 days, respectively. The findings suggest that the CMwc mix exhibits a 6.90% higher compressive strength compared to the CMrt mix at the end of the 28-day period. The decline in the strength of concrete may be ascribed to the insufficient accessibility of water for the process of hydration during the curing phase at room temperature (Jensen & Pietro, 2006; Evangeline, 2014).

Table:10 Compressive strength of SCSCC with LECA

S. No	Mix Id	Compressive Strength (MPa)				
		3 days	7 days	28 days	56 days	90 days
1.	CM_{wc}	19.24	38.00	44.10	46.56	47.78
2.	CM_{rt}	16.46	35.56	41.25	41.57	41.62
3.	L_5	14.36	27.46	37.79	42.65	44.03
4.	L_{10}	15.16	28.33	43.60	47.08	48.84
5.	L_{15}	15.35	29.16	44.93	48.45	50.52
6.	L_{20}	15.02	26.13	41.03	45.21	47.37
7.	L_{25}	13.95	25.98	39.30	43.12	45.86

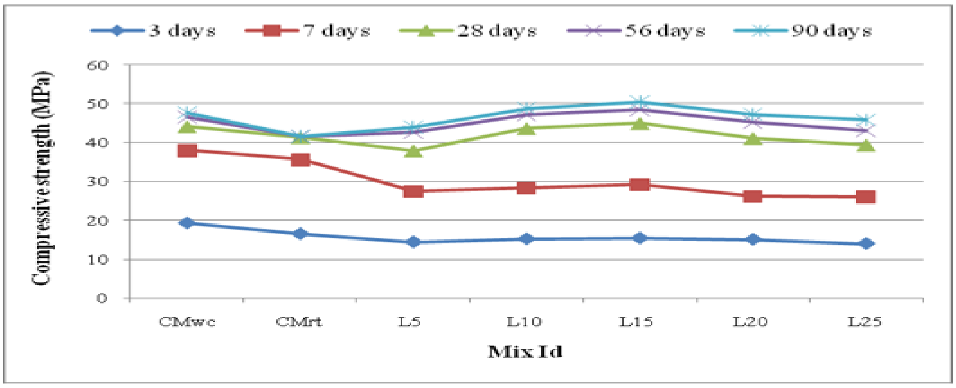

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Figure 3: Compressive strength of SCSCC with LECA

3.6 Compressive Strength Of SCSCC With FAA

The compressive strength test conducted on self-consolidating concrete with fine aggregate angularity. When fly ash is used instead of fine aggregate in self-compacting concrete at different ages, the compressive strength is very similar to that of self-compacting concrete made with lightweight expanded clay aggregate, as shown in Figure 4.2. A study by the Federal Aviation Administration (FAA) found that the self-compacting sustainable concrete composite (SCSCC) had much higher compressive strength than the SCSCC that used lightweight expanded clay aggregate (LECA) after 7, 28, 56, and 90 days. Additionally, it has been observed that all self-compacting concrete (SCC) mixtures that included fine aggregate additions (FAA) were stronger than the control mixture as the curing process went on. Moreover, it is apparent that the use of 15% fine aggregate replacement with FAA yields the most advantageous percentage for augmenting the compressive strength of SCSCC to its utmost capacity

Table:11 Compressive strength of SCSCC with FAA

S. No	Mix Id	Compressive Strength (MPa)				
		3 days	7 days	28 days	56 days	90 days
1.	CM_{wc}	19.24	38.00	44.10	46.56	47.78
2.	CM_{rt}	16.46	35.56	41.25	41.57	41.62
3.	F_5	14.68	28.50	43.90	46.28	48.59
4.	F_{10}	15.04	32.06	44.26	47.48	49.79
5.	F_{15}	15.94	34.40	50.90	52.95	54.17
6.	F_{20}	15.24	34.36	50.00	52.15	53.28
7.	F_{25}	14.82	33.87	49.12	51.12	52.45

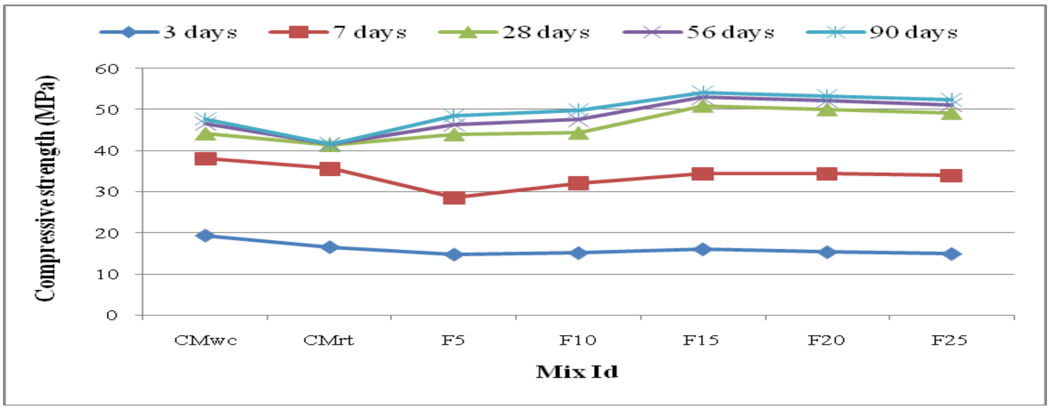

Figure 4: Compressive strength of SCSCC with FAA

3.7 Compressive strength of SCSCC with blend of LECA and FAA

The study looked at the compressive strength of self-curing concrete, focusing on what happened when different amounts of lightweight expanded clay aggregate (LECA) and fine aggregate addition (FAA) were used as self-curing agents. The collected data has been organized into a tabular format and is shown in Table 4.4. The

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compressive strength of self-compacting concrete, including lightweight expanded clay aggregate (LECA), has a decreasing pattern as the LECA content rises, while the fine aggregate (FAA) remains constant, as seen in Figures 4.3a–d. The observed phenomenon of an enhanced hydration process in SCSCC with a higher LECA concentration may be ascribed to the increased availability of internal water inside the mixture. A mix of lightweight expanded clay aggregate (LECA) and fine aggregate (FAA) makes self-compacting concrete (SCC) less strong at the start than regular vibrated concrete (CMwc).

Table :12 Compressive strength of SCSCC with blend of LECA and FAA

S.No	Mix Id	Compressive Strength (MPa)				
		3 days	7 days	28 days	56 days	90 days
1.	CM_{wc}	19.24	38.00	44.10	46.56	47.78
2.	CM_{rt}	16.46	35.56	41.25	41.57	41.62
3.	F_5L_5	14.81	29.56	42.25	47.65	49.25
4.	F_5L_{10}	14.47	28.95	41.38	46.58	49.05
5.	F_5L_{15}	14.20	28.42	40.64	45.72	48.12
6.	F_5L_{20}	13.72	27.43	38.65	44.12	46.85
7.	$F_{10}L_5$	15.15	30.55	43.15	47.68	49.84
8.	$F_{10}L_{10}$	14.91	30.16	42.53	46.87	49.15
9.	$F_{10}L_{15}$	14.52	29.42	41.15	45.55	48.27
10.	$F_{10}L_{20}$	13.56	28.25	39.21	44.92	47.38
11.	$F_{15}L_5$	15.35	30.7	44.24	49.31	51.18
12.	$F_{15}L_{10}$	15.08	30.15	42.92	48.63	49.85
13.	$F_{15}L_{15}$	14.85	29.71	41.64	47.18	48.47
14.	$F_{15}L_{20}$	13.92	28.92	39.86	45.83	47.22
15.	$F_{20}L_5$	14.05	29.45	42.66	47.35	48.33
16.	$F_{20}L_{10}$	13.41	28.24	40.78	45.14	47.13
17.	$F_{20}L_{15}$	12.25	27.17	39.4	44.03	45.74
18.	$F_{20}L_{20}$	11.55	26.08	37.32	42.72	44.25

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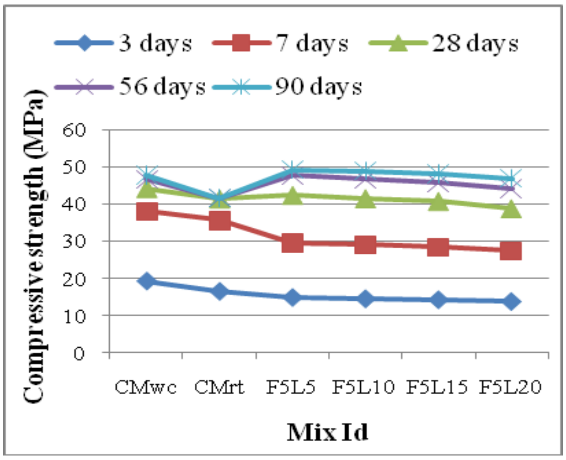

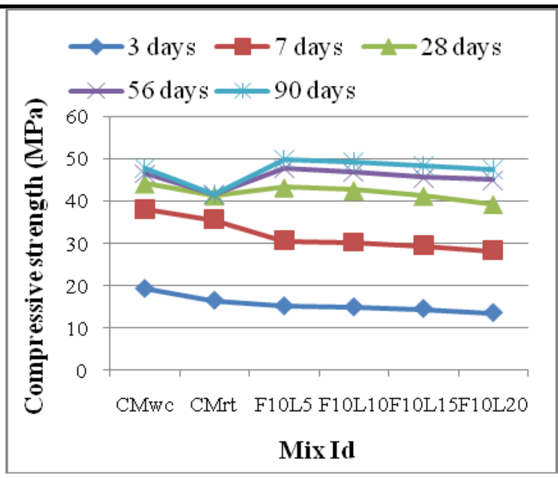

5% FAA with varied LECAcontent 10% FAA with varied LECAconte

3.8 Split tensile strength of SCSCC with LECA

The first stages of self-compacting self-curing concrete (SCSCC) with lightweight expanded clay aggregate (LECA) exhibit a somewhat diminished tensile strength when compared to conventional moisture-cured concrete (CMwc), namely at the 3-day and 7-day time points. However, a significant improvement in the tensile strength of self-compacting self-curing concrete (SCSCC) may be seen when lightweight expanded clay aggregate (LECA) is used, as shown at the 28, 56, and 90-day time points (Figure 4.4). Moreover, it has been shown via empirical research that the L15 combination exhibits a higher level of tensile strength when compared to all other mixes of SCSCC

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Table:13 Split tensile strength of SCSCC with LECA

S. No	Mix Id	Split tensile strength (MPa)				
		3 days	7 days	28 days	56 days	90 days
1.	CM_{wc}	1.54	2.96	3.98	4.05	4.10
2.	CM_{rt}	1.22	1.85	2.31	2.72	2.95
3.	L_5	1.36	1.87	3.37	3.62	3.82
4.	L_{10}	1.48	1.91	3.65	3.88	4.10
5.	L_{15}	1.52	1.92	4.32	4.48	4.57
6.	L_{20}	1.45	1.72	3.34	3.65	3.92
7.	L_{25}	1.38	1.68	3.14	3.48	3.70

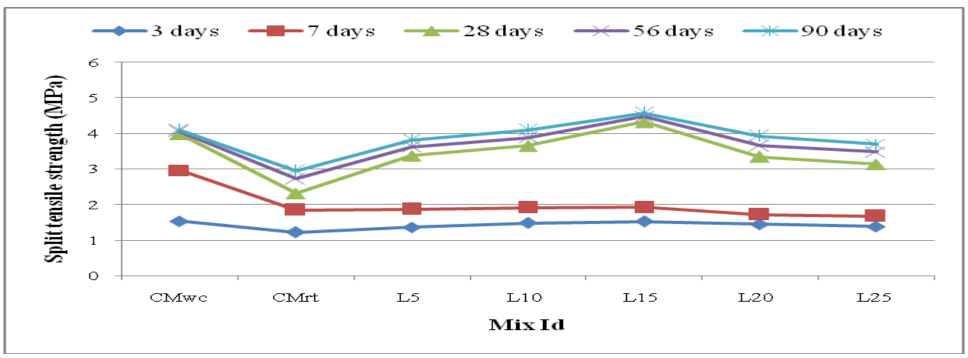

Figure 7: Split tensile strength of SCSCC with LECA

3.9 Modulus of rupture of SCSCC with LECA

The experimental results for the modulus of rupture of self-compacting steel fiber reinforced concrete (SCSCC) using lightweight expanded clay aggregate (LECA) are shown in Table 4.8. Based on the data shown in Figure 4.7, it is evident that the SCSCC combination, including 15% LECA, has the greatest modulus of rupture when compared to the other mixtures. A comparison of the L15 combination to the control concrete at 7, 28, 56, and 90 days showed that it had a higher modulus of rupture by 1.59%, 14.32%, 13.27%, and 11.74%.

Table 14: Modulus of rupture of SCSCC with LECA

S. No	Mix Id	Modulus of rupture (MPa)				
		3 days	7 days	28 days	56 days	90 days
1.	CM_{wc}	3.08	5.65	6.63	6.78	6.98
2.	CM_{rt}	2.51	5.04	5.52	5.59	5.63
3.	L_5	2.72	5.26	6.32	6.47	6.52
4.	L_{10}	2.81	5.39	6.52	6.68	6.75
5.	L_{15}	2.96	5.74	7.58	7.68	7.80

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6.	L_{20}	2.90	5.28	7.20	7.35	7.48
7.	L_{25}	2.84	5.12	7.15	7.24	7.34

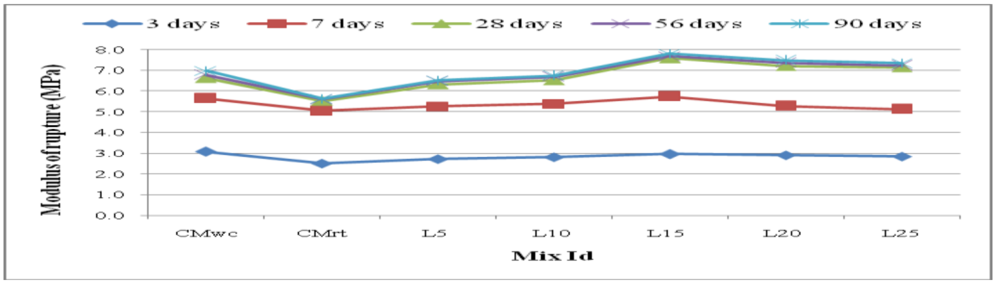

Figure 8: Modulus of rupture of SCSCC with LECA

3.10 Modulus of rupture of SCSCC with FAA

The modulus of rupture of SCSCC with FAA. The concrete combination, which included replacing 15% of the fine aggregate with fly ash (FAA), exhibited a higher modulus of rupture in comparison to the control concrete. This trend was also seen in other concrete mixes that incorporated varying quantities of FAA, as shown in Figure 4.8. The F15 combination showed increases in strength of 3.18%, 18.70%, 16.66%, and 13.89% compared to CMwc at 7, 28, 56, and 90 days, respectively.

Table 15 Modulus of rupture of SCSCC with FAA

S. No	Mix Id	Modulus of rupture (MPa)				
		3 days	7 days	28 days	56 days	90 days
1.	CM_{wc}	3.08	5.65	6.63	6.78	6.98
2.	CM_{rt}	2.51	5.04	5.52	5.59	5.63
3.	F_5	2.77	5.55	6.02	6.20	6.26
4.	F_{10}	2.89	5.67	6.65	6.76	6.84
5.	F_{15}	3.02	5.83	7.87	7.91	7.95
6.	F_{20}	2.94	5.30	7.33	7.40	7.45
7.	F_{25}	2.86	5.24	7.05	7.10	7.18

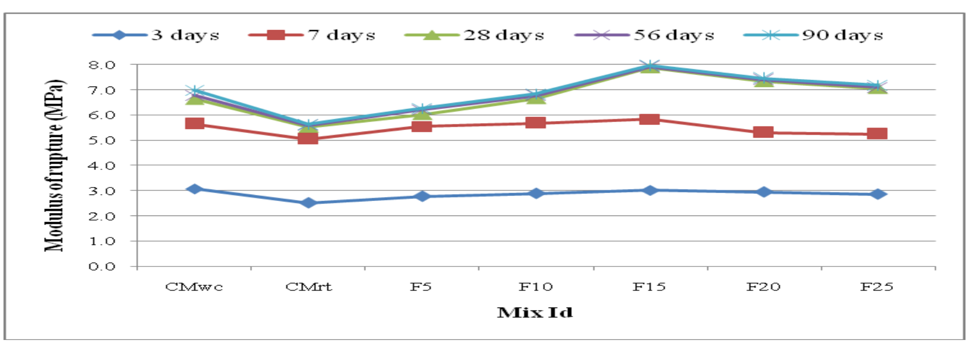

Figure 9: Modulus of rupture of SCSCC with FAA

4. CONCLUSIONS

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- Self-compacting self-consolidating concrete (SCSCC) mixtures are easy to work with because they meet the standards set by the European Federation for Specialist Construction Chemicals (EFNARC). In spite of this, adding more than 15% of lightweight expanded clay aggregate (LECA) and fine aggregate admixture (FAA) to self-compacting concrete (SCC) makes it less able to move through small spaces. The primary cause of this phenomenon may be primarily ascribed to the reduction in the total mass of the concrete.
- It has been found that using 15% of lightweight expanded clay aggregate (LECA) or fine aggregate alternative (FAA) instead of natural fine aggregate is the best way to get the highest compressive strength in self-compacting concrete (SCSCC). Finding the best ratio for replacing the fine aggregate in self-compacting concrete with a mix of 15% fly ash aggregate (FAA) and 5% lightweight expanded clay aggregate (LECA) is the goal of the study. This will help get the highest compressive strength.
- In addition, it was seen that the compressive strength of all three SCSCC mixtures (F15, L15, and F15L5) was higher than that of the control mixture. After 28 days, it was seen that the F15, L15, and F15L5 SCSCC combinations had higher compressive strengths than the control mixture. The differences were 15.42%, 1.88%, and 0.31%, respectively. To add to that, past research has shown that all self-compacting concrete (SCC) mixes consistently show better flexural behavior, stronger bond strength, and higher modulus of rupture compared to the control mix. The use of prewetted lightweight aggregates as self-curing agents is employed to ease the complete hydration of cement, hence improving the quality of concrete in terms of its porosity, permeability, and ultimately, its strength.
- Furthermore, among the various SCSCC mixes, it has been observed that the SCSCC mix including 15% FAA exhibits the highest level of compressive strength. The L15 and F15L5 mixes demonstrate comparable performance, closely trailing behind the aforementioned mix. The F15 SCSCC combination exhibited a significant enhancement in compressive strength, with a 13.28% increase compared to the L15 mixture and a 15.05% increase compared to the F15L5 mixture, after a 28-day period. Furthermore, it has been shown that the F15 SCSCC blend exhibits enhanced split tensile strength and modulus of rupture.
- The self-consolidating concrete mix in question has a better modulus of elasticity, bond strength, and flexural behavior compared to other mixtures. The increase in strength seen in the material is attributed to the densification of its microstructure. The interaction between the amorphous silica present in fly ash aggregate and calcium hydroxide results in the generation of additional cementitious material, which is what achieves this densification.

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